Children with Down's Syndrome

Motor Development and Intervention

Peter E.M. Lauteslager, PhD

's Heeren Loo
Zorggroep

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The logo

Like any other child, the Down’s syndrome child has a natural need for movement. The development of his motor behaviour, however, is subject to specific disorders. In spite of this, these children make use of the potential they possess and develop a modified form of motor behaviour. This specific behaviour is typified by functional limitations.

The logo is a symbol of the motor perspective. The little figure is jumping, dancing and reaching upwards. It is expressing the possibilities, freedom and delights of movement. It could even be singing a song. The logo symbolises the motor development perspective envisaged in this specific physiotherapeutic support.

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Foreword

I am very pleased to have the opportunity to provide a foreword to this book. There is no doubt in the opinion of physiotherapists and other motor specialists that such organized motor activities contribute to the motor development of children with Down's syndrome. Such activities have not always been a feature of home, school and care programmes for children with Down's syndrome, however. This book provides not only a well elaborated design for the application of a motor activity programme for young children with Down's syndrome, but also meets the demands of an evidence-based practice due to its solid scientific research.

Motor development is a core issue in the development of every child. It is a process that begins at conception and continues throughout life. In the early years, motor activities provide the possibility for a child to interact with its environment. It also gives parents the opportunity to have a direct contact with their child. Early communication between mother and child is immediately related to the movement control of the baby and the young child. It is very frustrating for a mother and a father if their child has no postural control, as a result of which there is no spontaneous eye contact or verbal contact between parent and child. Early communication forms the basis for pre-verbal communication, which contributes to the cognitive development of the child. Early communication also forms the basis for the affective and social development of all children, disabled or otherwise.

There are various views on the motor development of children with mental retardation. They could be summarized in two positions. In the first instance the motor development of children with mental retardation in general, and children with Down's syndrome in particular, is delayed. The changes in physical achievements during development exhibit the same pattern as in normal children. However, the children with mental retardation are increasingly behind in terms of prevailing standards. Current research supports the second position. Descriptions of individual differences both in movement patterns and in developmental patterns result in the hypothesis on the view that the motor development of children with mental retardation differs from that of normal children. This view is particularly applicable for children with Down's syndrome. The central nervous system of these children is constitutionally different due to chromosomal deviations. Peter

Lauteslager summarises the outcome of current research as follows: It appears that persons with Down's syndrome have syndrome-specific motor problems. This view legitimates the construction of a syndrome-specific scale to measure the motor development of young children with Down's syndrome.

These two views also have implications for intervention. When the motor development is judged to be delayed, programmes aimed at the provision of stimulation and the reduction of the delay are considered to be necessary. In particular, this approach is to be followed where the delay is considered to be caused by environmental factors, which is not primarily the case with respect to children with Down's syndrome. When the motor development is conceived to be different, the specific disorders are taken into account. Specifically designed therapeutic training and learning programmes are then needed. Intervention often consists of specific, individually designed stimulation. Proper stimulation should be adapted to the child's qualitative capacities, accounting for the fact that any mentally retarded child has his own individually structured central nervous system, dependent on his own natural history. That is exactly what Peter Lauteslager provides in this book: a motor intervention programme adapted to the syndrome specific motor problems of children with Down's syndrome.

I believe that therapists, teachers, special educators, parents, and other readers will find the information contained in this book interesting, stimulating and beneficial, regarding motor processes and the role they have to play in the life of children with developmental disabilities, in particular that of children with Down's syndrome.

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Preface

At what moment does a research study come into being? Or more specifically, what events inspired this investigation? What was the reason for doing research into the development of basic motor skills of children with Down's syndrome? Research starts with questions arising and the need for answers to them. Research can originate from situations that make an impression, through events which need clarification, but which simply do not have that clarification. Research can arise from impotence, from the need to be able to contribute and from the feeling of not being able to offer anything.
This research came into being in 1989 in the sitting room of a family in Harderwijk with a Down's syndrome baby. The questions, which led to this research crystallised at the moment that René came into the room with his four-month-old son and said: 'This is Emiel, and this is the problem.' The baby boy was not moving, did not seem to be able to move and his head and legs were hanging limply over his father's hands.

I took Emiel into my arms and immediately felt what René meant. That very moment was the incentive for this research, the moment at which I wondered what could be wrong with this child, how on earth such a thing could be possible and, as a physiotherapist, what I could do to assist. The problem in motor development was immense, nearly as great as my own feeling of helplessness.
I gave Emiel physiotherapy until he could crawl. At that point the physiotherapy stopped. The fact that Emiel could crawl was for him the moment he could express his enormous urge for action. He no longer needed my support.
I owe a lot to the period in which I treated Emiel. That was the time in which the questions arose. The questions and the urgent need to obtain clarity in a situation which, at that moment, was anything but clear. These same questions will be posed in the introductory chapter. They are the questions that signalled the beginning of an exciting search in the field 'Basic motor skills of children with Down's syndrome'.

Peter Lauteslager

1. Introduction

1.1 Foreword

Parents of a young Down's syndrome (hereafter DS) child are appealing for support from a physiotherapist to an ever-increasing degree during the first years of their child's life (van der Kleij, Hoekman, Retel & van der Velden, 1994). One of the reasons for this is that their child's motor behaviour differs substantially from that of non-disabled children. In addition, early stimulation has been hypothesized as having a positive effect (Henderson, 1985; Block, 1991).
Experience has shown that in general, physiotherapy is not adequately equipped to respond effectively to this cry for help. Within the professional group, however, an increasing number of physiotherapists have been inclined to approach specific requests for help with specialist skills, placing the practical physiotherapy treatment in a scientific context and testing it systematically (Ekkelboom, 1995). The obvious motor problems of young DS children, the request to the professional group of paediatric physiotherapists for help and the lack of a well-founded scientific framework, have formed the contributory circumstances leading to this research into 'The motor development and treatment of children with DS'.

1.2 The problem

The development of motor behaviour in DS children shows a profile different to that of non-disabled children. It is evident that their motor ability develops relatively slowly and that motor milestones are achieved later (Cunningham, 1982; Ulrich, Ulrich & Collier, 1992). In addition, however, it appears that the order in which motor skills are mastered also differs (Haley, 1987; Dyer, Gunn, Rauh & Berry, 1990). Finally, there are descriptions of specific postural and movement patterns which have not been observed in non-disabled children (Lydic & Steele, 1979; Rast & Harris, 1985).
Various authors have described characteristic motor disorders which occur in DS children and which seem to influence their motor development. Cowie (1970), for example, mentioned reduced postural tonus as a typical neuromotor symptom. Rast and Harris (1985) and Shumway-Cook and Woollacott (1985) described inadequate postural

reactions (including balance reactions), Davis and Scott Kelso (1982) mentioned insufficiency of stabilising myogenous contractions around joints (co-contractions). Dyer et al. (1990) postulated a disturbed proprioception; Parker and James (1985) reported hypermobility of joints.
Block (1991), in an overview article, indicated that frequently occurring health problems, such as a congenital heart defect or visual defects, can also influence motor development. In addition, the cognitive and social restrictions of children also play a role. Various authors concluded that the motor problems were specific to DS (Henderson, 1985; Connolly & Michael, 1986).
During the first years of their child's life, parents increasingly feel the need for guidance in motor development (van der Kleij et al., 1994). However, the outlook of referees on this development and on the nature of motor problems is diverse. The referral of a child to a paediatric physiotherapist at an early age, as described in the 'Introduction to the medical supervision of children with DS' by Borstlap (1996), is increasing, but is not yet standard procedure in the Netherlands. Van der Kleij et al. (1994) stated that in general the referral of parents by health care workers only took place to a limited extent. They concluded that paediatricians, general practitioners and doctors at clinics were not adequately aware of the assistance available.
Within the discipline of paediatric physiotherapy, views are not unanimous on the nature and background of motor problems and the appropriate intervention. Referral to a paediatric physiotherapist for development research and guidance is interpreted in various ways. For one thing, it depends on the outlook of the health care worker regarding the motor development of these children and his views relating to the most appropriate form of intervention. For instance, a number of them see no indication for treatment and consider an exploratory discussion with the parents to be sufficient. Others give guidance to the children twice a week by means of an exercise therapy treatment until they can walk independently. Between these two extremes there are all sorts of variations. Treatment methods vary and there is no scientific foundation for the treatment therapy.

There is little substance in the literature regarding intervention. Methodological problems are evident in intervention research (Gibson & Fields, 1984; Gibson & Harris, 1988) and not enough has been written about the treatment methods investigated. Consequently, the results of intervention and the most appropriate treatment methods remain unclear. Overview articles (Henderson, 1985; Gibson & Harris, 1988; Block, 1991) show that there have been frequent publications about the motor problems and about the effects of intervention. However, the research material available appears to be disjointed. The authors recommend a synthesis of the knowledge available as well as its integration in research and in daily practice. In view of the nature of the motor problems involved, the treatment and guidance of the DS child could take place within the domain of paediatric physiotherapy. In that case, paediatric physiotherapists should bear the responsibility for the therapy treatment. To date, however, physiotherapy has not had a tradition of scientific research. For some years, research in this domain has primarily taken place within medical frameworks (Ekkelboom, 1995). Until the present time practically no physiotherapists have been involved in research into the effect of stimulation on the motor development of DS children. It is possible that this has contributed to the fact that research has not been specific enough to objectify effects in the field of physiotherapy.

1.3 Objectives

The aim of this research is to contribute to the introduction of a scientifically based method in order to provide systematic and appropriate physiotherapy guidance in the motor development of DS children. Essential components of such a method are a treatment framework and an instrument to register motor competence. Both should be tailored to the specific motor problems involved. Based on individual differences within the population, treatment should be given in an individual form per child, in order to achieve optimal application. The treatment should do justice to the nature of the child, the parent-child relationship and the family situation. The motor competence of a child should be measurable objectively producing results which can (easily) be converted into specific physiotherapy treatment objectives. In order to make appropriate intervention possible, the measurement method should be able to register small changes in motor behaviour. It should be possible for paediatric physiotherapists to use both the method of registration and the method of treatment in their everyday practice.

1.4 Research questions

In the first place, it is important to investigate the motor profile of a DS child. There should be an examination of the manner in which movement patterns manifest themselves and the extent to which motor behaviour is functional. Motor competence should be appropriate and should underpin a child's development. There should be examination of the restrictions a child experiences in moving and the particular aspect of movement in which these restrictions occur. The first research question focuses on the manner in which the motor skills of young DS children develop and on the restrictions which occur during that development.

Due to their obvious motor problems, DS children have frequently participated in research studies into the effect of intervention. The second research question focuses on the intervention research previously carried out and on the applied methods of treatment and consequent results. There is an investigation into which intervention concept, measuring instrument and research design were applied and on which theoretical concept the method of treatment was based.

In each phase, motor behaviour develops on the foundations of acquired motor behaviour and experience gained in previous phases (Gallahue & Ozmun, 1998). It forms a basis for the development of behaviour in subsequent phases. With a view to managing this development, it is important to understand why the development of the motor skills of these children progresses as it does. There must first be insight into the way that the postural and movement patterns originate in which the problems occur, so that a well-founded choice of intervention method can be made. In order to arrive at a valid treatment proposal, the researcher should check whether the motor problems stated fit into a theoretical framework. The third research question, therefore, focuses on the definition of a theoretical framework which interprets the motor behaviour of DS children providing insight into the specific manner in which the motor development proceeds.

The level of motor competence of a DS child and the development of such should be registered in a valid and reliable manner. On the one hand, this provides an opportunity to establish the treatment objectives in the context of a motor treatment. On the other hand, a treatment method can be investigated as to its appropriateness in the framework of intervention research. The literature indicates that the motor development of DS children is distinct from that of non-disabled children (Dyer et al., 1990). Researchers, therefore, ask the question as to whether the usual measuring instruments, which are standardised on non-disabled children, can be used to measure the effect of intervention on the motor development of DS children (Harris, 1980; Sharav & Shlomo, 1986).

In the period of development of basic motor skills, the foundation is laid for further motor development (Gallahue & Ozmun, 1998). Development-oriented motor intervention takes place primarily during this period. A measuring instrument should thus be able to assess the development of motor behaviour in this period and should be able to provide insight into the restrictions in that development. The fourth research question, therefore, focuses on the definition of a measuring method with which the development of basic motor skills of a DS child can be recorded in a reliable and valid manner. The instrument should be based on a theoretical framework which interprets the specific motor problems of DS children.

As the basic motor skills develop in the early years of a child's life, the instrument will have to be able to be applied to children of the baby and toddler age who have a mental disability. The instrument must be sensitive (Harris, 1981a; 1981b) and should be able to register small variations in a child's motor competence. The process of the motor development of DS children is extremely diverse. The instrument must be able to provide insight into the individual specific process of that motor development, be able to evaluate the child's level of functional skills and the effect of the treatment on them (Ketelaar, Vermeer & Helders, 1998).

The fifth research question, in conclusion, focuses on the definition of a problem specific motor treatment method for young DS children. A component of this method is a therapeutic framework. Should such a therapeutic framework not be available then it will have to be set up, together with the measuring instrument, in connection with the defined theoretical framework. As the motor problems of DS children appear in very diverse forms, a therapeutic framework should be of such a structure that it can be applied to children with various levels of mental and motor competence.

In order to be able to work in a focused and methodical manner, it should be possible to operate treatment objectives with the defined measuring instrument. It should be possible to formulate individual specific objectives for a treatment on the basis of a test. The method

should be a daily feature of the paediatric physiotherapist's practice.
It is likely that stimulation of the development of motor behaviour offers more perspective when parents apply correction as an integral part of their daily interaction with their child. However, parents are primarily fathers or mothers and should not have the role of therapist foisted upon them. A child with a mental disability always requires a different sort of attention focus. That is why parental participation should fit in as closely as possible with the particular feature of individual family life. Parental participation should be a part of the treatment method and should underpin a normal parent-child relationship.
The defined method of treatment will be researched as to its effectiveness. With the current awareness of the motor constraints of young DS children it is not feasible, from an ethical point of view, to withhold motor stimulation from them. After all, children's development only takes place once. Furthermore, pure experimental research, in which use is made of an experimental and a control group, was not recommended because the subjects could not be compared (Harris, 1980). A quasi-experimental research design, in which each child is treated and in which the effect of intervention on the motor development is also assessed per child, seems to be a more feasible alternative.

1.5 Structure of the research

In Chapter 2, following the introductory chapter, there is a description of the characteristic movement patterns of young DS children based on structured observations and analysed in relation to the relevant literature.
In Chapter 3 there is a literature search of studies made from 1970 onwards, on the effect of intervention on the motor development of DS children. Based on these data, research conditions were then formulated relating to a theoretical framework, a method of treatment, a specific motor measuring instrument and a research design.
Chapter 4 is devoted to the definition of a theoretical framework. This chapter describes a literature study into descriptions of the characteristic motor behaviour of young DS children and the model used in clarification by the authors.
In Chapter 5, the motor measuring instrument 'Test of Basic Motor Skills in Children with Down's syndrome' or BMS is introduced and there is a description of the results of psychometric research into the reliability and construct-validity (content validity) of the measuring

instrument. Chapter 6 describes the method and results of the research into the effect of physiotherapy on the development of basic motor skills of DS children.
In Chapter 7 final conclusions are drawn regarding the research and the results which this study has produced. This chapter outlines the various research steps with the relevant conclusions. A summary is included.
There are two appendices: the measuring instrument 'Test of Basic Motor Skills for Children with Down's syndrome' (BMS) (appendix 1) and the physiotherapy framework 'Physiotherapy for young children with Down's syndrome' (appendix 2).

1.6 Literature

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2. Motor development in young children with Down's syndrome

Down's syndrome (DS) is a disorder, consisting of multiple congenital abnormalities, which arises, in approximately 93% of the cases, from an extra chromosome 21. The mental handicap is the most prominent: the level can vary from profound to mild mental retardation. For a long time motor development has been generally characterized as being retarded, but regular, and inextricably linked with the mental handicap. Consequently, the study of motor development in DS individuals has been mainly limited to the attainment of motor milestones.
In the last thirty years, however, studies have indicated increasingly that there are also specific problems in their motor development. Research carried out by Carr (1970) shows that the DS child achieves even less in the domain of motor development than in that of mental development. Connolly and Michael (1986) report that DS children also achieve less in motor development than those mentally handicapped in other ways. Cowie (1970) describes some very specific neuromotor disorders, which appear to have far-reaching consequences for the motor development of the DS child.
Several authors place the motor problems of the DS child in a developmental context (Harris, 1981; Haley, 1986). Apart from Lydic and Steele's article (1979), there are no publications in which, by describing the development of abnormal patterns of posture and movement, any attempt is made to come to an analysis of the problem relating to the quality of movement of the DS child.

The need for an analysis of the problem arose from practical experience in the department of physiotherapy at 's Heeren Loo

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Chapter 2 is based on

Lauteslager, P.E.M. (1991). Syndroom van Down; motoriek in ontwikkeling (Motor development in young children with Down's syndrome). *Nederlands Tijdschrift voor Fysiotherapie,* 101, 260-269.

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Midden Nederland in Ermelo (a residential institution for the mentally handicapped), where for some years five young DS children, living at home, had been treated who displayed what appeared to be characteristic motor problems. The decision was made to analyse the available video material of the children (evaluations of treatment) and to combine this with data from the literature which may contribute to a better understanding of the quality of movement of DS children. This chapter describes the characteristic movement patterns of DS children, based on observation and discussed in relation to the relevant literature. The aim is to arrive at a hypothesis whereby the motor problems of DS children can be placed in a developmental framework, enabling the physiotherapist involved to make educated choices regarding the exercise therapy treatment.

2.1 The literature

There have been many publications illustrating several aspects of DS. A limited number of these articles has been about motor development. A selection has been made from these articles, which may contribute to the understanding of the qualitative aspects of motor development in DS children. In order to obtain these articles, use has been made of the computerised literature bank of the university library in Groningen, the documentation centre of the Foundation for Science and Education in Physiotherapy at Amersfoort (Stichting Wetenschap en Scholing Fysiotherapie te Amersfoort) and from the DS foundation in Wanneperveen.

2.1.1 Mental and motor development

DS has been known for a long time as a fairly common disorder in which the mental handicap is the most obvious symptom. The fact that there are also specific problems in the field of motor development, such as, for instance, a lack of balance or trunk rotation and abnormal moving patterns, has long been overlooked.
In 1970 however Carr (1970) made it clear that the child with DS is relatively more handicapped in motor abilities than in mental abilities. She carried out a longitudinal study on 47 DS children, with a control group of the same number of non-handicapped children, matched for sex, age and social class. During the first two years of life she tested each child five times (at 6 weeks, 6 months, 10 months, 15 months

and 24 months), using the Bayley Infant Scales of Mental and Motor Development.

Both the mental and the motor mean scores of the DS children showed a sharp decline between six and ten months compared with the scores of the non-handicapped children. The mental score declined gradually up to 24 months, while the motor score continued to decline sharply to 15 months, then remaining unchanged between 15 and 24 months. From six months of age onwards the mean motor score was lower than the mean mental score. Scores were not related to differences in sex or social class. However, after six months DS children living at home (n = 40) scored better than those boarded-out (n = 7).

A marked characteristic of the motor development of DS children is that compared to non-handicapped children the motor milestones are not only achieved later, but that the age range at which a particular motor level is reached is greater. To illustrate this point, we refer to findings taken from Cunningham (1982) (see table 2.1).

Motor milestone	DS children		Non-handicapped children	
	Mean age	Range in months	Mean age	Range in months
Good head Balance	5	3- 9	3	1- 4
Rolls over	8	4-12	5	2-10
Sits erect more than one minute	9	6-16	7	5- 9
Pulls to stand	15	8-26	8	7-12
Idem with help	16	6-30	10	7-12
Stands alone	18	12-38	11	9-16
Walks without support	19	13-48	12	9-17
Climbs stairs with help	30	20-48	17	12-24
Comes down stairs with help	36	24-60+	17	13-24
Runs	± 48			
Jumps up and down, on the spot	48 tot 60			

Table 2.1 Motor milestones of DS children compared with non-handicapped children (Cunningham, 1982)

2.1.2 Specific motor problems

Mental handicap is often accompanied by an abnormal course of motor development and reduced motor abilities. Henderson (1985) gives two possible explanations for this. Reduced explorative behaviour can be of importance and neuromotor system impairments can play a role. Generally speaking, studies show that the level of motor achievements is on average lower for mentally handicapped children than for children of normal intelligence.

Connolly and Michael (1986) refer to various authors who have researched and described the motor characteristics of mentally handicapped people. Malpass (1963) for example, writes that the tempo in which abilities are acquired during motor development is clearly slower, but that the order in which this occurs is identical to the course of motor development in normal children, resulting in developmental delay. The mentally handicapped child usually has problems with fine motor skills (coordination, manipulation). Groden (1969) and Hayden (1964) contend that mentally handicapped children are on average less strong, have less stamina and more problems in the execution of complex motor tasks. Other authors describe problems in eye-hand coordination, dexterity and reaction speed.

One important question is whether the motor problems described above apply to the average motor situation of every mentally handicapped person, or whether the quality of movement of people with DS shows syndrome specific characteristics. Connolly and Michael (1986) clearly indicate these characteristics in describing the results of a study in which they tested the motor achievements of 24 mentally handicapped children using the Bruininks Oseretsky test. The mean age of the children was 9.25 years with a comparable mental age, 12 of them having DS. The results of the study show that the DS children achieve significantly less in terms of the speed of walking, balance, strength, eye-hand coordination and general gross and fine motor abilities, compared with the children mentally handicapped in other ways. They reported that their findings corresponded to the results of previous studies, such as those of Henderson et al. and Nakamura (1965) and they related the problems of balance to a retarded maturation of the cerebellum and a relatively small cerebellum and brain stem.

2.1.3 Specific neuro-anatomical abnormalities

Several authors, discussing these specific neuro-anatomical abnormalities, refer to an article by Crome (1965) in which a reduced total weight of the brain (an average of 76% of the normal weight) and in particular a smaller brain stem and cerebellum (66%) are reported. Benda (1960) states that the brains of DS children show characteristics of neurological immaturity in terms of smaller convolutions of the cerebral cortex and reduced myelination in, for example, the frontal lobes and the cerebellum. Davidoff reports too few neurons in the cortex, particularly of the temporal lobe, but also in the frontal, parietal and occipital lobes.

Colon (1972) points to a reduction in the occipital cortex of about 50% and an increase of one and a half times in the size of the nucleus of cells in the remaining neurons, mentioning in this connection disturbances in the process of cell differentiation. Marin-Padilla (1976) describes disorders in the structure of dendrites of pyramidal neurons in the motor cortex. Several authors refer to the findings of Takashima et al. that, in addition to the above-mentioned structural disorders, the development of neurons appears to be normal during pregnancy, yet postnatally a reduced number of dendrites is observed in comparison with non-handicapped children.
Many authors assume a relationship between these characteristic neuro-anatomical abnormalities of individuals with DS and a number of abnormal aspects of their motor abilities, such as lack of balance, coordination of movement and reduced muscle tension.

The cerebellum plays a central role in the coordination of posture and movement and receives information from the vestibulum and from the spinocerebellar tracts. It interacts with the neocortex from where voluntary movement commands originate. Information about the outside world is obtained via the higher senses. In addition, constant adjustment takes place from the cerebellar cortex via cerebellar nuclei to extra-pyramidal motor circuitry in the brain stem and via the thalamus back to the brain cortex. When defects of the cerebellum are involved, disturbances in, for example, balance and movement coordination, together with hypotonia, can be observed. It is essential for the maintenance of posture that the facilitation of the gamma-motor neurons be regulated at the level of the brain stem. Without this basic activity the facilitation of the Alpha motor neurons drops out via the gamma loop. In particular the extensors involved in the maintenance of body posture, should have enough tonus at their disposal through this system.

There would appear to be an obvious connection between the neuro-anatomical disturbances described above and the previously mentioned disturbances in the movement of individuals with DS; this fact is often quoted. However, an exact connection has not yet been demonstrated (Smith, 1976). Cowie (1970) considers a connection possible, but has clear reservations and Henderson calls this connection provisionally speculative (1985). In the course of normal development, motor abilities are a reflection of what has become possible neurologically (Association of NDT, 1984). At birth the organisation of the brain is not yet complete. Postnatally, the number of synapses increases dramatically and thereby the possible functions of the central nervous system. It is then possible that the differentiation defects previously mentioned play a particular role in the characteristic motor problems of individuals with DS.

2.1.4 Characteristic developmental neurological aspects

Cowie (1970) carried out a longitudinal study on the neurological development of 97 children with DS. She tested these children four times in the first ten months of life. The 10 months were subdivided into four periods: period A, 13 days and younger; period B, 2 weeks to 14 weeks; period C, 16 weeks and 4 days to 30 weeks and 3 days; period D, 33 weeks and 6 days to 46 weeks.
In this study she strove to objectify one of the most characteristic neuro-motor symptoms of the young DS child, namely the reduced muscle tension. Scores of 1 to 4 were allocated, whereby 1 denoted normal tonus, 2 moderate hypotonia, 3 conspicuous hypotonia and 4 extreme hypotonia. The score was based on four components: resistance to passive movement, flexibility around the joints, palpation, observation of three positions: prone, supine, supported sitting.
The registration of tonus brought a number of important results to light: not one child demonstrated normal muscle tonus, tonus developing from mainly conspicuous or extreme hypotonia in periods A and B, to mainly moderate hypotonia in periods C and D. This development of tonus is also reported for adults with DS (Owens, Dawson & Losin, 1971; Morris, Vaughan & Vaccaro, 1982; Smith, 1988). According to Henderson (1985) the data on adults are too poorly documented to provide any conclusions. She concludes that nearly all DS children are hypotonic, which may also influence their motor development. Not enough is known with regard to the situation at later ages.

Cowie's (1970) description of postures is particularly interesting because it provides some information about the functioning of the motor system of young DS children. In the prone position she describes an inert, extremely flat posture in which there is a total absence of any extension of the back and in which the head cannot be raised. This was particularly noticeable in periods A and B, but sometimes even after 40 weeks. In the supine position she reports an extremely flat posture without any flexion activity, in which the arms are widely abducted and the legs are in a frog position (see figures 2.1 and 2.2, adapted from Cowie).

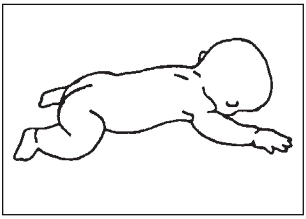

Figure 2.1 Prone position

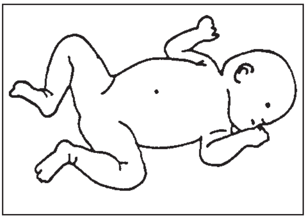

Figure 2.2 Supine position

The Landau reaction and the traction test reveal interesting information about postural regulation. In Cowie's view, both are powerfully influenced by the degree of hypotonia. The results of the traction test are strikingly different from what is regarded as standard. In period A, 100% of the children were adjudged to be negative, i.e. no flexion resistance was felt of the arms in traction and the head balance was poor. In period B, 96% scored negative and in period D there were still 49% who scored negative (see figure 2.3). Depending on what one takes as the decisive criterion, the children also scored very poorly on the Landau reaction test. The most striking detail is that many babies, especially in the first months of life, are folded double over the researcher's hand with the limbs hanging down loosely. Paine states that this reaction has never been observed in healthy children. In Cowie's research 91% of the children had a rounded back and hanging limbs in period A (see figure 2.4). In period D, 21% had a straight back with stretched head and limbs.

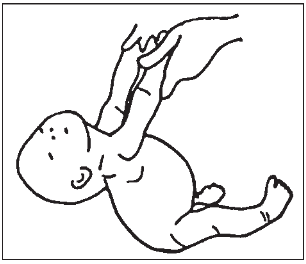

Figure 2.3 Traction test.

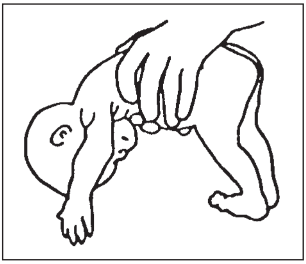

Figure 2.4 Landau reaction

Another conclusion from Cowie's (1970) research is that there is a delayed disappearance of earlier reflexes and automatisms (palmar grasp reflex, plantar grasp reflex, Moro reaction and neonatal walking) and that the knee jerk reflex is weak or absent. According to Cowie there is general agreement in the literature that the palmar and plantar grasp reflexes disappear with the development of voluntary grasping and standing. Thus, it would appear to be a manifestation of the delayed motor development of DS children. The weak or absent knee jerk reflex could be a consequence of slack ligaments and hypotonia. In keeping with this conclusion Henderson (1985) provided an overview of studies to indicate the value of early reflexes, reactions and automatic movement patterns as a basis for the development of normal differentiated movements.

2.1.5 Postural reactions

Bobath (1982) calls righting and balance reactions the "background against which the entire goal-directed, specific and highly developed motility takes place". Rast and Harris (1985) emphasize the importance of early postural reactions in developing balance and reaching motor milestones. Shumway-Cook and Woollacott conclude by measuring that electro-myograms in the postural reactions of DS children are almost the same as non-handicapped children, but also that the onset latencies of responses appear to be significantly delayed. According to Haley (1986) postural reactions (righting, balance and supporting reactions) automatically ensure stability of the head, trunk and extremities, as a result of which normal movement and weight-bearing become possible.
Haley carried out an interesting study on the quality of movement in DS children, which involved investigating the relationship between the occurrence of postural reactions and the achievement of motor milestones. He tested a group of twenty DS children varying in age from two months to twenty-four months and compared the data with findings on a group of 40 non-handicapped children between the ages of two months and ten months. He used the Bayley Scales of Infant Development and a modification of the Movement Assessment of Infants to test postural reactions.
First, he concluded that postural reactions in the group of DS children developed later than in the non-handicapped children. Postural reactions showed a close connection with the achievement of motor milestones and were not linked to age. Second, he found that the lag in motor development became even greater when an anticipated development of postural reactions between four and six months did not occur.
He also postulated that with DS children there is less variety of

postural reactions during the various motor phases. It seems as though DS children only develop the balance reactions necessary to achieve a particular motor phase. A healthy child develops a broad spectrum of balance reactions at every level of motor development, such variability not being seen in the DS child. It is interesting that he interpreted the specific manner of coming from the prone to the sitting position by means of extreme hip abduction and little rotation of the trunk as a compensation for reduced postural reactions. In addition, he indicated that this sort of abnormal movement pattern impedes the further development of postural reactions and normal movement patterns. In his article of 1987 Haley concluded that the sequence of developing postural reactions by DS children is significantly abnormal. Supporting reactions develop relatively quick as a substitute for the lack of balance reactions.

2.1.6 Abnormal postural and movement patterns

Lydic and Steele's (1979) contribution seems to be the only study to date to describe some abnormal movement patterns and their eventual presence while at the same time attempting to place them in a developmental perspective. They analysed questionnaires filled in by parents relating to the quality of movement of 104 DS children. The focus of attention was the quality of sitting, sitting down and walking. There is an interesting description of the symmetrical way of attaining the sitting from the prone position by means of extreme exorotation / abduction of both hips without rotation of the trunk.

From the questionnaires it appeared that 46.1% of the children demonstrated abnormal movement patterns in attaining the sitting position, with 72.9% using the extreme hip abduction/ exorotation. The leg position of the children while sitting was abnormal in 47.8% of cases. The hips were usually widely abducted and the knees extended. An abnormal walking pattern (walking with the legs wide apart, enlarged hip exorotation, waddling or abnormal accompanying movement of the arms) was observed in 34.7%, while 29.8% were not yet walking.

The analysis indicated that the manner of sitting significantly influenced the manner of achieving the sitting position, but that it cannot be related to the quality of walking (like walking with trunk rotation and hip stability). The common factor in abnormal movement patterns, according to Lydic and Steele, was the absence of trunk rotation. Through sitting without trunk rotation the DS child received sensory feedback in an abnormal manner, as a result of which other movement patterns (sitting) were built up on an abnormal basis. The authors, on the basis of the present study, consider to be premature any definitive rejection of a possible link between sitting and walking. In relation to motor intervention, they emphasized the importance of trunk rotation and, in a broader sense, direct attention to the quality of movement of DS children, rather than to the urgency of achieving motor milestones. It should be pointed out that data on the age of the children participating is very sketchy (52% are in the age category of one to three years). Furthermore, 90% of the children followed a motor development programme without the methodology of the intervention used being reported and the interpretation of the quality of movement of the children was made by non-professionals (parents).

2.2 Observations

There is not much information available in the literature on DS children's characteristic way of moving. In this section, therefore, we include a description of a number of abnormal postural and movement patterns observed in five DS children, which will normally not be seen in the motor development of non-handicapped children. The DS child develops an abnormal way of moving to compensate his specific motor problems. Through analysis it should become evident just how fundamental are the problems of motor ability, which, in relation to the function of movement, underlie the development of this "compensatory motor ability". The children, who were all living at home, were given varying degrees of physiotherapy in the Physiotherapy department of 's Heeren Loo Midden Nederland in Ermelo (The Netherlands) The treatment method was based on the Bobath concept. Relevant information on the five children (A, B, C, D and E) is detailed briefly in table 2.2.
Observation reports and video recordings, made to evaluate the treatment from 1987 onwards, were used to describe and analyse the quality of the children's movement. The method of observation

Subject	Age in months at time of observation	Sex	Medical description	Reason for referral
A	5 18	m	Down's syndrome Nystagmus	Supervision motor development
B	18	f	Down's syndrome 1 month premature	Supervision motor development Defaction problems
C	34	f	Down's syndrome 1 month premature Constricted pulmonary artery Heart valve and septum faulty corrected	Supervision motor development
D	22 35 46	m	Down's syndrome 2 months premature Mitral inadequacy Defect endocardial partition corrected	Stimulation motor development Respiratory problems
E	34 46	f	Down's syndrome	Supervision motor development

Table 2.2 Subjects: age, sex, medical description and reason for referral

employed was based on the Bobath or Neurodevelopmental Treatment (N.D.T.) assessment. Where possible the children were observed supine, prone, sitting and rolling over, moving forward on the ground, sitting as a transitional posture, standing and walking. An impression of tonus was also recorded. In total there were nine observation sessions, in which the ages of the children varied from five months to 46 months. For the children B, C, and D we adhered to the developmental age, i.e. chronological age corrected by the number of months by which the birth was premature. With children C and D it is possible that the heart abnormality and the timing of surgical correction may have influenced their development. The interpretation of the motor abilities is based on the author's analysis. In this he was given support and corroboration by fellow physiotherapists.

2.2.1 Tonus

Before describing the children's motor abilities it is important to give some insight into the degree of their hypotonia. Muscle tension is, however, very difficult to objectify; a measure of tonus is no more than a subjective judgement. An impression of the tonus can be obtained by combining details of passive movement, placings and observations of motor abilities. A distinction is made between severe, moderate and mild hypotonia.

All five children were to a greater or lesser degree hypotonic and all demonstrated a lower muscle tension in the legs than in the arms. Child A showed a tonus development from severely hypotonic (5 months) to moderately hypotonic; B and C were moderately hypotonic; D had between severe and moderate hypotonia, while E had mild hypotonia in the arms and moderate hypotonia in the legs.

2.2.2 Supine position

Child A (5 months) lay on his back with the whole of his body very flat and almost without any movement. His arms were usually in the "hurray position" i.e. with the shoulders abducted about 40° and enough exorotation for both the upper arm and the dorsal side of the underarm to lie flat on the surface. The elbows were flexed at about 90°. His legs were in the so-called "frog position", the hips abducted at about 45° exorotated to the extent that the outer side of both upper and lower legs were on the surface. The knees were flexed at about 90° (see figure 2.5). The child hardly moved, he rotated his head a

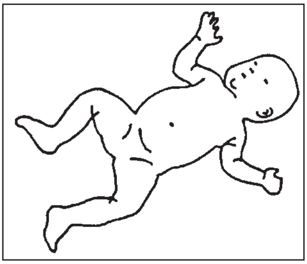

Figure 2.5 Supine position

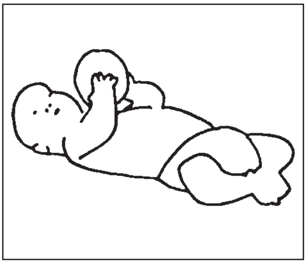

Figure 2.6 Reaching out in supine position

little but did not actually leave the described position. There was an observable difference in activity between the arms and the legs. The legs were more or less still, while the arms were pushed over the floor, causing a variable amount of shoulder abduction and elbow flexion. Neither arms nor legs came off the surface. It seems probable that this had consequences for sensorimotor development (voluntary movement, prehensile activities, eye-hand coordination, body schema, sensibility).
Child D (22 months) lying on his back could join his hands over his chest. Yet what one notices here is that his arms could not overcome the

force of gravity, but that he held his upper arms tightly against his chest while playing with his hands and lower arms at right angles to his chest. Stabilising co-contractions around the shoulder joints were apparently not enough to enable him to reach out. In compensation, he made a fixed point of the upper arm on the chest. The legs were relatively passive in the "frog position" previously described (see figure 2.6). Children B and C (18 months and 34 months respectively) did not remain on their backs for one moment; perhaps the prone position gave them more movement possibilities. For child E (34 and 46 months) the supine position did not have much to offer either. She preferred sitting, standing and walking.

2.2.3 Prone position

The first thing one noticed about child A (5 months) was the absence of movement. With the trunk resting completely on the surface, the head could be raised a little, enabling it to rotate. However, there was not enough stability to keep the head raised. The arms were lying flat on the surface, with the shoulders abducted at about 90°, with enough exorotation to support the upper and lower arms on the surface, the elbows were flexed at about 80°, the hands lying with the palms on the floor and the fingers extended. There was not enough stability in the trunk and shoulder girdle for the child to lean on his elbows. The legs were flexed, with hip and knees flat on the floor, hips abducted at about 90° and exorotated, knees flexed at about 100°, and the feet in a light plantar flexion (see figure 2.7). The child was lying very flat on the floor and did not move from his place. There was some movement in the extremities in the horizontal plane, but no lifting against the force of gravity.

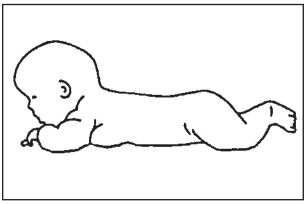

Figure 2.7 Prone position

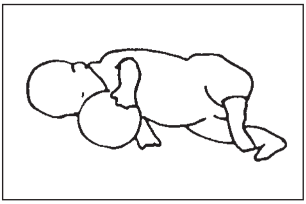

Figure 2.8 Reaching out in side position

The arms were relatively more active than the legs. In the prone position the child had very limited possibilities of movement, he could not

get going. In the prone position child D (22 months) leaned symmetrically on his elbows, holding his head up, but apart from that, made a passive impression. The shoulder girdle was stabilised by supporting the upper arm on the chest. The preferred position of the legs was the previously described flexion/ abduction/ exorotation posture. This child extended his knees regularly, but never his hips. Whenever one of his arms was freed from the floor to stretch out, the extension in the back, particularly the lumbar extension, was increased to such an extent that pelvis and flexed knees came away from the floor and the child fell over. The activity of the trunk musculature, in this case lumbar, was not sufficiently stabilizing to make it possible to stretch out.
Child D (22 months) did not like the prone position, perhaps as opportunities for playing in this posture were very limited. Nevertheless, in order to reach out and play, he rolled over without trunk rotation to lie on his side from where he could stretch out for a toy with his free arm. In this case too, there was compensation for the instability of the shoulder girdle. A fixed point was created distally by putting the hand on the plaything. Stability and balance of the trunk were attained by flexing the hips (see figure 2.8).
Child B (18 months) also stabilized the upper arms against the trunk by symmetrically leaning on the elbows. It is striking that the extended spinal column did not show a nice regular curve, but that the cervico-thoracic part of it was kept more or less straight, while at the thoracic-lumber section a sharp extension could be seen. Stomach and pelvis were again lying flat on the surface, the hips remained rounded and abducted, the legs relatively passive (see figure 2.9).
When one arm was stretched out the stabilizing capacity of the shoulder on which the child was leaning was insufficient to maintain the trunk position, the shoulder on the side of the stretched out arm dipped, the adduction of the supporting shoulder increasing. This

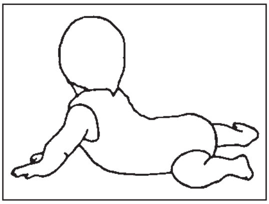

Figure 2.9 Thoracic-lumber extension in prone position

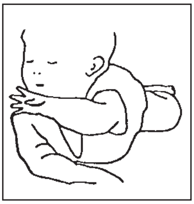

Figure 2.10 Reaching out in prone position

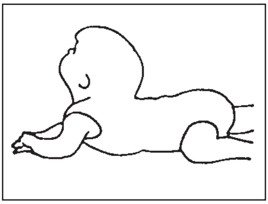

Figure 2.11 Head support in prone position

posture could also be observed in child C (34 months) during stretching out in the prone position (see figure 2.10). Furthermore, child B was able to lean symmetrically on both extended arms. The position of the head in the prone position when leaning on the elbows was also striking: it rested regularly on the back of the neck (as with child A [18 months]); possibly in order to achieve extra support (see figure 2.11). Child E (34 and 46 months) showed no peculiarities in the prone position.
In general, these children in the prone position seemed to have problems in stabilizing the position of the head and shoulders. In compensation, they preferred to support their weight symmetrically on their elbows, as stretching out with one arm seemed to present problems. It is possible that this had consequences for the development of balance reactions and trunk rotation.

2.2.4 Rolling over

The most striking thing about children B, C and D when rolling over was that this occurred without trunk rotation, both at 18 months (B), at 34 and 35 months (C and D) and at 46 months (D). Child A (18 months) and child E (34 months) showed trunk rotation during rolling over. Children A, B and C did not roll over spontaneously from the prone to the supine position. The supine position was an unattractive posture for them in which there was little opportunity for activity. In addition, to roll from the stomach to the back demanded a transfer of weight and the freeing of an arm or leg, while the children apparently preferred to remain balanced with symmetrical support. It is equally possible that the abducted, exorotated and flexed legs stabilized the posture on the stomach to such an extent that the rotation movement could not take place. Child D preferred the supine position, possibly because it offered him the opportunity of two-handed play with his upper arms supported on his chest. Children B, C and D rolled over without disassociation, the shoulder and pelvic girdle did move in synchrony. When supine, children B and D flexed the hips to bring the legs out of balance until rolling over ensued. The arms were used actively (pushing and stretching out) to support rolling over. The part played by the legs was relatively unimportant. The role of the legs was, however, much more active in child C. Child B greatly extended her spinal column to initiate rolling over. Child E rolled over smoothly in a disassociated way, with fewer activities of the leg compared to the arms.

2.2.5 Moving forward on the ground

Child E (34 months) was the only child to crawl competently with the requisite trunk extension and rotation. In comparison with crawling at 46 months, the leg function looked rather hypotonic and uncoordinated. Child C (34 months) had difficulty stabilizing the hips in the crawling posture and the legs repeatedly slid away sideways (hips to abduction) (see figure 2.12). She moved hands and lower legs almost sliding over the floor in such a manner that the supporting surface was kept as large as possible and less weight had to be transferred. It is possible that the lack of hip stability was compensated in this manner. The children A (18 months), B (18 months) and D (46 months) did not crawl. When placed in the crawling position their legs slid away sidewards (hips to abduction).

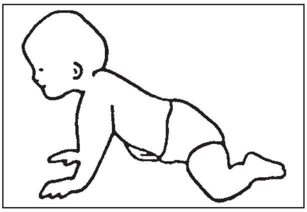

Figure 2.12 Crawling

Child C (34 months) also used to "creep" a good deal to move herself forwards. Forward propulsion was achieved mainly by the arms (alternating), with the legs, kept in the previously described abduction/exorotation position, taking absolutely no part in pushing forwards. Transferring the weight to one arm exposed inadequate stability in the shoulder joint responsible, abduction increased because the other shoulder was lowered.

Children A and B "moved like seals", i.e. they pushed themselves forward in the prone position symmetrically supporting themselves on their hands. Child A, in particular, used his legs to some extent in a sort of pushing off movement from the previously described abduction/exorotation/flexion posture, while child B kept her legs still in this position and did not use them to propel herself forward.
Child D at 35 months was capable neither of "moving like a seal" nor of "creeping", not to mention crawling. Yet as he did feel the need to move forwards, he rolled from the prone position to the supine position then stretched out past his ear with the arm on top, flexed the trunk

somewhat and flexed the leg lying on top at the hip and the knee, thus shifting his pelvis a little and then rolled without trunk rotation back to the prone position. Distance covered: 5 centimetres. At 46 months child D moved forward in the prone position by placing the elbows on the ground, after which the trunk was pulled forward by the arms. He used the legs a little when he was pushing off.

2.2.6 Sitting on the ground

Each of the children stabilized the sitting position by broadening the base. Children B (18 months) and C (34 months) did this by sitting cross-legged, with the whole of the upper leg in contact with the surface. Child A (18 months) sat with his legs stretched out in front of him, child D (35 and 46 months) sat both cross-legged and with his legs splayed out, and child E (34 and 46 months) preferred to sit in a T.V. position (with hips in endorotation and buttocks between the ankles), but could move further quite freely. At 22 months child D did not have enough trunk extension to sit.
In addition, children A, B, C and D often further stabilized their sitting

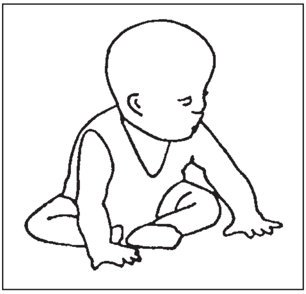

Figure 2.13 Sitting position with arm support

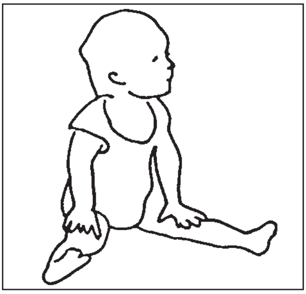

Figure 2.14 Sitting position, broad base

position by supporting themselves with stretched-out arms on their upper legs or on the ground (see figures 2.13, 2.14 and 2.15). They preferred to keep only one hand free for reaching and grasping, so that the other arm could maintain its supporting function. Transfers of weight were stabilized with the help of arms and legs taking support; trunk lateral flexion and rotation not being observed at all. This gave a peculiarly static character to sitting, whereas sitting should be primarily a play and transitional position. The children appeared not to have the balance and stability to change their posture easily; something which may well have consequences for the further development of the trunk motor abilities.

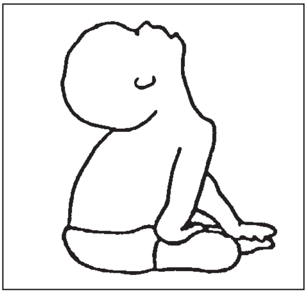

Figure 2.15 Head support in sitting position.

If, when in a sitting position, the hands were principally used to maintain posture, it seems likely that the normal development of prehensile activities would be affected, with particular consequences for the cooperation between the two hands.

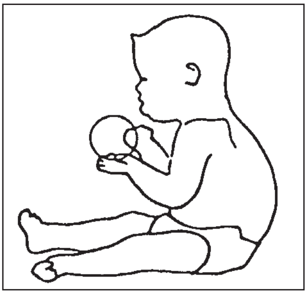

Figure 2.16 Reaching out in sitting position

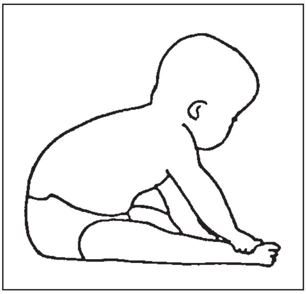

Figure 2.17 Sitting position, poor trunk extension.

It is of further interest that children D (35 months) and A (18 months) frequently rested their heads on the backs of their necks and that children D (35 months) and C (34 months) clamped their upper arms against their chest in order to be able to play (see figure 2.16). Child D (35/46 months) had very poor trunk extension (figure 2.17).

2.2.7 Sitting as a transitional posture

Child B (18 months) could sit unsupported. The child could not come to a sitting position on his own and did not go actively from sitting to another posture. The only variation in posture observed was the shifting of weight to the side, in which the homolateral flexed leg was used as a supporting leg and the heterolateral leg was raised a little. The trunk remained symmetrical, there was no rotation or extension and certainly no side-sitting. Both arms, or in some cases the homolateral arm, were placed on the surface for support.

Child D (35 months) did not leave his sitting posture. When, from a sitting position with his legs wide apart, he wanted to grasp something in front of him, he flexed his trunk and hips until he was lying on the floor with widely abducted legs. At 48 months child D used this movement to go from the sitting to the prone position. In the course of flexing the trunk and hips he abducted the hips to such an extent that he did the "splits" as it were, in order to bring his legs behind him and lie on his stomach. Child A (18 months) and child C (34 months) also used this form of extreme abduction to get from sitting to the prone position with absolute symmetry (see figure 2.18).

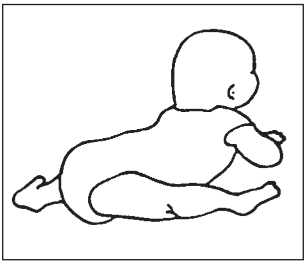

Figure 2.18 Sitting to prone position.

Movement patterns normally observed in these changes of posture require asymmetrical motor skills, i.e. side-sitting and trunk rotation/ extension, whereby good motor ability in the trunk is essential. No side-sitting or trunk rotation could be observed in these children in the sitting position. Their specific manner of moving from sitting to the prone position was also targeted at reducing the loss of balance to a minimum and at maintaining trunk extension developed through symmetry as far as possible.

Child C (34 months) could sit up on her own. She did this from the crawling position by placing one foot in front of her on the ground just

behind the homolateral hand, after which the other leg was moved forward in the same manner. She subsequently flexed, abducted and exorotated the hips until she was sitting cross-legged. Once again, these movements took place symmetrically, there was no side-sitting and no demand was made on balance or trunk rotation.
The children C (34 months) and E (34 months) went from sitting cross-legged to the crawling position without transitional side-sitting and practically without rotation of the trunk. On the one side knee and hand were used as supports, after which the whole body was tilted on the axis which could be drawn between the two supports. The free leg was still greatly flexed at the knee.
From a cross-legged position child E (34 months) reached a kneeling position by placing her outstretched arms in front of her on the ground and then leaning forwards with the trunk so that the pelvis was tilted forwards over both kneecaps. This was also an alternative to going into the crawling position. Once again, the movements were symmetrical and side-sitting and trunk rotation were not observed.

2.2.8 Standing up

Child E (46 months) stood up from the crawling position by alternately putting her feet behind her hands on the ground, bringing her body weight above her feet as much as possible in order to stretch her legs with the support of both arms and so to stand up (figure 2.19).
Child C (34 months) also stood up from the crawling position but first placed both hands just in front of the knees. She could then kneel, as it were, could bear optimal body weight on both arms and was then in a position to take the weight off one knee in order to be able to put one foot on the ground. Here again, standing up occurred as symmetrically as possible, with virtually no trunk rotation, but with maximum support of hands and feet to avoid loss of balance as much as possible by bringing the body weight directly above the feet. From the standing position she then attained the sitting position symmetrically by placing her buttocks on the ground via the squatting position.
Children A, B and D (5 and 18, 18 and 22, 35 and 46 months respectively) were not yet ready to "stand up".

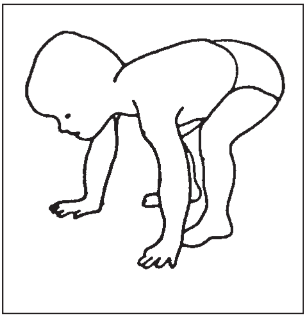

Figure 2.19 Standing up.

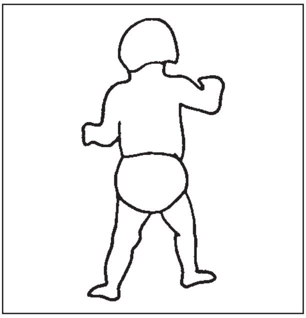

Figure 2.20 Walking

2.2.9 Walking

Child C (34 months) walked without support, legs wide apart and extending the arms sideways. She did not flex the hips forwards, but, with abduction and exorotation, walked without trunk rotation, displaying many balance reactions with her arms. The leg action looked hypotonic (see figure 2.20).

Child E (46 months) was walking without support, quickly and with rotation of the trunk. She had a somewhat wide-legged gait, her hips were endorotated. The leg action appeared hypotonic and thus uncoordinated. The child could not stand on one leg.

Children A, B and D (5 and 18, 18 and 22, 35 and 46 months respectively) were not yet at the walking stage.

2.3 Discussion

Although one associates the DS child primarily with mental handicap, various studies indicate problems with motor abilities. Cunningham's (1982) overview shows that there is a marked delay in reaching motor milestones compared with normal children and that the range in the age at which a particular motor level is attained clearly becomes greater. Carr (1970) demonstrates that, when compared with healthy children, both the mean mental and motor scores on the Bayley Infant Scales of Mental and Motor Development dip sharply between six and ten months, and also that DS children after six months score relatively better on the mental than on the motor tasks. Finally, Connolly and Michael (1986) indicate that DS children achieve significantly less on several sections of the Bruininks Oseretsky test compared with otherwise mentally handicapped children of the same mental age. The latter would appear to indicate syndrome specific motor problems in the DS child. Vermeer and Beks (1993) support the conclusion that the motor development of a DS subject is different rather than retarded.

A relationship between motor problems (balance and coordination of movement) and the specific neuro-anatomical abnormalities would appear obvious, but has not been demonstrated and is thus speculative at present (Cowie, 1970). It is possible that postnatal disorders of differentiation in the central nervous system play a role. In any case, the motor abilities of DS children seem to be characterised by what Bobath (1982) describes as disorders in the posture reflex mechanism. An intact posture reflex mechanism leads to a normal posture tonus, adequate co-contractions in which, through dynamic fixation of more proximal parts of the body, selective and controlled distal movements become possible together with a great variety of posture and movement patterns.

Cowie (1970) describes the DS child's hypotonia, which is often severe, and also the increase of muscle tonus which nevertheless takes place in the first ten months of life. How long this development continues is unclear (Henderson, 1985). The children we observed suggest, however, that there is reduced muscle tension for several years and that there is a possible difference between arms and legs, with the lower extremities achieving less. There may be a relationship with the tardy start of motor activity in the legs, which is delayed, even in comparison with the arm function.

Cowie (1970) links this hypotonia with the lack of posture regulation, as evidenced in testing the Landau reaction and traction tests. Haley (1986) concludes that posture reactions (righting, balance and supporting reactions) develop later in DS children than in normal children. The motor lag becomes even greater when an expected development of posture reactions between four and six months does not appear and the variability in posture reactions during various motor phases is significantly smaller.

Our own observations suggest the continuous emergence of compensatory movements. This appears to be the result of inadequate opportunities to stabilize joints due to insufficient co-contractions and unsatisfactory balance reactions. The poor muscle tension causes, in general, problems with the maintenance of postures and, in addition, the assumption and variability of postures. Parker, Bronks and Snyder (1986) also suggested the abnormal walking patterns of DS children to be indicative of a compensation of instability around specific joints. Ulrich, Ulrich and Collier (1992) found the basic neural substrate generating walking patterns to be available long before other essential components for walking, like strength and postural control, had been developed sufficiently. Dyer, Gunn, Rauh and Berry (1990) concluded that a lack of postural control was causal, among other things, to the abnormal sequence of developing certain items of the Bayley Scales of Infant Development of DS children. Considering this topic, Vermeer and Beks (1993) support the conclusion that the motor development of a DS subject is different rather than retarded. Macneil-Shea and Mezzomo (1985) concluded that heels-down squatting of DS subjects could be a compensatory mechanism due to insufficient balance or insufficient agonist and antagonist muscle activation around the ankle. These results are supported by Davis and colleagues; Davis and Kelso (1982) found differences in the ability of DS persons to control the stiffness and damping of muscles around joints compared to non-handicapped subjects, and Davis and Sinning (1987) found differences in the ability to fully activate their muscles.

This lack of stability now seems to be the crucial point at which the DS child's development is going to be deviant. Co-contractions around joints, but also in a wider sense round the spinal column, do not provide enough stability to facilitate dissociated movement, and therefore development. The reason seems to be a lack of postural coordination and control instead of a lack of muscle power. The DS child makes optimal use of his motor possibilities, enlists arms and legs to overcome problems of stability and in this way develops a very static, little dissociated, symmetrical movement pattern. The qualitative development of trunk motor abilities remains retarded (rotation and balance) and perhaps prehensile activities are also negatively influenced. It seems conceivable that the degree to which compensatory movement develops is dependent on the degree of hypotonia. Haley (1987) indicates that abnormal movement patterns impede the further development of postural reactions and normal patterns of movement; Lydic and Steele (1979) posit that the DS child receives abnormal sensory feedback from this compensatory movement, as a result of which other movement patterns are built up on an abnormal basis. Block (1991) recommends further research into the connection of missing motor components and the development of motor compensations.

Cowie's research shows that the inert prone and supine postures recorded in the observations, particularly in the first periods of development, are more the rule than the exception (1970). The flexion/adduction phase and the asymmetrical phase of normal development were not observed. Inadequate stability, for example in the shoulder girdle, is reported. Stretching out in the supine and supporting body weight in the prone position are problematic. It is therefore difficult, in the supine position, to bring the hands to the mouth or to bring the hands together, to reach out and to grasp things. It is possible that the basis of functional manipulation, the discovery and inclusion of the hands in the body schema, also stretching and grasping, is inadequately developed. The legs lie mainly flat in the frog position and are hardly moved. The feet do not come to the mouth or to the hands. It is possible that this has consequences for the development of body schema, trunk motor abilities and voluntary movement.

Not being able to raise the head plays an initial role in the prone position, which, together with instability around the shoulder joint, means that the child can only raise his head by supporting himself on his elbows at a later stage. Co-contractions are then just enough for him to be able to support himself with the upper arms symmetrically supported against the chest. Putting weight on one arm and stretching out creates problems. The first stage of the development of balance in this posture does not take place, neither does the development of rotation and extension of the trunk. Prehensile activities and the development of playing are negatively influenced.

Another aspect of this posture with possibly important consequences for the development of motor abilities, is the passive flexed position of the legs. Good extension of the trunk, combined with extension of the hips, is only rarely recorded. According to the N.D.T. concept, this may have consequences for the quality of standing.

In the prone and supine positions the young child's motor abilities are characterized by passivity and symmetry, with only very poor development of trunk rotation. Three of the five children did roll over without trunk rotation, in which the legs were more or less passive. One can probably posit that this line continues in more vertical postures and that this may have an effect on the disassociation possibilities of the trunk.

Our own observations show that the children have problems in maintaining an extended sitting posture. To be as stable as possible, they sit symmetrically, the sitting base being enlarged by, for example,

keeping the legs in a cross-legged position and supporting themselves with extended arms on the upper legs or on the ground. Lydic and Steele's (1979) study indicates that there is an abnormal leg position in nearly 50% of the children involved. The sitting position thus becomes static in nature, while, particularly for young children, it should be the ideal play and transitional posture. The DS child prefers to stretch out and play with just one arm, using the other arm to stabilize the sitting position. His balance has only a poor chance of developing because he experiences trunk rotation and/or trunk lateral flexion as a threat to the stability of his sitting position.
This situation can also have far-reaching consequences for the development of prehensile activities. There is only a mediocre development of two-handedness, while, because trunk rotations do not take place, crossing the hands at midline cannot be adequately developed. It is possible that this has consequences for a hand preference.
To progress via side sitting to the crawling position, or to reach the sitting position from the prone position using trunk rotation, does not fit in with the DS child's predilection for symmetrical and stabilized movement patterns. At a given moment DS children also have the opportunity to sit unaided or to go from the sitting position to the crawling position or to standing, yet trunk rotations are scarcely used at all, while the extremities have to ensure as much support and stability as possible. A characteristic DS movement pattern is reaching the sitting position using extreme abduction of the hips. This is also described by Lydic and Steele (1979). Haley (1986) also interprets this as a compensatory motor activity resulting from inadequate posture reactions. Motor activity of the trunk will only develop further to a very limited extent with clear consequences for the quality of balance and the variability of movement. It seems probable that the consistently poor development of trunk motor abilities, rotation and balance has consequences for the quality of walking and standing. It is also possible that this is the cause of the characteristic wide-legged gait, without trunk rotation, seen in mentally handicapped persons with DS. The Duchenne gait which can sometimes be observed could be related to insufficient co-contractions and therefore problems of stability round the hip joint.

2.4 Conclusion

The DS child's quality of movement seems to be greatly influenced by an insufficiency of stabilizing co-contractions around joints, resulting from reduced muscle tonus. The child consequently develops a compensatory, symmetrical manner of moving, mainly characterized by a lack of variability. It is more particularly the development of the trunk motor abilities (rotation, lateral flexion, balance) that are insufficient. It is possible that this affects the development of prehensile activities. By putting the motor problems in a developmental context the physiotherapist gains a framework from which well-grounded choices can be made in the exercise therapy of young DS children. Further study of the effect of such a treatment would probably be of great benefit in increasing our understanding of the motor development of DS children.

2.5 Summary

Chapter two describes the characteristic movement patterns of DS children, based on observation and discussed in relation to the relevant literature. There appear to be syndrome specific motor problems; the DS child's quality of movement seems to be influenced markedly by an insufficiency of stabilising contractions around joints due to reduced muscle tone. As a result, the child develops a very symmetrical manner of movement, characterized by a lack of variability. In particular, the quality of the trunk motor system development remains retarded (rotation, lateral flexion, balance). It is possible that this has consequences for the development of prehensile activities. Putting such motor problems in a developmental context provides the physiotherapist with a framework from which well-grounded choices can be made in the exercise therapy treatment of young DS children.

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3. Motor intervention for children with Down's syndrome: a review of the literature

The obvious motor problems of Down's syndrome (DS) children are apparent from review articles of Henderson (1985) and Block (1991). Various authors conclude that there are specific motor problems for DS children in comparison with other forms of disablement (Henderson, 1985; Connolly & Michael, 1986; Lauteslager, 1991, 1995; Vermeer, 1993). Hypotonia, abnormal development of reflexes, instability and excess weight appear to play an important role in this respect. The influence of medical and health aspects, such as congenital heart defects, sensory-motor problems and hypermobility of joints also play a role. In addition, the cognitive and social constraints of these children are significant (Block, 1991). The obvious motor retardation was seen as having an influence (Kugel, 1970; Henderson, 1985; Gunn & Berry, 1989). DS children, therefore, frequently take part in intervention programmes. Due to specific problems in motor behaviour, the paediatric physiotherapist is increasingly involved in the supervision of these children's motor development in the first years of life.

3.1 Literature

This chapter will provide insight into the variety and appropriateness of motor intervention methods. This will take place on the basis of a

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Chapter 3 is based on

Lauteslager, P.E.M., Vermeer, A. & Helders P.J.M. (1995). Theoretische fundering van motorische interventie bij kinderen met het syndroom van Down; een literatuur studie (Theoretical foundation of motor intervention for children with Down's syndrome: a review of the literature). *Nederlands tijdschrift voor de zorg aan verstandelijk gehandicapten*, 21, 108-122.

Lauteslager, P.E.M., Vermeer, A. & Helders P.J.M. (1996). Motorische interventie bij kinderen met het syndroom van Down; een literatuur studie (Motor intervention for children with Down's Syndrome: a review of the literature. *Nederlands Tijdschrift voor Fysiotherapie*, 106, 52-61.

Article	Population: number, age		Reference
	Experimental	Control	
Brinkworth, 1972	n=5, 0-6m	n=12, 29-55w	
Hayden & Dmitriev, 1975	n=44, 1-72m	None	Norms of ND Children
Aronson & Fällström, 1977	n=8 21-69m	n=8	
Hanson & Schwarz, 1978	n=12, 4w-6m, average 14w	None	Based on normal development ND children and DS children
Clunies-Ross, 1979	n=36, 3-37m, average 15m	None	Norms of ND children Comparison subjects
Piper & Pless, 1980	n=21 average 9.33m	n=16	
Sharav & Shlomo, 1986	n=51 0-13j	None	Norms of DS children
Cunningham, 1987	n=181, 0-2 y, n of sub-cohorts are unknown	Matched group within cohorts	

Table 3.1 General stimulation programmes

Article	Population: number, age		Reference
	Experimental	Control	
Kugel, 1970	n=7, 4-17m average 9,8m	None	Development norms of ND children
Connolly & Russell, 1976	n=40, 0-36m	None	Development norms of DS children
Kantner, Clark, Allen & Chase, 1976	n=2 6-24m	n=2	
Harris, 1981	n=10 2,7-21,5m	n=10	

Table 3.2 Specific motor programmes

Motor intervention Therapist	Frequency	Measuring instrument	Gross motor results	
			Short-term	Long-term
Proprioceptive and kinesthetic stimuli Passive and active excercises Unknown	1x per w for 6m	Griffiths'	Positive non-significant	Sharp relapse of DQ
Sensori-motor training Training of motor milestones	Variable	Denver Gesell	Positive	
Playing outside on the steps and with a ball, based on normal development Psychologist	2 x per w for 18m	Griffiths'	Positive significant	No significant difference
Based on normal development Parental advisor	1x per w 15 to 30 m	Standard checklist	Moderate positive	
Based on normal development Physiotherapist	2 to 3 x per week for 4 to 24 m	EIDP Stanford-Binet Peabody	Positive	
Based on normal development Physiotherapist	2x per w for 6m	Griffiths'	Negative, non significant	
Unknown Physiotherapist and occupational therapist	1x per w to 18 m, variable	Bayley Stanford-Binet	Negative to 18m, between 18m and 5y positive, after 5y slightly negative	
Exercises to strengthen and tone muscles Improve equilibrium in sitting Maintain primitive walking reflex Unknown	1 to 3x per week duration is variable (± 1 y)	Bayley	Positive	No significant difference

Motor intervention Therapist	Frequency	Measuring instrument	Gross motor results	
			Short-term	Long-term
Based on normal development with some specific accentuations Nursing staff under supervision of Physiotherapist	Daily for 18m	Gesell	Good, age adequate	
Muscle training, sensory and gross motor stimulation Facilitation of rightning reactions Physiotherapist	2x per year stimulation of parents	Gesell	Accelerated development	Specific problems remain visible
Specific vestibular stimulation Unknown	10 x per day for 10 days	Quantitative test Cupulogram	Good (N=1)	
NDT Physiotherapist	3x per week for 9w	Bayley Peabody Individual objectives	Significantly positive for objectives Further no differences	

Abbreviations used			
n Number w Week	m Month y Year	ND Non-disabled DS Down's syndrome	DQ Developmental Quotient

discussion of twelve studies into the effect of early intervention on the motor development of DS children. Eight intervention studies cover a broad area of development (including motor development) and are generally stimulating in nature (table 3.1); four intervention studies have a specifically motor approach (table 3.2). To illustrate this point, there is a description of the two most recent research findings of the generally stimulating programmes and of the specifically motor programmes. The discussion is based on four aspects: the theoretical framework adopted, the method of treatment, the effects of intervention in the field of gross motor skills and the manner of intervention measurement.

Literature selection was based, up to 1988, on an article by Gibson and Harris (1988). This gave an overview of intervention studies of early intervention programmes for DS children. An overview article of Harris (1981a) contributes further to the field of specific motor intervention. Using the computerised literature search of the Groningen university library, the documentation centre of the Physiotherapy Science and Training Institute in Amersfoort and the Down's Syndrome Foundation in Wanneperveen, the literature selection was updated to 1995. In the context of this study, use was made of the Medline database to update the literature further to September 1999.

3.2 General stimulation programmes

Sharav and Shlomo (1986) described the results of a longitudinal intervention research study carried out over ten years with 51 DS children living at home in Jerusalem (26 boys, 25 girls; age: 0 to 13 years). There was no control group. The results, dependent on the age of the child tested, were compared with developmental norms for DS children provided by Carr (1970) and Dicks-Mireaux (1972), among others.

From the age of four to six weeks, the children were treated for one hour per week at home by an occupational therapist and parental participation was established. From eighteen to twenty-four months, the children went to a play-school four to six mornings a week. In small groups of six to eight children they were under the supervision of a special teacher. In addition, individual therapy was given by a physiotherapist and a speech therapist. From the age of five, the children proceeded to special education and were therefore no longer the responsibility of the centre. However, they were still tested

periodically. Development was tested by means of the Bayley Infant Motor and Mental Scales and, as far as possible, from the age of three with the Stanford-Binet Intelligence Scales. Testing took place every three months in the first year of life, every half-year between the ages of one and three and after that once a year.
When compared with non-disabled children, the results on development scales up to the age of eighteen months showed a downward trend, both in motor and in mental areas. Up to the age of twelve months, these motor and mental scores were more or less equivalent, after which the mental score was somewhat higher than the motor score. After eighteen months, however, this downward trend, also compared with the data of Carr (1970) and Dicks-Mireau (1972), changed into a rising score up to the age of three years.
The authors found it a disadvantage that their group was small and also that, for ethical reasons, they had not worked with a control group. The advantages cited were the stable population and the ensuing longitudinal data, the standardised method of testing, the systematic early intervention programme and the parental participation as an integral part of the treatment. They concluded that the programme described was capable of curbing the developmental decline in DS children and produced improved results on development tests in comparison with the reference data used.

Cunningham (1987) did research with a representative group of 181 families with a DS child, in Manchester and the surrounding area (UK). These children were born between August 1973 and August 1980. Cunningham related the motor problems of DS children (hypotonia, lack of co-ordination) to the relatively small cerebellum and small brain stem and the retarded maturation of the central nervous system (Cunningham, 1982).
In relation to the intervention, a distinction was made between a ‘standard approach’, used for every family, and a more intensive and precisely defined approach which was used within the research group for a number of sub-groups. The intended objective was to research the effect of specific variables by comparison of children from a subgroup, with comparable control groups from the entire research group. The standard approach consisted of home visits which began immediately after the diagnosis had been made. They were carried out with a frequency of once every six weeks up to the age of eighteen months. Subsequently, home visits took place every twelve weeks up to the age of two years. After that, with a view to the long-term effects,

the families were visited every half-year until the child was five years old. During the visits, information was given, for example, general details about DS and about the relevant support bodies. Where necessary, practical and emotional support was provided. Furthermore, the developmental level of the child was tested (Bayley Scales of Infant Development) and, in consultation with the parents, it was determined which games, activities and physical exercises were appropriate for the child's development at that time.
The more intensively researched sub-groups were visited one to three times a week. Parents were asked to do certain exercises with their child four or five times a day. Within two sub-groups the emphasis was on motor development. In one group, it consisted of stimulating motor skills during the first year of life (muscle strengthening and toning exercises, balance in sitting). This approach resulted in these children reaching the motor milestones more quickly in that year than the control group. However, there was no long-term effect: the children in the therapy group achieved sitting earlier than the children from the control group, but they did not walk earlier. In the other group, the primitive walking reflex was encouraged from eight weeks onwards. The result was that all children from this group walked earlier than the children in the control group.
On analysis, Cunningham concluded that in connection with 'motor development' 'medical problems' (particularly heart defects) were the most significant variable and that the effect of intensive motor training was particularly visible during that training.
He further posited that the specific intensive stimulation had had no significant effect on the development of the children tested and recommended general motor stimulation through sporting activities.

3.3 Specific motor programmes

Connolly and Russell (1976; 1980; 1984; 1993), in collaboration with various colleagues (Connolly & Russell, 1976; Connolly, Morgan, Russell & Richardson, 1980; Connolly, Morgan & Russell, 1984; Connolly, Morgan, Russell & Fulliton, 1993), researched the effect of interdisciplinary motor stimulation on the development of DS children living at home. Forty children (two age groups: 0 - 18 and 18 - 36 months) were involved in the original intervention research (Connolly & Russell, 1976). The hypothesis was that early intensive motor and sensory stimulation had a positive influence on children with potentially retarded development. The choice was made for DS children because of assumed similar physical problems (hypotonia) and since statistical data were available on their general development. The results were compared with the developmental norms for DS children formulated by Fishler, Share and Koch (1964) on the basis of the Gesell Schedules of Motor Development. The selection of the children was dependent on the willingness of the parents to go to the centre and to participate actively in the programme. Other health problems, for example, a congenital heart defect, did not exclude the children from participation. Twice a year, for a period of ten weeks and in a group situation, parents and children received individually focussed, broadly oriented information and training for one half-day per week, for example in the field of sensory and motor development. Subsequently, for the rest of the year, guidance took place in the home. A physiotherapist provided motor activities in the field of muscle strengthening, mobility, sensory and gross motor stimulation and play activities. For the house programme, vibrators, large beach balls and rolled-up towels were used with a view to stimulating weak muscle groups such as neck, back, elbow and knee extensors and hip abductors to facilitate righting responses.

The children in Connolly and Russell's (1976) research acquired gross motor skills, such as head-control, sitting and walking, more quickly than the children in Fishler et al.'s (1964) report. Results in the field of fine motor skills, social skills and feeding were also positive. The research indicated that results were better when children started with intervention before the age of six months. Subsequently, in three consecutive articles, Connolly and Russell, in collaboration with various co-authors, reported on the long-term results of the study. They compared the data of the original research group, which was gradually decreasing, with data of groups of DS children collected on the basis of varying criteria (1980: n = 20, age from 3.2 to 6.3 years; 1984: n = 15, age from 7.3 to 10.3 years; 1993: n = 10, age from 13.9 to 17.9 years). The control groups varied in size, the children in the control groups had in no case taken part in early intervention programmes. The comparison was made on the basis of data collected with various instruments of measurement (Stanford-Binet Intelligence Scale, Cattell Infant Intelligence Scale, Vineland Social Maturity Scale, Bruininks Oseretsky Test of Motor Proficiency, Gesell Schedules of Motor Development).

The results displayed as development quota from the follow-up studies showed that children who had taken part in an early intervention programme at a young age scored better on various test items than children from control groups without early intervention. The authors also indicated that this could not be attributed merely to participation because of constraints in the various research designs. Although initially the motor results were good (1976), in spite of some development, there were still specific problems visible in the gross and fine motor areas (1993). The lack of equilibrium and of pelvic stability, flat-footedness and the problems in running were particularly specified. These were attributed to muscular hypotonia related to a retarded cerebellum function development and a relatively small cerebellum and small brain stem. Somato-sensory and vestibular disorders were also posited.

Finally Harris (1981a, 1981b) opted for Neuro-Developmental Treatment (NDT or Bobath method) as an intervention strategy. Harris assumed that the general objectives of this method in a therapeutic sense, were relevant to the motor problems of DS children. In the author's opinion, important objectives in the NDT are the facilitating of normal muscle tension and facilitating of righting, equilibrium and protective responses so as to enhance the development of normal patterns of movement. Furthermore, Harris posited that facilitating automatic movement was an adequate method of treatment for very young or mentally disabled children. The author found a relationship between the hypotonia characteristic of DS children and the delayed attainment of motor milestones by these children.
The study was carried out with a group of twenty DS children living at home, aged 2.7 to 21.5 months old at the time of the first test. It was known that two of the children had a heart defect and that all the children had hypotonia to a varying degree. The allocation of children to an experimental and a control group took place on the basis of age and sex, there were no significant differences between the two groups. Treatment took place primarily in the children's homes and was carried out by qualified physiotherapists. It was given over a period of nine weeks with a frequency of three times per week, each session lasting about forty minutes. The treatment was carried out on the basis of four individual specific objectives per child and on the basis of three general objectives: facilitating a normal postural tonus, facilitating righting, equilibrium and protective responses and the enhancement of normal patterns of movement. Normalisation of tonus was facilitated with specific NDT techniques such as joint approximation, 'tapping' and resistance to movement. Postural responses were facilitated in

prone and supine positions, quadruped, sitting and standing. Developmentally appropriate movement patterns were facilitated after activities to increase postural tone. They included pivoting in prone, rolling from prone to supine and supine to prone, prone progression on abdomen, reciprocal creeping and moving into and out of the sitting position using trunk rotation. Parental participation was not considered desirable due to the introduction of a variable which could not be controlled.
Intervention measurement was done (blind) with the Bayley Scales of Infant Development and the Peabody Developmental Motor Scales. In addition, measurements were made with quantifiable, individually specified treatment objectives. The inter-rater reliability of this had been tested and found to be in order. Intervention measurement with the Bayley Scales of Infant Development and the Peabody Developmental Motor Scales showed no significant difference in the motor and mental developmental level between treatment and control group. The individually specified objectives did vary significantly to the advantage of the experimental group. Harris concluded that the results of the research actually supported the hypothesis that therapy according to the NDT method improved the motor achievement of DS children. The fact that this was not apparent from testing with the two developmental scales was attributed by the author to the small research group, the short intervention period and in particular to the inadequate sensitivity of the measuring instruments used. She advocated the development of a fine assessment tool specifically for DS children with which to register the level of quality of the motor abilities and changes in them. Harris also advocated another form of research methodology. In view of the complex forms of the problems, she found group comparison not realistic and recommended the single subject design (n=1).

3.4 Discussion

3.4.1 The theoretical framework

In relation to the motor abilities of DS children, there are two distinct views apparent in the twelve research studies described, from which the stated disturbances in the field of motor development were interpreted. On the one hand, this motor development was seen as retarded, but otherwise developing normally, on the other hand specific motor problems were suggested. The underlying theoretical

framework determined, to a significant extent, the content of the treatment method applied, as well as the manner of intervention measurement.
In five of the eight programmes, which were generally stimulating (Hayden & Dmitriev, 1975; Aronson & Fällström, 1977; Hanson & Schwarz, 1978; Clunies-Ross, 1979; Piper & Pless, 1980; see table 3.1), the motor abilities of DS children were considered to be retarded. In addition, there was the suggestion of the positive effect of an enriched environment on the development of children with a developmental disadvantage. This motivated intervention by means of a broadly oriented, more or less general stimulation. The effects were measured with development tests standardised on non-disabled children.
Touwen (1988), however, suggested that the term 'retardation' gave the idea that a disadvantage could be rectified by stimulation. He preferred the concept of 'alternative development' for persons with a mental disability and referred to 'individual age-specific development' and an 'individual, often reduced variability' in this respect.
Various authors stated that the motor development of DS children contained many aspects which actually make this development 'other'. What is very fundamental is the deviating developmental sequence of motor skills noted by Dyer, Gunn, Rauh and Berry (1990) and by Haley (1987). In addition, various authors described the development of postural and movement patterns characteristic of DS (Lydic & Steele, 1979; Lauteslager, 1991; Åkerström & Sanner, 1993). Finally, Connolly and Michael (1986) made it clear that the motor problems of DS children are specific for that syndrome; they achieve significantly less in the motor area compared with children with other forms of mental disablement.

Specific problems in the motor development of DS children were recognised in the three other stimulation programmes. Brinkworth (1972) referred to an underdeveloped nervous system with a limited degree of stimulus processing and hypotonia. Sharav & Shlomo (1986) considered early treatment by an occupational therapist and a physiotherapist to be necessary, but did not provide a theoretical framework for this. Finally, Cunningham (1987) recorded hypotonia and a lack of co-ordination. He attributed this to a relatively small cerebellum, a small brain stem and a retarded maturation in the central nervous system. In the four specific motor programmes, the theoretical underpinning of intervention is, in general, more extensive.

Kugel (1970) reported specific motor problems. He mentioned hypotonia and co-ordination disorders and described, without further naming it, the insufficiency of stabilising myogenous co-contractions of joints. Problems of equilibrium, however, were not mentioned. The manner in which the motor problems influenced various stages of motor development was inadequately illustrated and the specific developmental coherence between motor phases was not indicated.
Connolly et al. (1976; 1980; 1984; 1993) recorded muscular hypotonia as a basic problem, but did not make a connection with the consequences of this for the postural control system. They interpreted stability problems around joints as a lack of muscle power and treated them as such; problems with equilibrium were not mentioned. The emphasis was on the tempo in which motor milestones were achieved and not on the quality of movement. There was no focus on the qualitative motor process, nor on the relationship between the specific motor problems and the various phases of motor development.
The intervention of Kantner, Clark, Allen and Chase (1976) was not, in fact, based on any theoretical framework. The authors selected vestibular stimulation because this form of stimulation was a constituent of various exercise therapy methods. They stated that the effect thereof had not, in itself, ever been researched. This approach is not relevant to the motor problems of DS children. The inadequacy of equilibrium reactions is evident, but is an element of complex motor problems.
The theoretical framework in Harris' (1981a; 1981b) research was not based on any analysis of the specific motor problems of DS children. Its general treatment objectives were derived from the NDT method. Harris' choice of the NDT method as a treatment method is understandable, because hypotonia in DS children is a characteristic problem in relation to disturbances in postural control. That is why normalisation of tonus and the facilitation of postural reactions appear to be useful as a basis for the development of normal posture and movement patterns. Yet it is essential that in applying developmentally-oriented motor intervention, such as the NDT, there is insight into the specific development path of DS children. Only then can individual treatment objectives be laid down.

In summary, in view of the nature of the motor problems, it is not tenable to consider the motor development of DS children as retarded. In the remaining three general stimulation programmes and in the four specific motor programmes, varying aspects of specific motor problems were assumed. However, in none of those studies was the treatment method based on an analysis of the motor development problems of DS children. It can therefore be concluded that in none of the intervention studies discussed was a theoretical framework used that interpreted the specific motor problems of DS children from a developmental perspective. The theoretical foundation and also the applied treatment methods and measuring instruments are therefore open to discussion. The necessity underlined by Henderson (1985) and Block (1991) to process available research material in intervention research was endorsed.

3.4.2 The treatment methods

An important element in evaluating the results of the intervention studies is insight into the treatment methods used. It is all the more striking therefore that, of the twelve authors, eleven do not report them. A case in point is Sharav & Shlomo's (1986) article, in which there is no mention of the content of the treatment in the motor area. The treatment methods on which the negative results of Piper & Pless (1980) are based, are also unclear. Only Harris (1981a; 1981b) made use of a method (NDT) which enjoyed broader recognition among paramedics. As far as this is concerned, it can be stated that the studies discussed offer insufficient insight into the motor treatment used. That means that the results presented can only have a limited meaning for the field of study.

In five of the eight general stimulation programmes discussed (Hayden & Dmitriev, 1975; Aronson & Fällström, 1977; Hanson & Schwarz, 1978; Clunies-Ross, 1979; Piper & Pless, 1980; see table 3.1), use was made of broadly oriented, developmentally focussed intervention based on the developmental patterns of non-disabled children. In so far as it was mentioned, the manner of motor stimulation was non-specific. To a limited extent, the three remaining programmes referred to specific motor problems. Brinkworth (1972), on the basis of a limited number of theoretical premises, attached some importance to the stimulation of brain activity through wide-ranging stimulation, to the stimulation of equilibrium and of proprioception. This method of treatment is not nearly specific enough for the complexity of the motor problems of DS children. Sharav and Shlomo (1986) did not give any information about the methods of treatment used, nor about the theoretical framework. As the measuring instrument used was standardised on non-disabled children, it seems probable that

insufficient attention had been paid to motor problems specific to the syndrome. Finally, Cunningham (1987) based his intervention on limited theoretical premises and had insufficient attention for qualitative aspects of motor development. Three of the eight studies (Sharav & Shlomo, 1986; Clunies-Ross, 1979; Piper & Pless, 1980) reported the involvement of a physiotherapist.
It may be concluded that in the general stimulation programmes discussed, motor intervention was not based on an adequate analysis of the motor problems of DS children. As a result, objectives and treatment were not sufficiently specific and the merit of the results is limited.

There appears to be considerable variation in the approach adopted in the specific motor programmes (see table 3.2). In three of the four programmes, exercise therapy was selected as the intervention method. Kantner et al. (1976) opted for specific vestibular stimulation. In the studies of Kantner et al. (1976) and Harris (1981a; 1981b), the intervention period was of short duration (two and nine weeks respectively), which did not include parental participation. In Connolly & Russell's (1976) study, intervention took place during the first three years of life of the children participating; in Kugel's (1970) study, intervention lasted for eighteen months. Both studies described a form of participation (by parents and nursing staff respectively). In view of the length of the intervention, the approach of Kugel (1970) and of Connolly & Russell (1976) should lead to a more structural effect on the motor development. The length of intervention involved in the studies of Kantner et al. (1976) and of Harris (1981a; 1981b) is rather short for conclusions to be drawn about developmental stimulation. The four studies correspond roughly with regard to the age of the children participating (0 - 36 months).
Kugel's (1970) research is to some extent based on the observation of specific postural and movement patterns, but does not adequately illustrate the problems indicated from the perspective of a specific developmental framework. Furthermore, the treatment was also based on normal motor development and was carried out by nursing staff under the supervision of a physiotherapist. Connolly & Russell (1976) interpreted problems of stability as weakness of the muscles resulting from muscular hypotonia and opted for strengthening of the muscles in combination with general motor stimulation. The treatment team included a physiotherapist. Insufficient attention was paid to qualitative aspects of motor ability: normal motor milestones were used as the

point of reference. As mentioned above, motivation and treatment methods in Kantner et al. (1976) study differ considerably from the other programmes. Motor intervention measurement took place in a quantitative sense, the treatment was not based on a problem analysis and only covered a limited facet of the motor problems experienced by DS children. That is why its relevance for the evaluation of developmentally-oriented intervention programmes is restricted. Finally, Harris' (1981a; 1981b) general objectives of intervention were based on the objectives of the NDT method and were not founded on an analysis of the motor abilities of the target group. Although these objectives did conform roughly with the objectives of the NDT method, there was nevertheless a lack of insight into the correspondence between the specific motor problems and the development of specific motor patterns. The treatment took place on the basis of individual therapy objectives and was carried out by qualified physiotherapists.
It may be concluded that the basis of objectives in the specific motor programmes is limited. As a result, there was not enough focussed investigation of the motor problems of DS children. The nature of these problems made the NDT method appear to be the most appropriate, but also necessitated some adaptation. Henderson (1985) recommended setting up a hypothesis relating to the problems of DS children. Gibson & Harris (1988) suggested integrating knowledge about the problems in intervention programmes.

3.4.3 The results

The target group of the twelve intervention studies consisted of young mentally disabled children who were in the process of developing their motor abilities. It is therefore important to know whether the results stated signify a temporary training effect or contribute structurally to the quality and functionality of the development of the child treated.
With the general stimulation programmes (see table 3.1), Brinkworth (1972) claimed a slight positive, statistically non-significant short-term effect; Hayden & Dmitriev (1975) also stated positive effects. Aronson & Fällström (1977) indicated a positive short-term effect in the field of locomotion, which, after one year, turned out not to be structural. Hanson & Schwarz (1978) and Clunies-Ross (1979) described a relatively minor positive short-term effect. Piper & Pless (1980) reported a declining motor score and in Sharav & Shlomo's (1986) study a declining developmental trend was discernible up to eighteen months. Finally, Cunningham (1987) described a positive effect for the

duration of the stimulation applied without any generalised effect. The results in the field of gross motor abilities, therefore, are diverse but mainly slightly positive. Should there be any positive effect in the field of motor abilities, that it consists of a structural developmental contribution is not clear.

The specific motor programmes show marked positive short-term effects in the field of gross motor abilities (see table 3.2). In Harris' (1981a; 1981b) research this is not evident from the scores on the Bayley Scales of Infant Development and the Peabody Developmental Motor Scales, but it is apparent from the scores on individually specified objectives. Connolly et al. (1980; 1984; 1993) reported disappointing long-term effects in the field of gross and fine motor abilities. The specific motor programmes did not indicate any clear benefit for DS children's motor development either, but the short-term effects gave a more positive general picture than the general stimulation programmes.

The significance of the results presented depends on the manner in which they were achieved. Gibson & Harris (1988) concluded that results of early stimulation on the development of DS children were confusing because of methodological problems. In relation to the above, there are significant points of criticism regarding the measuring instruments used and with regard to outcome control.

3.4.4 Outcome measurement

In the twelve intervention research studies discussed, a total of seventeen, mainly reliable measuring instruments were used. Only in the study of Hanson & Schwarz (1978) was the reliability of the intervention measurement not clear. In three intervention studies the Gesell Schedules of Motor Development, the Griffiths' Development Scales, the Stanford- Binet and the Bayley Scales of Infant Development were used, and in addition measurements were made with thirteen other measuring instruments (see tables 3.1 and 3.2). From this diversity of instruments, it can be inferred that not one of the measuring instruments was found to be particularly appropriate for the registration of the motor behaviour of young DS children. It was also apparent that, in order to measure the effect of intervention, developmental scales were mainly used which were standardised on normal, healthy children.

Eiper and Azen (1978) recommended the Bayley Scales of Infant Development for DS children. Other authors, however, attributed the decline in developmental quotient of these children during the first years of life to the structure of this measuring instrument (Sharav & Shlomo, 1986; Dyer et al., 1990). In this phase, test items are usually based on motor skills and the level achieved by DS children is negatively influenced by hypotonia. In comparison with non-disabled children, DS children master several items of the motor scale of the Bayley Scales of Infant Development in a different developmental sequence (Dyer et al., 1990). In addition, the researchers posit that such developmental tests do not reveal the specific motor problems of DS children. Van Empelen (1992) concluded that the measuring instruments used at present in paediatric physiotherapy are inappropriate to evaluate the quality of movement. Developmental progress as a result of intervention with the NDT method was not registered by the Bayley Scales of Infant Development and the Peabody Developmental Motor Scales due to the lack of sensitivity of both measuring instruments (Harris, 1981a; 1981b). What is needed, therefore, is the development of a fine measuring instrument, tailored to the syndrome, in order to score the quality level of the motor abilities and changes in them.
Results of intervention must be reliably tested; there does not appear to be an adequate measuring instrument available. It should be possible, following Harris' (1980) example, to define ordinally classified, corresponding levels of development for a number of basic motor skills, with the result that administration of the test will provide insight into the motor development of a child. The extent of functionality of a posture or movement and the individual nature of the process of development of a DS child should be the driving force here. The lack of such a measuring instrument, moreover, means that the results described above are only of relative value.

Several authors did not opt for use of a control group, partly from ethical considerations. Norms from developmental tests were used as reference, standardised for healthy children or developmental norms which were based on a specific group of DS children (Fishler et al., 1964, Dicks-Mireaux, 1972). The comparison with normal children caused a distorted picture because the specific problems were not indicated (Dyer et al., 1990). The distinctive development of the DS child, moreover, was ignored. The use of norms for DS children did not occur because there were no uniform, universally applicable, standardised norms available (Gibson & Fields, 1984). Harris (1980) posited that from a practical point of view it was not possible to set up equivalent experimental and control groups for DS children, which are necessary for pure experimental research. This was caused by the complexity of their motor problems. The degree of hypotonia, individual variations in tonus distribution, mental level, social background and general health problems, such as the frequent occurrence of heart defects and respiratory disturbances, entailed a multiplicity of variables. Harris' (1980) response was to postulate the single-subject design (n=1) as a research method. In the context of a quality-oriented research study, a time series, in which each child treated forms its own framework of reference, is perhaps a sound possibility.

3.5 Conclusions and recommendations

On the basis of studies carried out to date into the effect of intervention on the motor development of DS children, it is not possible to indicate their merit for the development of these children. There are several reasons for this. In none of the studies was a theoretical framework used which interpreted the specific motor problems and placed them in a developmental perspective. The treatment methods and measuring instruments used turned out not to be sensitive enough and were not sufficiently based on an appropriate assessment of the motor problems. The result was that the treatment and the intervention measurement were not emphasised. In addition, insufficient attention was devoted to the content of the motor interventions with the result that the relevance for the therapist and for the target group could only be determined to a limited degree. Finally, there were problems in the provision of an adequate form of control because of the lack of appropriate reference data and due to the heterogeneity of the target group.

Parents of DS children call for more and more motor intervention. There are sufficient indications from the literature suggesting the importance of specific intervention. In addition, satisfactory motor skills underpin cognitive and social interactions (Henderson, 1985) and a reciprocal relationship is hypothesized between the development of cognitive functions and that of sensori-motor skills (Griffiths, 1976). Touwen (1989) indicated that in the infant and toddler period motor and mental development are closely intertwined. Adequate motor

possibilities can give the DS child more developmental opportunities in a broad sense.
The motor problems of DS children are obvious, so that intervention in their motor development seems to be desirable. On the basis of a comprehensive theoretical framework of the development of specific postural and movement patterns in DS children, it is perhaps possible to develop a model, specific treatment method and a specific measuring instrument. In an intervention study, a time series would appear to be the research design indicated in order to avoid problems of reference.

3.6 Summary

The motor problems of children with DS described in chapter 2 give cause for intervention (see introduction). The present chapter will provide an overview of studies from 1970 onwards which examine the effect of particular interventions on the motor development of DS children. The aim of this chapter is to formulate the definition of a well-founded method of treatment. The discussion will be focussed on four aspects of the twelve intervention studies reviewed, i.e. the theoretical framework adopted, the method of treatment, the effects of intervention on gross motor skills and the method of measuring intervention.
The studies reviewed appear to be inappropriate to demonstrate the value of interventions described for the specific motor problems of DS children. The important factor is that none of the research studies reviewed used a theoretical model with which motor problems could be interpreted from a developmental perspective. Methods of treatment and instruments of measurement are therefore not based on a theoretical framework, as a result of which the motor problems do not receive adequate specific treatment and testing. In addition, there seemed to be a problem in the provision of an adequate form of monitoring in the context of intervention research.
The discussion led to the following recommendations for investigation into the effect of intervention on the motor development of young DS children. It is essential that research is based on a theoretical framework established on an adequate inventory of the motor problems of these children. Such a framework would make it possible to formulate specific treatment objectives for each phase of motor development and to define the intervention desired. In addition, on the basis of that framework, a specific motor test can be developed in

order to measure the effects of intervention in a controlled manner. A quasi-experimental research design may be a good option to overcome.

3.7 Literature

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4. Disturbances in the motor behaviour of children with Down's syndrome: the need for a theoretical framework

Many researchers are involved in studying the motor development of children with Down's syndrome (DS). Reviews by Henderson (1985) and Block (1991) report that there is extensive and varied research available relating to factors which influence their motor development. There are sufficient indications for specific motor problems. Hypotonia, abnormal development of reflexes, instability and obesity seem to play important roles. In addition, medical and health aspects, such as congenital heart abnormalities, sensory-motor problems and hypermobility of joints are important, as are the cognitive and social limitations. However, the information available is extensive, but unconnected. Both Henderson (1985) and Block (1991) express the need for a synthesis of the research material available.
The studies reviewed in chapter 3 appear to be inappropriate in demonstrating the value of interventions on the motor development of DS children. One of the important factors is that none of these research studies used a theoretical framework with which motor

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Chapter 4 is based on

Lauteslager, P.E.M., Vermeer, A. & Helders, P.J.M. (1994).
Houdingsregulatie stoornissen bij kinderen met het syndroom van Down; een literatuurstudie (Disturbances in the regulation of postural control; a review of the literature). *Nederlands Tijdschrift voor Fysiotherapie*, 104, 160-169.

Lauteslager, P.E.M., Vermeer, A. & Helders, P.J.M. (1998).
Disturbances in the motor behaviour of children with Down's syndrome: the need for a theoretical frame work.
Physiotherapy, 84, 5-13.

Lauteslager, P.E.M., Vermeer, A., Helders, P.J.M. (1998). Zaburzenia zachowania motorycznego u dzieci z zespotem Downa-potrzeba opracowania teoretycznego (Disturbances in the motor behaviour of children with Down's syndrome: the need for a theoretical framework). *Rehabilitacja Medyczna*, Tom 2, nr 4, 47-55.

problems of children could be interpreted from a developmental perspective. It is important to develop such a framework. It should be on the basis of goal-directed, disease-related motor intervention for DS children (Lauteslager, Vermeer & Helders, 1995; 1996).

4.1 Literature

The recent discussion regarding the value of developmental tests for children with DS may be a starting point for such a synthesis. The use of psychometric tests, which are standardised for healthy children, is inadvisable in the opinion of many authors (Henderson, 1985; Sharav & Shlomo, 1986; Piper et al., 1986). The motor development of children with DS shows its own specific development course, as a result of which reference to normal development cannot be justified. This is confirmed by the study of Dyer et al. (1990). They investigated the usefulness of the Bayley Scales of Infant Development (BSID) motor scale as an instrument to measure motor development of children with DS. They analysed 707 scores on the BSID, registered with 229 home-based children with DS. The outcome of their analysis was a corrected, specific motor development curve. This curve shows a progression which is admittedly retarded, but constant and similar to that of non-handicapped children. However, the sequence of developmental skills mastered by children with DS clearly deviates. More particularly those skills which are dependent on postural control, occur later. Evidently a child with DS has a retarded yet constant motor development, but the sequence in which the developmental phases are reached is affected by a lack of postural regulation.
In view of the fact that psychometric tests such as the BSID provide no insight into the process which leads to the test outcome, the results of Dyer et al. (1990) give rise to two questions. The first question concerns the way in which motor abilities develop qualitatively in children with DS. The second regards the influence of posture regulating factors, such as balance, co-contractions and muscle tonus, on their motor development.

Gallahue and Ozmun (1994) divide normal motor development into four phases: the phase of reflexive movements (prenatal and first year of life); the phase of rudimentary movements (first two years of life); the phase of fundamental movements (second to seventh year of life); and the phase of specialised movements (from the tenth year onwards). In the literature, there are eleven authors (see table 4.1) who have described and interpreted qualitative aspects of posture and movement at the phase of rudimentary movements in children with DS. These authors have distinguished nine basic motor skills for the phase of rudimentary movements, namely, motor skills in the prone and supine positions, rolling over, moving forwards over the ground, sitting, mobility when sitting, standing, standing up and walking.

In the following part of the paper, postural and qualitative aspects of motor behaviour, described by the eleven authors, are assembled under the nine above-mentioned basic motor skills. Together with the theoretical explanations they offer and the research material available, an attempt will be made to develop a theoretical framework relating to the motor problems of children with DS. Table 4.1 gives a synopsis of the background information about the studies discussed. With a view to the discussion and the development of a theoretical framework, the theoretical explanations offered by the authors are also recorded.

Author	Subjects: number and age	
	Experimental	**Control**
Åkerström & Sanner, 1993	n= 14 (DS) 3 w-74m	
Cowie, 1970	n= 97 (DS) 0 - 46 w	
Dyer, Gunn, Rauh & Berry, 1990	n= 229 (DS), 1-83 m	
Haley, 1986	n= 20 (DS) 2 - 24 m	n= 40 (NH)
Kugel, 1970	n= 7 (DS) 4 - 17m average 9.8 m	
Lauteslager, 1995	n= 5 (DS) 4 - 46 m	
Lydic & Steele, 1979	n= 104 (DS) 1 - 3 y (52% of population)	
Parker, Bronks & Snyder, 1986	n= 10 (DS) average 5 y	n= 9 (NH) average 5 y
Rast & Harris, 1985	n= 15 (DS) 3.5 - 4.5 m	n= 15 (NH) 3.5 - 4.5 m
Shumway-Cook & Woollacott 1985	n= 6 (DS) 22 m - 6 y	n= 11 (NH) 15 m - 6 y
Ulrich, Ulrich & Collier, 1992	n= 7 (DS) mean 11 m	n= ? (NH) 1 - 10 m

Table 4.1 Subject details, measuring instruments and theoretical explanations

Measuring instrument	Explanation for motor problems
Structured observation	Neuroanatomical disorders, hypotonia, inadequate and retarded development of postural reactions, disturbances in coordination, hypermobility of joints
Neurological assessment, Bayley Scales of Infant Development	hypotonia in relation to a lack of self-righting and postural control
Bayley Scales of Infant Development (motor scale)	Hypotonia, inadequate proprioceptive feedback, hypermobility of joints, retarded balance reactions
Bayley Scales of Infant Development Movement Assessment of Children	Adequate postural reactions (self-righting, balance and antipatory reactions) are the foundations for attaining motor milestones
Gesell Developmental Scales	Hyptonia, disturbances in coordination
Structured observation	Inadequate co-contractions as a result of hypotonia lead to syndrome-specific motor problems
Questionnaire	Importance of trunk rotation for motor development
Computer analysis of film recording	Instability, insufficient neuromuscular control
Movement Assessment of Children	Adequate postural reactions as condition of normal motor development
Electromyographic research	Insufficient postural reactions
Registration of treadmill stimulation	Inadequate postural reactions, reduced need for exploration, hypermobility of joints, overweight, insufficient muscular stability and strength

Abbreviations used			
n	Number	NH	Non-handicapped
w	Week	DS	Down's syndrome
m	Month		
y	Year		

4.2 Specific motor behaviour during the development of rudimentary movements

4.2.1 Motor ability in the prone position

In a longitudinal study covering the neurological development of 97 children with DS, Cowie (1970) describes an extremely flat prone position, in which extension of the back and head lifting frequently did not occur before the age of 14 weeks, but sometimes not even before 40 weeks. With the Landau reaction she notes a lack of trunk extension and self-righting reactions of head and limbs in 79% of the group under investigation (age 33 to 46 weeks). She indicates a clear connection between the degree of muscular hypotonia and the lack of trunk extension and self-righting reactions in testing the Landau reaction.

In his report on the effect of motor intervention, Kugel (1970) notes that four of the seven participating children with DS (mean age 9.8 months) showed inadequate head and neck control in the prone position before the beginning of the intervention. In addition, he describes marked stretching of the head in the prone position. Kugel relates both the lack of postural control and the head stretching to hypotonia.

In an investigation into the emergence of early postural reactions (self-righting, balance and anticipatory reactions), Rast and Harris (1985) compared 15 children with DS with non-handicapped children of the same age. The authors indicate problems in maintaining the position of the head relative to the trunk. Some children compensated by resting the head on the neck to support the head position. The differences are statistically significant. Rast and Harris regard adequate postural reactions as a condition for attaining motor milestones and think that these reactions can prevent the emergence of syndrome-specific compensatory movements.

Based on observations of 14 children with DS (age three weeks to 74 months) in the prone position, Åkerström and Sanner (1993) describe problems connected with raising the head, lifting the chest from the ground and leaning on the arms. Three children showed a marked extension of the back when stretching the arms. When the pelvis and the legs were raised from the ground (active movement) the child seemed to lose balance and topple over. Two children were not capable of maintaining balance in the prone position. The authors suggested problems in maintaining posture, muscular hypotonia and an enlarged joint mobility, together with a retarded development of self-righting reactions. Lauteslager (1995) reports on nine structured observations of children with DS on video (aged five to forty-six months). He describes problems with raising the head, supporting and transferring weight to the arms, extending the trunk and hips and stretching out the arms. Two children regularly rested their heads on their necks (age 18 months), one child (22 months) raised the pelvis and legs from the ground when stretching out. The author attributes these problems to an inability to stabilise positions of the head, shoulder girdle and trunk as a result of inadequate co-contractions arising from hypotonia.

To summarize, in the prone position problems occur in maintaining posture to overcome the force of gravity, particularly in stabilizing a raised position of the head and supporting with the arms and on stretching them out. The inability to stabilize the trunk is described by two of the five authors, one author describes problems in merely maintaining the prone position. Three authors describe resting the head with a strong cervical extension. Two authors interpret this as a compensatory mechanism to support the head position. The causes indicated are hypotonia, but also hypotonia in relation to posture-regulating processes such as stabilizing co-contractions, and a retarded development of self-righting reactions.

4.2.2 Motor ability in the supine position

Cowie (1970) reported a passive, flat posture without any degree of trunk flexion. Up to 14 weeks, widely abducted arms were observed; the legs were frequently in a 'frog-like' position. Cowie interpreted these motor problems as symptomatic of hypotonia.
Åkerström and Sanner (1993) observed an inability in three children to settle in the supine position during the first three months. Three children (age two months) moved their limbs stretched out along the surface, two children raised their legs with straight knees so that they could not touch their feet. Hypotonia and disturbances in the regulation of posture were indicated as causes.
Lauteslager (1995) described a 'hurray position' of the arms in the supine position and a 'frog-like' position of the legs (age five months). The posture was passive, limbs were not raised from the ground. One child (age 22 months) had problems in reaching out with the arms. In compensation, the posture was stabilized by clamping the upper arms

to the chest. Hypotonia was indicated as the cause, resulting in a lack of stabilizing co-contractions round shoulder and hip joints.

To summarize, the findings of the three authors are similar with regard to the inability to raise limbs from the surface; in addition Cowie (1970) reported the absence of flexion activity in the trunk and Åkerström & Sanner (1993) described excessive extension of the trunk. The causes stated by the authors can be collectively defined as disturbances in postural regulation and can be related to hypotonia.

4.2.3 Rolling over

Lauteslager (1995) pointed out an absence of trunk rotation in rolling over (ages 18, 34, 35 and 46 months). Rolling over occurred without dissociation between the shoulder and pelvic girdles; the role played by the legs was relatively minor. One child (18 months) strongly extended the spinal column in order to roll over. The same was also reported by Åkerström and Sanner (1993) for a ten-week-old child. Lauteslager (1995) indicated that rolling over demands trunk extension and the transfer of weight as well as freeing an arm or a leg. The children, however, preferred to remain balanced with symmetrical support as a consequence of the lack of stabilizing myogenous contractions around the joints related to a clear hypotonia.

To summarize, inadequate trunk motor ability and limited leg function were reported in rolling over. The cause was stated to be a lack of postural regulation relating to hypotonia. This is manifested in insufficient co-contractions.

4.2.4 Moving forward on the ground

Lauteslager (1995) described children pushing themselves forward while supporting themselves symmetrically on their hands. Support from the legs was minimal (age 18 months). Alternating 'creeping' showed, in addition to the inadequacy of forward propulsion of the legs, a problem in stabilizing the alternating weight-bearing shoulder joint (age 34 months).
Both Åkerström and Sanner (1993) and Lauteslager (1995) described problems in maintaining the crawling posture. The legs slipped sideways whenever children were placed in the crawling position. Åkerström and Sanner (1993) considered this to be an extreme

extension pattern, Lauteslager (1995) suggested a lack of stability round the shoulder and hip joint as a result of hypotonia and a deficiency in forward propulsion of the legs.
In summary, stabilizing problems of the joints occur and an absence of forward propulsion by the legs could be observed in moving over the floor. As a result, deviant posture and movement patterns developed. The cause given was insufficient co-contractions related to hypotonia.

4.2.5 Sitting posture

On the basis of an analysis of a questionnaire relating to the quality of movement filled in by the parents of 104 children with DS, Lydic and Steele (1979) reported widely abducted hips and extended knees in sitting in 47 % of the children. There was no trunk rotation. The authors indicated the importance of trunk rotation for the development of further movement patterns.
Åkerström and Sanner (1993) pointed out an identical sitting posture, adding that extension of the trunk was moderately developed. Children also did not change their sitting posture very much; side-sitting rarely occurred. Hypotonia, disturbances of posture regulation and hypermobile joints were given as causes.
Kugel (1970) reported inadequate head and neck control, legs wide apart and a slumped trunk in sitting. The author related this to hypotonia.
Lauteslager (1995) described a static sitting posture stabilized by extending the base (legs wide apart or cross-legged) and supporting weight with extended arms on the upper legs or the ground. Trunk lateral flexion and rotation were hardly ever observed; transfer of weight was supported by arms and legs. Trunk extension was moderately developed and the head frequently rested on the neck for support. The cause was stated to be a lack of balance and stability, together with hypotonia.

To summarize, all the authors reported a deviant leg position in sitting, and three of the four authors a lack of trunk extension. One author interpreted the wide-legged sitting position and the arm support he described, as a compensation for a lack of balance and trunk extension. Three of the four authors described a deficiency in the qualitative aspects of posture and movement in sitting, such as trunk rotation and lateral flexion, the absence of side-sitting and a lack of variation in posture. Two authors described a deviant position of the head. Hypotonia was seen as a causal factor by three of the four authors, two emphasized disturbances in posture regulation such as a lack of balance and co-contractions, whether or not in combination with hypotonia, and one author stressed the increased joint mobility.

4.2.6 Mobility in the sitting position

Lydic and Steele (1979) reported that 46.1% of the 104 children included in their study demonstrated abnormal movement patterns in coming to a sitting position. Extreme symmetrical hip abduction/ exorotation (splits) was used by 35 children in pushing up from the prone to a sitting position. Arising from a lack of trunk rotation, this had important consequences for the development of further motor skills. Haley (1986) interpreted this symmetrical manner of coming to a sitting position as a compensatory movement pattern resulting from reduced posture reactions (balance and self-righting).
Åkerström and Sanner (1993) described an identical movement pattern in one of the 14 children. They mentioned the lack of trunk rotation and discussed problems with posture regulation, muscular hypotonia and the hypermobility of joints.
Kugel (1970) wrote about a lack of trunk rotation when coming to a sitting position and attributed it to hypotonia and to the relatively short length of the arms.
Lauteslager (1995) described more specific movement patterns of children with DS in achieving sitting, kneeling and crawling positions, including the one mentioned above (three of the five children). Common factors cited are the absence of side-sitting, trunk rotation and trunk lateral flexion. For these movements good trunk control is necessary. Due to a lack of postural tonus, children with DS do not have the stability to develop a good trunk rotation and they compensate by adapted movement patterns.
Cowie (1970) reported a poor postural regulation of the head in coming to a sitting position with help (traction test; 49% of 97 children, age between 33 and 46 weeks). She found a clear connection with the degree of hypotonia. Rast and Harris (1985) reported a compensatory movement pattern in this respect. The head was stabilized in extension; flexion activity was largely absent.

In summary, four of the seven authors described a symmetrical abduction pattern of the hips in attaining the sitting position. Four authors mentioned the absence of qualitative elements of trunk motor ability, such as rotation and side-sitting. This was interpreted as compensatory movement by two authors. Two authors gave accounts of disturbances in the postural regulation of the head during the traction test and one of them described a compensatory movement pattern. Children with DS generally demonstrate symmetrical movement patterns in the sitting position. Four authors stated the cause as being a reduced postural tone, whether or not it was related to aspects of disturbances in posture regulation, such as an absence of a self-righting reaction, balance and an insufficiency of stabilizing co-contraction round the joints.

4.2.7 Standing

Åkerström and Sanner (1993) stated that children with DS have a tendency to stand supported by over-extended knees without stepping or jumping, suggesting a deficiency in postural regulation as a cause. From the research of Dyer et al. (1990), it emerges that problems of balance also occurred in standing. They accounted for them as arising from a slow reaction to changes in posture with balance reactions, hypotonia and hypermobile joints.
Shumway-Cook and Woollacott (1985) investigated, by means of electromyographic research, the reactions of six children with DS (aged 22 months to 6 years) to disturbances in balance when standing. These data were compared with data from non-handicapped children. They concluded that postural reactions between four and six years of age were more or less identical to those of non-handicapped children. However, the postural reaction occurred (extended latent period) significantly later, resulting in an increase of body movements and also in loss of balance. The authors emphasized a specific difference in the ontogenetic development of postural control between children with DS and normal children, but considered further research necessary.

To summarize, one of the three authors described static standing with over- extended knees; two authors indicated problems of balance in standing. The cause given was that there was also an absence of postural regulation in standing. In this connection hypotonia and hypermobile joints were indicated. The coordination of collaborating groups of muscles seemed to be particularly important in ensuring sufficient co-contractions around joints, thereby effecting stability and balance.

4.2.8 Standing up

Dyer et al. (1990) showed that getting up asymmetrically, for which balance, trunk rotation and lateral flexion are necessary, were mastered relatively late. In general, this was attributed to posture regulation problems combined with hypotonia and hypermobility of joints.
Lauteslager (1995) stated that getting up is performed in a mainly symmetrical manner, usually without trunk rotation and with maximum support from the hands and feet. Losing balance was avoided as far as possible. The author interpreted this in the light of inadequate co-contractions and hypotonia, as a result of which insufficient stability could be built up; there was a lack of postural regulation.

To summarize, one of the two authors indicated that getting up asymmetrically, for which qualitative motor aspects are necessary, developed relatively late. The other author stated that getting up was characterized by compensatory symmetrical movements without trunk rotation and with the maximum support possible. The cause given was problems of postural regulation (lack of balance and co-contractions), hypermobile joints and hypotonia.

4.2.9 Walking

Parker, Bronks and Snyder (1986) provided information about the walking pattern of children with DS, using a computer analysis of film material of ten five-year-old children with DS. Information was collected about movement trajectories, cadence, step-length and the standing and swaying phase. The data were compared with material from non-handicapped children. The authors indicated significant differences in walking patterns. They reported a small average step-length which was attributed to a smaller mean leg-length. A shortened standing phase was attributed to instability and in turn contributed to the inability to extend the step-length. The general posture demonstrated relatively more flexion (trunk, hip and knee) to compensate for instability. Fluctuations were observed during movements of the ankle, which implied a reduced joint control and suggested either weakness of the muscles or an abnormal neuromuscular control.
Ulrich et al. (1992) investigated the emergence of alternating stepping patterns in a gliding posture in seven DS children of 11 months old, placed on a treadmill. They compared these data with those from non-handicapped children. At the time of the test, the children could not

walk. They found that the children with DS reacted to the treadmill stimulation in a manner identical to very young (in development), non-handicapped children. In their opinion, this showed that the neuromuscular ability to generate stepping patterns is present before other essential components of being able to walk are adequately developed. With respect to non-handicapped children, Ulrich et al. here refer to a lack of strength and postural control. With respect to DS children they were also referring to additional factors, such as retarded posture reactions, hypermobility of joints, extra weight, lack of muscular stability and less active exploration.
From the research of Dyer et al. (1990), it appeared that motor ability in BSID items relating to walking is relatively retarded in development. This was attributed to a lack of postural control, hypotonia and hypermobile joints.
Lydic and Steele (1979) indicated that 34.7% of the 104 children had a wide-legged walk and a Duchenne gait, with a relatively large amount of hip exorotation and an abnormal arm position; 29.8% were not yet walking. In their view adequate trunk rotation is particularly lacking.
Åkerström and Sanner (1993) observed over-extension of the knees in walking and some eversion of the foot in two of five walking children. The cause stated by the authors was a combination of muscular hypotonia and laxity of ligaments.
Lauteslager (1995) indicated a hypotonic leg action, problems of balance (age 34 and 46 months) and a wide-legged gait with exorotated and abducted hips without trunk rotation (age 34 months). The cause given was a lack of stabilizing co-contractions related to hypotonia, as a result of which inadequate postural control, and insufficient trunk rotation and balance developed.

To summarize, two of the seven authors described a wide-legged gait in which the hips were in exorotation, an absence of trunk rotation and problems in coordination of feet and ankles. Furthermore, it was indicated that younger children walked with over-extended knees, but that from the age of five years onwards they actually walked with more flexion in the hips, knees and trunk than non-handicapped children. Walking, measured by the BSID, turned out to be an ability which, in comparison with other items, was retarded in development; several authors also cited problems of balance in walking. In addition, a reduced step-length, a shorter standing phase, a Duchenne gait, an abnormal arm position and a hypotonic leg action were noted. Neuromuscular mechanisms for generating stepping patterns appeared to be present before strength and postural control were sufficiently developed to enable walking. Causes identified were a lack of postural control and hypotonia, also hypermobile joints, lack of muscular stability, obesity and less active exploration as a result of the mental handicap.

4.3 Theoretical framework

The 11 articles reviewed indicate the motor problems of DS children in the period of developing rudimentary movements. The description and analysis of the specific posture and movement patterns clarify how DS children adapt their motor behaviour to accommodate their motor disturbances. Interpretation of this adapted motor behaviour stimulates the formation of a hypothesis. Table 4.1 demonstrates that each author provided an explanatory model for the emergence of a specific motor behaviour. Part of this is hypothetical, the authors posit an assumed explanation for the motor problem described. Cowie (1970), Rast et al. (1985), Shumway-Cook et al. (1985), Haley (1986) and Dyer et al. (1990), on the other hand, introduce scientifically based elements as part of a theoretical framework to be formulated.
It is interesting that the findings of Rast et al. (1985), Shumway-Cook et al. (1985) and Haley (1986) support each other. They concluded that there are insufficient postural reactions in DS children. Haley (1986) and Rast et al. (1985) state that adequate postural reactions are an important condition for the development of normal posture and movement patterns. This condition is not fulfilled in DS children. These results correspond with the findings of Dyer et al. (1990), from which it is apparent that BSID items regarding postural concern, are more retarded in the development in DS children than in non-handicapped children. This is further illustrated when all 11 authors describe problems in maintaining posture. It can be stated that a significant element of the inadequate postural control is due to insufficient balance reactions.
Bobath (1982) describes the importance of an adequate regulation of tonus and of sufficient co-contractions for the development of posture and movement patterns. Cowie (1970) demonstrates unequivocally that each young DS child has reduced muscle tonus. This reduced muscle tonus will have a disadvantageous effect on the development of the posture and movement patterns of DS children. This supposition (hypothesis) should be placed in a theoretical framework. The

connection between hypotonus and neuroanatomical disturbances of the cerebellum and the brain stem posited by Åkerstrom et al. (1993) deserves further consideration.
In 3 of the 11 studies hypermobility is cited as an explanatory model (Dyer et al., 1990; Ulrich et al., 1992; Åkerstrom et al., 1993) and in 3 of the studies joint instability (Parker et al., 1986; Ulrich et al., 1992; Lauteslager, 1995). Bobath indicates the importance of adequate joint stabilisation for the development of posture and movement patterns. From a neurological point of view, the efficiency of the ability of a joint to stabilise is linked to a sufficiency of co-contractions and, from an orthopaedic point of view, with mobility. The system of proprioceptive feedback on posture and movement is also influential. As these are important conditions for postural control it is worthwhile studying the literature in more depth in order to discover the foundations for the above hypotheses.
The co-ordination disturbances posited by Kugel (1970) and Åkerstrom et al. (1993) can be interpreted by viewing the motor disturbances from a developmental perspective. The reduced urge to explore, reported as a cause by Ulrich et al. (1992), does of course have an influence, but does not apply exclusively to DS children. Connolly and Michael (1986) have demonstrated that children with DS have specific motor problems in comparison with children with other learning disabilities. Their obesity, mentioned by Ulrich et al. (1992) appears secondary from a causal point of view.
In order to achieve a coherent theoretical framework, the following section will explore the connection between neuro-anatomical disturbances, the disturbances in muscle tension, balance reactions, joint mobility and the proprioceptive feedback on posture and movement.

4.3.1 Syndrome-specific neuroanatomical abnormalities

A number of authors, in discussing the motor problems of children with DS, refer to Crome (1965), who reported a reduced total weight of the brain (an average of 76% of the normal weight), and in particular a smaller brain stem and cerebellum (66%). The cerebellum plays a central role in the coordination of posture and movement and receives information from the vestibulum and the motor apparatus. When disturbances occur in the cerebellum, disturbances in, for example, balance, coordination of movement and hypotonia, can be observed. The facilitation of the gamma-motor neurons is regulated at the level of

the brain stem. The activation of alpha motor neurons via the gamma loop is essential for the maintenance of posture, as the extensors involved must have enough tonus at their disposal through this system (Bernards & Bouman, 1976).
The connection between these neuro-anatomical disturbances and the disturbances in the movement of DS persons, while seemingly obvious, has not yet been demonstrated (Cowie, 1970; Henderson, 1985). However, since it is a case of neuro-anatomical disturbances (Crome, 1965), and because the most evident motor characteristic is a neuromotor one, i.e. the reduced postural tonus (Cowie, 1970), it seems appropriate to view the development of specific motor behaviour as resulting from a neuromotor development disturbance.

4.3.2 Hypotonia and co-contractions

One of the most characteristic neuromotor disturbances of children with DS is their reduced muscle tension. In a study on the neurological development of 97 children with DS, Cowie (1970) reports that none of the children had normal muscle tension. In addition, an increase of muscle tension takes place in the first ten months of life. This development seems to continue (Owens, Dawson & Losin, 1971; Morris et al., 1982; Smith, 1988), but data on adults are too poorly documented to provide any conclusions. In her review of the literature Henderson (1985) concludes that all children with DS are hypotonic, which may possibly influence their motor development.
Cowie (1970) reports a clear connection between hypotonia and the lack of postural control. In her study the hypotonia is evident in an insufficiency of co-contractions. Davis and Kelso (1982) provide information about the quality of myogenous stabilization of joints on the basis of a comparison between seven children and young adults with DS (14-21 years of age) and six non-handicapped children. The results of both groups corresponded significantly. The organization of motor control under static conditions is basically the same. In both groups the nervous system was capable of fine-tuning the system of muscles/joints by regulating the length and power of the muscles involved, whereby a co-contraction was built up. In a qualitative sense, however, there are differences to be reported. The group with DS was less able to stabilize a position of the joints and had significantly more difficulty in maintaining the position of the joints with reducing resistance. There was movement around the position of the joints, and co-contractions were unstable.

It is possible that persons with DS are less able to activate their muscles (Davis & Sinning, 1987). Davis et al. (1982) dispute that hypotonia is the most significant symptom of the motor problems. In their opinion, tonus is not related to active movement, being tested passively, and does not contribute to our understanding of movement deficiencies. They propose that the degree to which co-contractions provide stability gives more insight into the problems of movement rather than into the problems of reduced muscle tonus.
Several studies highlighted inadequate co-contractions at various stages of postural and movement development, but particularly in relation to hypotonia. Insufficiency of stabilizing myogenous contractions around joints is one of the manifestations of hypotonia. Yet in this respect it is correct to replace the concept tonus by postural tonus, thus relating tonus to posture and movement. Bobath (1982) reports the importance of a normal postural tonus in combination with sufficient co-contractions for the development of a broad variation of postural and movement patterns. A lack of postural tonus is accompanied by a lack of co-contractions and leads to stabilization problems during the development of posture and movement. Children with DS compensate for problems of stabilization by using static and symmetrical movement strategies, as a result of which qualitative elements of movement are not adequately developed.

4.3.3 Postural reactions and hypotonia

Shumway-Cook and Woollacott (1985) investigated the quality of the postural control system in children with DS by means of an electromyographic recording of balance disturbances while standing. They concluded that the postural reactions measured in children with DS were more or less identical to the postural reactions of normal children, but that these reactions occurred significantly later (extended latent period). There is an abnormality in the postural control system whereby problems of balance originate.
Rast and Harris (1985) emphasized the importance of early postural reactions for the development of balance reactions and the attainment of motor milestones. Haley (1986) stated that postural reactions (self-righting, balance and anticipatory reactions) ensured automatic stability of head, trunk and extremities, whereby normal movement and transfer of weight then became possible. On the basis of his comparison of 20 children with DS (aged 2 to 24 months) with 40 non-handicapped children (aged 2 to 10 months), he concluded that

postural reactions in the group of children with DS developed later. In addition, he concluded that there was a close connection between the emergence of postural reactions and the attainment of motor milestones, but that there was no relation to age. Children with DS demonstrate less variation in postural reactions; they develop only those reactions necessary to achieve a particular motor phase. Furthermore, Haley (1987) reported that the order in which postural reactions developed deviated significantly from that in normal children. Anticipatory reactions developed relatively earlier as a substitute for the lack of balance reactions. Haley (1987) related the low trunk tonus of children with DS to the relatively late development of balance reactions and the relatively early development of anticipatory reactions.

4.3.4 Hypotonia, joint mobility and proprioception

In their extensive research on 229 children with DS, Dyer et al. (1990) claimed that hypotonia had a disruptive effect on proprioceptive feedback from sensory structures in the muscles and joints. Proprioception is information emanating from the musculoskeletal system (muscles, tendons, capsules, ligaments, joints), with which a conscious image can be formed of posture and movement and thereby controlled (Bernards & Bouman, 1976). Hypotonia in children with DS, therefore, can influence the intrinsic information regarding posture and movement and can have a negative effect on the appropriateness of co-contractions and postural reactions.

On the basis of a study comparing 30 children with DS with non-handicapped children, Parker and James (1985) showed that the group of children with DS had, on average, more joint mobility, both the study group and the control group showing a decrease in mobility with increasing age. They concluded that in both groups there was no essential difference in the biological process which regulates the maturation of the tissue in the joints. There is, however, a difference in pattern. Non-handicapped children showed a consistent decrease in mobility with increasing age, while the mobility of children with DS decreased more particularly between the ages of five and ten years, which Parker and James (1985) related to the reduction of tonus. Livingstone and Hirst (1986) reported that children with DS frequently had one or more hypermobile joint, but that there was no question of a generalized laxity of joints. Like Parker and James (1985), they considered a relationship with muscular hypotonia to be more likely.

Increased joint mobility may contribute to postural control in a negative sense. Together with the insufficiency of co-contractions this would influence the stability of joints. It is possible that proprioceptive information from joint sensors would also be influenced and would affect the registration of posture and movement.

4.3.5 Synthesis

Literature reveals extensive research into the motor problems of children with DS. Engelbert & Lauteslager (2000) concluded that DS children have a disorder-specific motor development profile. Their motor ability is relatively slow to develop and they are late in achieving motor milestones (Cunningham, 1982). In fact, the motor disturbance seems relatively greater than the mental one (Carr, 1970). In comparison with non-disabled children, there is also a different sequence in which motor skills are mastered (Dyer et al., 1990). When compared with people otherwise mentally disabled, there are specific motor problems (Connolly & Michael, 1986). Finally, specific postural and movement patterns are described which are not observed in non-disabled children (Lauteslager, 1995).

The literature shows that there are two main problems which occur in the development of the motor behaviour of children with DS. On the one hand there are the problems which occur in adopting and maintaining postures against the force of gravity and on the other hand there is a lack of development of qualitative elements of movement, for example, aspects of trunk control, such as balance, rotation, lateral flexion and extension. The motor problems can be defined by the concept of 'disturbances in the system of postural control'. Regulation of postural control is defined as the coordination of the body's own processes, which enable the adopting and maintenance of posture during motor behaviour. Of major importance here, is the reduced postural tonus of each child, which has a negative effect on the adequacy of co-contractions and balance reactions, being related to a defective proprioceptive feedback on posture and movement and to an increased joint mobility (table 4.2).

Primary	- reduced postural tonus
Secondary	- insufficiency of co-contractions - insufficiency of balance reactions - reduced propriocepsis - increased mobility of joints
Consequences	- problems in achieving and maintaining positions in posture and movement - inadequate development of qualitative aspects of motor ability - inadequate appropriate motor ability

Tabel 4.2 Disturbances in the system of postural control

This is naturally in combination with the neuroanatomical and neurophysiological systems which, in a conditional sense, are at the base of all such reactions. The motor problems should be placed in a developmental perspective. The manifest problems in one motor phase do not stand alone, but are developed in previous phases and have consequences in future phases of motor development. In this respect, problems which occur in stabilizing posture and movement, lead to a static and symmetrical motor ability, to compensatory movements and thereby to a defective development of qualitative motor elements such as trunk rotation and balance. The lack of extension development in the prone position will, for example, influence the ability to stretch the trunk and hips in the sitting and standing positions.
As the postural control of a DS child increases with time, the ability to control the posture also increases. However, the ability to control posture is initially insufficient for the child to be able to assume an adequate posture and to stabilise it. The child is ready for the development of certain motor skills however and, for the time being, integrates adequate compensation mechanisms in motor skills. So this motor development has a strongly idiosyncratic nature. One characteristic for instance is the postural support that the DS child uses in the course of motor behaviour. For example, the posture of the trunk in sitting is supported by the hands and in crawling the child slides the legs instead of raising them.
Asymmetrical motor activities require a more adequate system of postural control than are required by a symmetrical motor behaviour.

DS children compensate their disturbances in postural control by symmetrical motor activities. Balance reactions, by definition, require asymmetrical movements (lateral trunk flexion and rotation of the trunk). The DS child's balance responses are insufficient and inadequately developed. The child compensates for this by enlarging the supporting surface of the posture and by moving within this extended supporting area. For example, he sits with legs wide apart and does not move the trunk outside the extended supporting surface. This has a negative effect on the dynamics of motor behaviour. Motility and variation of movement require adequate postural control. The level of postural control of a DS child is inadequate; his motor behaviour develops in a static and uniform manner.

4.3.6 Physiotherapy treatment framework

As the foundations for further motor development are laid in the period of developing basic motor skills (Gallahue & Ozmun, 1998), it is preferable to have motor intervention take place within this period. An elementary aspect in the occurrence of limitations in the motor behaviour of DS children is the inability to stabilise postures. In the context of physiotherapy treatment, this means that in the development of each basic motor skill the primary posture should be stimulated, such as a raised head in the prone position, a crawling posture or a standing posture. It is important to encourage adequate stability of a posture by encouraging sufficient stabilising, myogenic contractions of groups of muscles around joints (co-contractions). As is usually the case in motor development, utilisation is made in the first instance of symmetrical basic postures, support being given where necessary. In view of an increasing scale of difficulty, motor activity may initially be of a static nature.
The next stage is that the child is encouraged to start moving from the previously mentioned symmetrical postures, if possible without support. Thus, to an increasing extent, a demand is made on the practicality of the system of postural control. It is made easier for the child to transfer body weight sideways, for example in a sitting or standing position, whereby demand is made on trunk motor activity (trunk rotation and lateral trunk flexion), on postural response (balance), on movement dissociation and on the variation of movement. Lastly, movement dissociation is made easier in asymmetrical basic positions, efforts are made to improve the level of postural responses and more extensive movement variation is stimulated. It is

obvious that each child develops differently. The physiotherapy treatment takes place on the basis of individual goals.
Since it here concerns exercise therapy for young children with a mental disability, it is preferable that meaningful situations be provided that fit in with the child's environment. Motor activity should be functional and should, in a broader sense, support the child's development. From a practical point of view, compensatory motor behaviour is evaluated positively and is used as an intermediate step towards the development of more dissociated and varied motor behaviour. Desirable motor behaviour is encouraged in a functional context. Parental involvement and participation are seen as appropriate means to encourage the child actually to apply the newly acquired motor skills in various situations. As parents are asked to encourage integrated skills in their daily contact with their children in play and care situations, implementation in motor behaviour is thus realised.

4.3.7 Measuring instrument for motor skills

The acquired level of postural control is displayed in the appropriateness of the child's motor behaviour. With a view to constructing a measuring instrument for motor skills, the idea occurred, following the example of Harris (1980), of describing the development of a number of basic motor skills in several consecutive stage levels. The developmental stages described have an ordinal coherence. By means of the developmental stages per motor skill described, the development of the ability to regulate posture should be put into practice. Descriptions can then be used to define specific stages of this developmental path. The motor development of a child can subsequently be evaluated by making a comparison between the manifest motor behaviour of that child and the defined sub-sections. The specifications of these sub-sections for each basic motor skill can be constructed on uniform lines, because an increasing level of postural control is displayed in a comparable manner in such development. The first stage level stands for the first observable manifestation of motor behaviour relating to the development of the motor skill. The last stage level described stands for motor behaviour with a practical level of postural control. The basic motor skill can then be adequately applied in the course of posture and movement. The intermediate stage levels represent the developmental course as such is manifested under the influence of an increased ability to control posture.
For each basic motor skill the first motor behaviour to be described

must be that from which the ability to maintain a posture symmetrically can be registered. Subsequently, motor behaviour is defined in which an increasing postural control is obvious from the ability to move out of that symmetrical posture. In the third place, for each skill there is a definition of which motor behaviour is representative of the ability to use postural responses, for example balance responses. Furthermore, motor behaviour can be defined from which it is apparent that the increasing development of postural responses has evolved into an increasing ability to move in a posture. The variation of movement intensifies and thereby the efficiency of the motor behaviour. In addition, it is important that the postural and movement patterns typical of DS be included in the definitions.
By comparing the motor behaviour of a child with the stage specifications, a stage classification can be made. A standardised method of eliciting specific behaviour from a child and registering and evaluating the behaviour observed, should be a component of the measuring instrument. The same rule applies here: that the motor behaviour to be evaluated should be meaningful for the child and should be stimulated in a practical context. Both the validity of the measuring instrument and the effectiveness of the physiotherapy framework should be further investigated.

4.4 Conclusions and recommendations

In comparison with other children with a learning disability, there are certain specific motor problems with children with DS. In terms of the causes, the reduced postural tonus, manifest in each child, plays a key role. The reduced postural tonus is related to an insufficiency of co-contractions, to inadequate balance reactions, to a defective proprioceptive feedback on posture and movement and to hypermobility of the joints.
In summary, the motor development of children with DS is influenced in an adverse way by disturbances in the system of postural control. As a result, problems of adopting and maintaining posture and movement arise, whereby an inadequate development of qualitative aspects of movement occurs. Examples of this are the static and symmetrical posture and movement patterns, the compensatory movement strategies and the lack of variability, all of which are interwoven during development. Motor problems during a developmental phase do not occur in an isolated form, but are the result of

previous phases and have consequences for the following ones.
The postural tonus of children with DS increases in the course of time, but the development of basic motor abilities takes place under the influence of a reduced postural tonus. Taking these motor problems into account, influencing developing motor patterns is both desirable and meaningful. In this chapter the problems are placed within a developmental perspective. Intervention on the basis of this theoretical framework seems to be a valid option. Increase in postural tonus may mean that, through intervention, adjusted posture and movement patterns finally achieve a better basis for maintaining movement.
In general, a treatment will be focused on improving the stability around the joints in each phase of motor development, as a result of which the child is enabled to assume a posture. Initially, he will do this symmetrically and if necessary with support, but with increasing postural control he is working towards asymmetrical postures and support is gradually decreased. To an increasing extent, a demand is made in this way on the effectiveness of the system of postural control. Ultimately, movement dissociation is made possible in asymmetrical initial positions, efforts being made to improve the level of postural control and variation of movement thus being stimulated.
The increasing postural tonus of the DS child means that postural and movement patterns corrected by intervention get a better foundation, in the long run, of being maintained for movement.
A suitable motor measuring instrument should be able to register the increasing ability of the child to adopt and maintain postures, statically but also during dynamic motor behaviour.
Research into the effects of such a form of intervention would make a further contribution to our knowledge and understanding of the motor development of children with DS.

4.5 Summary

In this chapter a theoretical framework has been developed with regard to the specific motor problems of DS children based on a review of disturbances which occur in the various phases of their motor development. Regulation of postural control is defined as the coordination of the body's own processes, which enable adopting and maintaining posture during motor behaviour.
The motor development of DS children is adversely influenced by disturbances in the system of postural control. The reduced postural

tonus, manifest in each child, plays a key role. The reduced postural tonus adversely influences the sufficiency of co-contractions and balance reactions. The lack of postural control is further exacerbated by inadequate proprioceptive feedback on posture and movement, and by an increased mobility of the joints. These lead to problems in adopting and maintaining positions in posture and movement. Consequently, qualitative aspects of motor skills are insufficiently developed, thereby reducing the goal-directedness of posture and movement. Characteristic features of children with DS are static and symmetrical movement patterns, compensatory strategies of movements and a lack of variability. Developmental phases are strongly interrelated. Motor problems during a developmental phase do not occur in an isolated form, but are the result of previous phases and have consequences for the following ones.

On the basis of the theoretical framework some starting points have been formulated according to a motor-measuring instrument and a physiotherapeutic treatment programme.

4.6 Literature

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5. Test of 'Basic motor skills of children with Down's syndrome': reliability and construct validity

The motor development of children with Down's syndrome (DS) presents specific problems (Lauteslager, 1991; 1995; Connolly & Michael, 1986). Development is not only delayed (Cunningham, 1982), but it also has an abnormal sequence in the acquisition of motor skills (Dyer, Gunn, Rauh & Berry, 1990).
All DS children have a reduced postural tonus (Cowie, 1970). Incidental to this is the occurrence of insufficient co-contractions (Davis & Scott Kelso, 1982), inadequate postural reactions (Shumway-Cook & Woollacott, 1985), hypermobility (Parker & James, 1985) and a disturbed propriocepsis (Dyer et al., 1990). The problems are referred to as 'Disturbances in the system of postural control' and have a developmental coherence (table 5.1) (Lauteslager, Vermeer & Helders, 1994; 1998). Disturbances in this system are a major reason for the occurrence of the specific pattern of motor development in DS children.
These problems require motor intervention. Its positive effect has not yet been demonstrated satisfactorily. One important reason for this has been the lack of an adequate measuring instrument. In order to objectify the result of motor intervention, the development of a disorder-specific measuring instrument is essential (Lauteslager, Vermeer & Helders, 1995; 1996a).

Chapter 5 is based on

Lauteslager, P.E.M., Pennings, A.H. (†), Vermeer, A. & Helders, P.J.M. (1996). Motorische basis-vaardigheden bij kinderen met het syndroom van Down: de ontwikkeling van een meetinstrument (Basic motor skills of children with Down's syndrome: the construction of a motor measuring instrument). *Bewegen & Hulpverlening*, 13, 40-52, 65, 67.

Lauteslager, P.E.M., Pennings, A.H. (†), Vermeer, A., Helders, P.J.M. & Hart, H. 't. (1998). Test van Basis-motorische Vaardigheden van Kinderen met het syndroom van Down: onderzoek naar betrouwbaarheid en construct-validiteit (Test of 'Basic Motor Skills of children with Down's syndrome': reliability and construct validity). *Nederlands Tijdschrift voor Fysiotherapie,* 108, 155-163.

Primary	- reduced postural tonus
Secondary	- insufficiency of co-contractions - insufficiency of balance reactions - reduced propriocepsis - increased mobility of joints
Consequences	- problems in achieving and maintaining positions in posture and movement - inadequate development of qualitative aspects of motor ability, - inadequate appropriate motor ability

Table 5.1 Disturbances in the system of postural control

Intervention should take place during the period of the development of basic motor skills (Lauteslager, Pennings, Vermeer & Helders, 1996b). It is during this period that the foundations are laid for further motor development (Gallahue & Ozmun, 1998). Since disorders in the system of postural control constitute the core problem, a disorder-specific measuring instrument should register the level of postural control during the development of basic motor skills. The test 'Basic Motor Skills of children with Down's syndrome' (BMS) has been constructed to this end. Chapter 5 will report on the psychometric evaluation of the BMS.

5.1 Purpose of the research, measuring instrument and hypothesis

5.1.1 Purpose of the research

The purpose of this research is twofold. In the first place, the intention is to construct a unidimensional variable, operationalized in the BMS, which can express a DS child's level of postural control during the development of basic motor skills. In the second place, we shall examine the reliability and construct validity of the BMS viz. the extent to which the BMS fulfils expectations drawn up on the basis of the underlying theoretical framework.

5.1.2 Measuring instrument

The BMS has been developed on the basis of the theoretical framework 'Disturbances in the system of postural control' (Lauteslager et al., 1994; 1998). The instrument measures the level of postural control of 18 basic motor skills by means of 18 test items (table 5.2).

1. Raising head when prone	10. Sitting
2. Reaching in supine position	11. Moving along the ground
3. Elbow support in prone position	12. Standing with support
4. Raising head in supine position	13. Sitting up
5. Raising legs in supine position	14. Standing up with support
6. Rolling over from prone to supine	15. Walking with support
7. Supporting hands when prone	16. Standing without support
8. Extension when prone	17. Walking without support
9. Rolling over from supine to prone	18. Standing up without support

Table 5.2 Eighteen BMS test items

The 18 test items, placed in developmental sequence, form a scale from 1 to 18 and represent an increasing level of postural control. Each basic motor skill in turn also indicates a specific development in postural control. In the BMS there is a description for each skill of this development in defined subsections. These subsections constitute a developmental sequence per test item, representing an increasing level of postural control and jointly forming a scale (e.g., test item 10, table 5.3).

Execution The child is placed in the sitting-without-support position on a horizontal surface and is encouraged to stretch from the trunk by eliciting reaching upwards with the arms and to transfer weight laterally by eliciting sideways reaching out with the arms.
Scale 0. The test item has been correctly administered, however the child shows no motor behaviour that is described in any of the stage specifications below. 1. The child sits independently during stimulation for at least 5 seconds while supporting the position with two hands. 2. The child sits independently during stimulation for at least 5 seconds while supporting the position with one hand. 3. The child sits independently during stimulation for at least 2 seconds without support from the arms and with a bent back. 4. The child sits independently during stimulation for at least 2 seconds without support from the arms with a straight back without lumbar lordosis. 5. The child sits independently during stimulation without support from the arms. When stretching the back, a clear lumbar lordosis can be observed for at least 2 seconds. 6. The child sits independently during stimulation without support from the arms. When stretching the back and transferring weight to the lateral a clear lumbar lordosis and a clearly lateral flexed trunk can be observed for at least 2 seconds.

Table 5.3 Classification of test item 10, 'Regulation of postural control when sitting'

When defining the subsections of the 18 motor skills, the distinctive feature of the problems of DS children in postural control becomes apparent (Lauteslager, et al., 1996b). A standardized manner of testing was achieved by an explicit specification of the purpose of the test item, together with establishing the conditions for administering the test and the method of stimulation. The administration of each test was recorded on video. The positions of the camera in relation to the child were fixed (table 5.4). Hypotheses were formulated about the ordinal placing of the test items and subsections, and concerning the relation between BMS total score and age.

Objective
- Registration of the stage at which the child is capable of sitting unsupported.

Execution
- Initial posture: independent sitting position.
- Stimulate the child to maintain the sitting position for 5 seconds with as little arm support as possible.
- Stimulate the child to extend the trunk for 5 seconds by reaching out forwards and upwards.
- Stimulate the child to show lumbar lordosis of the trunk for 2 seconds by reaching out forwards and upwards.
- Stimulate the child to lordosis and lateral flexion of the trunk for 2 seconds by reaching out upwards and sideways.

Stimulation
- Offer the motivating toy in front of, and somewhat above the child.
- Move the toy forward and above, just out of the child's reach.
- Move the toy sideways and above, just out of the child's reach.
- If necessary, position the trunk passively.
- If necessary, position the arms passively.

Camera position
- Obliquely behind the child at an angle of about 45° with respect to the sagittal plane.

Table 5.4 Procedure for test item 10. 'Regulation of postural control when sitting'

5.1.3 Hypothesis 1: Developmental sequence of test items

The developmental sequence of the 18 test items for DS children cannot be deduced from the literature. For that reason the ordinal scaling of the test items was derived from the developmental sequence of motor milestones in non-disabled children (Gallahue & Ozmun, 1998; Flehmig, 1982). However, there is a significant difference between test items and the milestones with which they are compared. Each test item relates to the development of a motor skill and covers a developmental period. A motor milestone, on the other hand, marks a moment in a developmental period. In the present

study, the ordinal classification of the 18 test items is stipulated as applicable to DS children. Since these children go through their own distinctive motor developmental course, it is supposed that the sequence will deviate from that of healthy children, but that elementary relationships found for normal motor development will remain evident in the final classification of the test items.
In order to test this supposition, the 18 test items have been divided into 4 groups of mutually related basic motor skills. This relationship is derived from normal motor development. Group A (items 1,2,3,4,5,7 and 8) consists of skills which develop in the prone and supine positions. Group B (items 6,9,10,11 and 13) consists of skills for which axial motor abilities and trunk disassociation are increasingly necessary. Group C consists of skills related to standing and walking performed with support (items 12,14 and 15), with Group D consisting of skills relating to standing and walking without support (items 16,17 and 18). The assumption is that Groups A to D are in developmental sequence and represent an increasing degree of postural control. Groups can be compared by describing the level of postural control needed per test item according to a certain measure and then by calculating the mean measure per group of test items. The average level of postural control of Group A will be lower than Group B, that of Group B lower than Group C, that of Group C lower than Group D. As a result, hypothesis 1 is as follows: 'the four defined groups of basic motor skills from A to D represent an increasing level of postural control'.

5.1.4 Hypothesis 2: Developmental sequence of subsections per test item

Each basic motor skill has its own development. A primary element of this development is the ability to control posture. The more this ability increases, the more a child is able to achieve adequate motor behaviour, in other words the basic motor skill becomes increasingly functional.
Due to the disturbances in the system of postural control, each of the 18 motor skills of the BMS for DS children has a specific development. This development is defined per skill in subsections classified ordinally. These subsections together form a scale per skill and represent an increasing level of postural control. For each scale, the motor behaviour described shows an increasing degree of difficulty, requiring postural control to an increasing extent. Subsection 1 is more complex

that subsection 0, subsection 2 more than 1, subsection 3 more than 2 etc. One important research question relating to the construct validity of the BMS is whether the subsections are in the hypothesized sequence per test item. This has led to the formulation of hypothesis 2: 'the motor behaviours defined in the subsections represent an increasing level of postural control per test item'.

5.1.5 Hypothesis 3: Relation between BMS score and age

If the BMS turns out to be reliable and internally consistent, and hypotheses 1 and 2 are confirmed, then the relation between the total score and the age of a child is obvious. In view of the construction of the test and the presumed relation with motor development, it is to be expected that a child's score on the BMS will increase with age. Hypothesis 3 has been formulated on the basis of this expectation: 'a child's total score on the BMS is related positively to the age of that child'. It is not to be expected that any difference between the two sexes will be found regarding the BMS score (Carr, 1970).

5.2 Method

5.2.1 Participants

The participants were gathered via the Down’s Syndrome Foundation in the Netherlands. The Foundation has on file the addresses of 66 families with a DS child aged from 0 to 4 years of age in the regions in the middle of the Netherlands. Of the 66 families addressed, 52 positive reactions were received. Every attempt was made when selecting the children to create a sample evenly divided according to age. The BMS was finally administered in this study to 42 participants with DS living at home (16 girls, 26 boys) aged from 0 to 4 years of age with an average age of 2.57 years and a standard deviation of 15.96 (table 5.5).

group	n	Sex		Age		
		m	f	range	mean	SD
0	7	4	3	0 - 11	6.86	2.10
1	8	5	3	12 - 23	18.38	2.87
2	10	7	3	24 - 35	30.40	3.44
3	9	4	4	36 - 47	40.89	2.60
4	8	5	3	48 - 59	53.50	4.00
total	42	26	16	0 - 59	31.00	15.96

Table 5.5 Participants. Five age groups of 12 months; number (n) per age group and per sex (m/f); age in months

5.2.2 Statistical analysis

In order to test hypotheses 1, 2 and 3, it is important to construct a variable with which the level of postural control of the test items, the subsections per test item and of the subjects can be expressed as a measure. For this purpose, the data obtained were analysed with the Partial Credit Model (PCM) (Wright & Masters, 1982; Wright & Linacre, 1992). The PCM is a statistical analysis model which is a part of the group of 'latent trait models' and is derived from the item-response model of Rasch (1960). Using the PCM, a variable can be constructed with which the level of postural control can be expressed. In statistical terms, the variable is generic; it can be used to classify comparable persons within the sample.

One important quality of the Rasch models is that they facilitate the development of measuring scales with a unidimensional hierarchical structure. A hierarchical scale consists of a group of consecutive items which display an increasing complexity. Mastery of items on a lower scale is the condition for success on items at a higher level. When empirically obtained data can be analysed with a Rasch model, the scale is unidimensional. In this research it should be found that the 18 test items of the BMS display a progression from easy to difficult (hypothesis 1).

In addition, the PCM is suitable for analysing performances of subjects on items with consecutive and interrelated levels of competence

(Masters, 1982). The consecutive subsections of the BMS per test item each give an indication for partial and increasing success in that test item. Measures are analysed as interval-scaled scores in order to compare subjects and test items, and to calculate standard estimation errors. The hypothesized sequence of subsections per test item (hypothesis 2) can be tested using the PCM.

It is assumed that a subject more competent in postural control would score higher on the BMS than a less competent subject and that this competence would increase with age. The performances of a subject on the BMS lead to the total score. The relation between BMS score and age can be tested (hypothesis 3).

The PCM can be used to determine for each child which score level can be expected on a test item. For the construction of the BMS, it is important to consider to what extent a test item provides subjects' scores which deviate from this expected score. Deviant scores can be made visible with the PCM by means of a ’goodness of fit’ analysis. The degree of deviance in subjects' scores from anticipated scores is expressed in a standardised residual. These residuals are converted for each test item into a fit score. The PCM makes a distinction between deviant scores within the measuring range of a test item (’infit') and deviant scores on the border of this range (‘outfit'). Test items with too great a 'misfit' (norm: <-2 and > +2) can be further analysed. The ‘goodness of fit’ analysis provides insight into the undimensionality of the BMS.

The infit and outfit of subjects can be calculated in an identical fashion with the PCM. Subjects with scores deviating from the anticipated scores are indicated for further analysis, together with the test items on which these scores are based. Analysis provides insight into the homogeneity of subjects' scores on the BMS.

The computer programme 'Big Steps' (Wright & Linacre, 1992) was adjusted to test hypotheses 1 and 2 on scale construction and ordinality. A check was carried out with the programme One-parameter Logistic Model (OPLM) (Verhelst, Glas & Verstralen, 1995). The programme package Statistical Product and Service Solutions (SPSS/PC+) was used to examine hypothesis 3 regarding the relation between age and BMS score.

5.2.3 Procedure

The test was carried out in 6 different locations under standardised conditions by one test leader (physiotherapist). Testing a child took between 15 and 30 minutes. All the children were tested in a cooperative condition. Each test was recorded on video according to a standardised procedure. Each videotape was scored by two different observers (physiotherapists) independently (inter-rater reliability). After 3 months, 10 tests, chosen at random, were again rated (intra-rater reliability).

As far as data analysis is concerned, three problems occur in the raw scores. First of all, the scores of the two observers show a number of differences. Data processing, however, demands unequivocal scores. Since the ordinality of test items and subsections was determined from the ultimately unequivocal scores, a choice was made by a third observer from the attributed scores based on the video recordings.
In the second place, the number of subjects turned out to be too small to obtain a complete set of scores for each subsection described. The number of subsections per test item varied from 4 to 9. The decision was made to allocate the subsections into 4 score categories per test item (0,1,2 and 3) resulting in 18 x 4 = 72 possible score categories. Test item 10 (Postural control in sitting), for example, has 6 subsections (table 5.3). The subsections 1, 2 and 3 are combined in score category 1, the subsections 4 and 5 in score category 2, subsection 6 represents score category 3.
In the third place, a number of scores were not filled in, as not every BMS administration resulted in 18 scores. Non-completed scores occured in three different situations. First, on the higher test items with children who do not have the motor competence to show the required behaviour (0-scores). Second, with children of toddler age who can sit independently. These children allowed their actual development range to be recorded adequately, but were insufficiently cooperative in carrying out test items in the supine and prone positions; they sat up (3-scores). An example of this is that rolling from the supine to prone position (test item 9) can be administered in such cases (the child goes on to sit up), but rolling from the prone to supine (test item 6) cannot. Third, the scores of children who can stand, walk and stand up without support were not filled in. The corresponding test items with support were not administered (3-scores).
In order to be able to process the data statistically, each subject should have a complete series of 18 scores. Non-completed scores, however, are inherent to the use of measuring instruments in evaluating a developmental domain with a particular range. In administering the BOS 2-30 (van der Meulen, Smrkovsky, 1983), it is usual to

determine the actual developmental domain of a child and then to evaluate positively the developmental domain the child has completed. This is based on the fact that more basic motor skills integrate into more complex motor skills. It should be pointed out that, in contrast with the BMS, we are here concerned with a normalised measuring instrument. The decision was made to determine the actual developmental domain of the subject. Non-completed scores below this domain were filled in with a 3-score, non-completed scores above this domain with a 0-score. Within the developmental domain, non-completed scores were filled in interpretatively, based on the motor performances of the child during administration of the BMS.
A total of 18 x 42 = 756 scores were allocated to the 42 subjects. Of these, 516 (68.3%) were determined by the observers on the basis of the video material. 204 scores (27%) related to non-completed 0-scores and 3-scores outside the actual developmental domain. 36 non-completed scores (4.7%) led to interpretative scores within the developmental domain of a child.

5.3 Results

5.3.1 Reliability

The inter-rater reliability (Cohen's kappa) of the 18 test items varies from .61 to 1.00. Apart from test item 3 (.61), all the test items were above .71. Cohen's kappa was .85 on average. The mean intra-rater reliability calculated per test item (Cohen's kappa) was .89. Cronbach's alpha was .94 on average (internal consistency).

5.3.2 'Fit' analysis

Subsequently, a 'goodness of fit' analysis was carried out on the 18 test items. Table 5.6 classifies the test items according to the estimated level of postural control and gives an infit and an outfit value per test item. These values appear to be extreme for test item 1. The infit of the remaining test items falls within the boundary of the stated misfit criterion -2 to +2. The test items 7, 8, 6, 5 and 9 display outfit values which are too high (5.1, 4.6, 2.8, 2.4 and 2.2). These findings are strongly supported by the results of the analysis with the OPLM programme. Table 5.7 portrays the score progression of the 42 subjects on these test items. For each test item, the categorical scores of 42 subjects are

Test item (TI)		Measure	Infit	Outfit
TI 18	Standing up without support	2.78	-1.6	-0.9
TI 8	Extension when prone	1.88	0.2	4.6
TI 17	Walking without support	1.75	-0.8	-1.0
TI 13	Sitting up	1.67	-0.9	-0.4
TI 16	Standing without support	1.62	-0.5	-0.9
TI 14	Standing up with support	0.64	-1.1	-1.4
TI 12	Standing with support	0.45	-0.8	-1.2
TI 15	Walking with support	0.45	-0.2	-1.1
TI 7	Supporting hands when prone	0.40	2.0	5.1
TI 11	Moving along the ground	-0.19	-0.6	-1.1
TI 10	Sitting	-0.43	-1.2	0.1
TI 9	Rolling over from supine to prone	-0.49	1.2	2.2
TI 6	Rolling over from prone to supine	-0.62	1.2	2.8
TI 3	Elbow support in prone position	-1.31	0.0	1.2
TI 4	Raising head in supine position	-2.69	0.7	-0.4
TI 2	Reaching in supine position	-2.86	-1.6	-0.7
TI 5	Raising legs in supine position	-3.04	-0.8	2.4
TI 1	Raising head when prone	-5.96	extreme	extreme

Table 5.6 Eighteen test items classified according to extent of postural control (measure). Infit and Outfit

```
Test item                                   Measure   Outfit   Infit
------------------------------------------------------------------------

TO7 Supporting hands when prone                .40     5.08     2.01
    Score   : pp  1-25:  0 0 0 2 2  1 2 2 2 2  3 2 2 2 1  3 1 2 2 2  2 2 3 2 1
    Residu  :                  3 4  1     1 2    1               -1   -1  -1

    Score   : pp 26-42:  2 1 2 2 2  2 2 2 2 3  1 3 1 2 3  3 3
    Residu              -1-2-1             -1 -3  -4-2

TO8 Extension when prone                      1.88     4.62      .24
    Score   : pp  1-25:  0 0 1 1 1  1 1 1 1 1  1 1 1 1 1  1 1 1 1 1  1 1 1 1 1
    Residu  :                5 3 5  2 1 1 1 2    1   1 1 -1 1         -1-1   1

    Score   : pp 26-42:  1 1 1 1 1  1 1 1 1 1  1 1 1 2 3  2 3
    Residu  :           -1               -1-1   -1-1   1  1

TO6 Rolling over from prone to supine         -.62     2.75     1.23
    Score   : pp  1-25:  1 0 0 1 0  3 3 3 3 0  2 2 3 2 2  3 3 1 3 2  3 3 3 3 3
    Residu  :            2          1 1   1-1 -1            -1  -2

    Score   : pp 26-42:  3 3 3 3 2  3 2 2 3 3  3 2 3 3 1  3 3
    Residu  :                   -1   -1         -3    -6

TO5 Raising legs in supine position          -3.04     2.44     -.85
    Score   : pp  1-25:  1 3 2 3 2  3 3 3 3 2  3 3 3 3 3  3 3 3 3 3  3 3 2 3 3
    Residu  :              1                 -1                           -9

    Score   : pp 26-42:  3 3 3 3 3  3 3 3 3 3  3 3 3 3 3  3 3
    Residu  :

TO9 Rolling over from supine to prone         -.49     2.15     1.15
    Score   : pp  1-25:  0 0 0 0 0  3 3 3 3 0  2 2 3 2 2  3 3 1 3 2  3 3 3 3 3
    Residu  :                       1 1   1-1 -1            -1  -2           1

    Score   : pp 26-42:  3 3 3 3 2  3 2 2 3 3  3 2 3 3 1  3 3
    Residu  :                   -1   -1         -3    -6
```

Table 5.7 test items with an outfit above 2.0. Horizontally, the categorical scores (score) of 42 participants (pp) per test item, divided over two lines (pp 1 - 25 an 26 - 42, classified according to age with the appropriate residual displayed below. The measure, the outfit and the infit are given for each test item

displayed, divided horizontally into 2 lines (line 1: subjects 1 to 25, line 2: subjects 26 to 42). The extent to which this score deviates from the expected score is indicated below the score (residual). Discussion has led to test items 1, 7 and 8 being removed from the BMS. Next, the infit and outfit of the 15 remaining test items were again determined. In addition to the too high outfit of test items 6, 5 and 9, test item 3 was also indicated (outfit: 3.3), as well as test item 18 (infit: -2.4). Discussion resulted in maintaining the 15 test items.
Table 5.8 indicates all possible BMS scores (0 to 45 points) with the appropriate measures.

Score	Value	SE	Score	Value	SE
0	-5.96E	1.80	23	.14	.36
1	-4.80	.98	24	.28	.37
2	-4.13	.70	25	.41	.37
3	-3.72	.59	26	.55	.37
4	-3.40	.53	27	.69	.37
5	-3.13	.50	28	.83	.38
6	-2.89	.49	29	.98	.38
7	-2.65	.48	30	1.12	.39
8	-2.41	.48	31	1.28	.39
9	-2.18	.48	32	1.43	.40
10	-1.95	.47	33	1.60	.40
11	-1.74	.46	34	1.76	.41
12	-1.53	.44	35	1.93	.42
13	-1.34	.43	36	2.11	.42
14	-1.16	.41	37	2.30	.44
15	-.99	.40	38	2.50	.45
16	-.84	.39	39	2.71	.47
17	-.68	.38	40	2.95	.50
18	-.54	.38	41	3.22	.54
19	-.40	.37	42	3.55	.60
20	-.26	.37	43	3.97	.71
21	-.12	.37	44	4.65	.98
22	.01	.36	45	5.82E	1.79

Table 5.8 Variable; BMS categorical total score (15 test items), value (extent of postural control) and standard error (SE)

In an identical manner, a 'goodness of fit' analysis was carried out on the subjects. Two of the 42 subjects had a deviant outfit (9.9; 2.5), one had a deviant infit (2.3) and another a deviant infit and outfit (2.3; 3.3). The scores of the remaining 38 children remained within the limit of the stated misfit criterion -2 to +2.

5.3.3 Hypothesis 1: sequence of test items.

The ordering of the remaining 15 test items in terms of the level of postural control (measure) can be seen in table 5.9. The lowest

measure was noted for test item 5 (-3.16), the highest for test item 18 (3.34). These findings are also supported by the results of the analysis using the OPLM programme.
In order to calculate the mean measure of the defined groups of test items, use was made of the measures from table 5.9, i.e., after the test items 1, 7 and 8 had been removed from the BMS. Discrimination of groups as laid down was also adjusted accordingly. The mean measure (level of postural control) per group is displayed in table 5.10.

Test item (TI)		**Measure**	**Infit**	**Outfit**
TI 18	Standing up without support	3.34	-2.4	-0.5
TI 17	Walking without support	2.20	-1.4	-1.0
TI 13	Sitting up	2.10	1.5	1.2
TI 16	Standing without support	2.05	-0.9	-0.8
TI 14	Standing up with support	0.86	-1.4	-1.4
TI 12	Standing with support	0.63	-0.8	-0.7
TI 15	Walking with support	0.63	-0.6	-1.2
TI 11	Moving along the ground	-0.10	-0.5	-0.8
TI 10	Sitting	-0.36	-1.0	2.0
TI 9	Rolling over from supine to prone	-0.43	1.7	2.6
TI 6	Rolling over from prone to supine	-0.58	1.8	3.3
TI 3	Elbow support in prone position	-1.36	0.5	3.3
TI 4	Raising head in supine position	-2.82	1.0	-0.2
TI 2	Reaching in supine position	-2.98	-1.9	-0.4
TI 5	Raising legs in supine position	-3.16	-0.9	3.9

Table 5.9 Fifteen test items classified according to extent of postural control (measure). Infit and outfit

Defined groups of test items (TI)	**Mean measure**
Group A (TI2, TI3, TI4, TI5)	-2.58
Group B (TI6, TI9, TI10, TI11, TI13)	0.13
Group C (TI12, TI14, TI15)	0.71
Group D (TI16, TI17, TI18)	2.53

Table 5.10 Mean measure (extent of postura control) per defined group of test items (TI)

5.3.4 Hypothesis 2: sequence of subsections per test item

The graph in table 5.11 displays the necessary level of postural control per score category (categorised subsections) estimated by the PCM. The figure displays the 15 remaining test items in a vertical row from top to bottom in order of decreasing difficulty. Horizontally, there is the logarithmic scale of the variable (level of postural control). The figure displays the level of postural control needed for motor behaviour which is specified in the score categories 0, 1, 2 and 3. The classification between test items can be seen from figure 5. The categorised subsections of all 15 test items have a sequence of 0, 1, 2, 3.

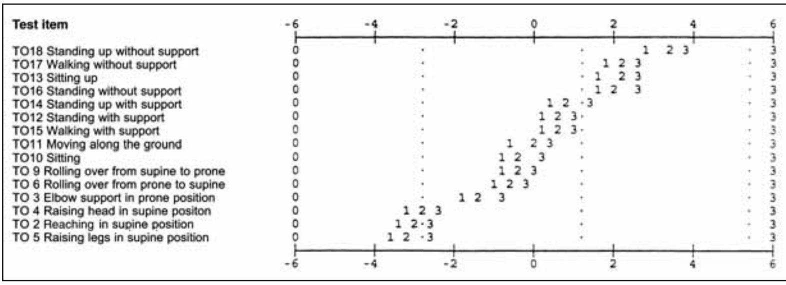

Table 5.11 Per test item (vertical) the classification according to extent of postural control of the categorical scores 0, 1, 2 and 3 along the variable (horizontal). Between ‘0’ and ‘1’ the categorical score is 0, between ‘1’ and ‘2’ the categorical score is 1, between ‘2’ en ‘3’ the categorical score is 2, between ‘3’ en ‘3’ the categorical score is 3

5.3.5 Hypothesis 3: correlation between BMS score and age

To begin with, the product-moment correlation coefficient was calculated for age and BMS total score (level of postural control). A significant correlation between age and BMS score could be established ($r = .81$, $p < .001$).

Next, the differentiating power of the BMS was examined (analysis of variance). For this purpose, the subjects were divided into 4 age groups (see table 5.5; group 0: 0 to 11 months, group 1: 12 to 23 months, group 2: 24 to 35 months, group 3: 36 to 47 months, group 4: 48 to 59 months). The BMS made a significant difference statistically ($p<.05$) between the group of children from 0 to 1 year old, the group from 1 to 2 years old and the group of children from 2 to 3 years old. The age groups 3 to 4 years and 4 to 5 years were also different, but not significantly so.

Finally, the correlation between the level of postural control and gender (t-test) was analysed. There appeared to be no significant difference between boys and girls with reference to postural control.

5.4 Discussion

A few comments have to be made concerning the research method adopted. In the first place, the observations were carried out by physiotherapists who had been closely involved in the development of the BMS. In addition, the sample is relatively small. That means that the results should be interpreted cautiously. The major point of discussion, however, is the fact that, for analyses with the PCM, it has been necessary to fill-in non-completed scores. By filling-in the scores, the fit of the test items was improved. That is why not only the fit, but also the ordinality of the items was monitored using the OPLM. A feature of this programme is that it can operate with non-completed scores. It is therefore not necessary to have the complete score series of the subjects. The fit analysis carried out with the PCM and the classification of test items found are strongly supported by the results of the analysis with the OPLM. Since OPLM analysis does not produce any usable data about the ordinality of the score categories per test item (hypothesis 2), the decision was made to continue the analysis with PCM. A protocol regarding the filling-in of non-completed scores should be added to the test instructions.

5.4.1 Reliability

The assessment of the inter-rater and intra-rater reliabilities indicates that the system of administering the BMS and evaluating motor behaviour on the basis of the sublevels has a good reliability. Kappas of .70 and higher function as an indication of good reliability. The kappa measure found is higher than the kappa of the preceding pilot study (.82) (Lauteslager, et al., 1996b).
Attention is focused more specifically on the kappas of test items 2 and 15 because these were too low in the preceding pilot study (.54 and .22 respectively) (Lauteslager, et al., 1996b). Due to this, the test instructions for the test items 2 and 15 have been adjusted accordingly, resulting in good values. The kappa value .61 for test item 3 is relatively lower. Since a kappa of .77 was recorded in the pilot study, as yet no consequences have been drawn.
It is of vital importance that the BMS test items measure the variable 'level of postural control' unidimensionally and contribute homogeneously to the final BMS score. Cronbach's alpha is appropriate for checking this. A measure of .94 can be said to indicate a good internal

consistency. In view of the high alpha measures, it can be concluded that the 18 test items have a good correlation and contribute homogeneously to the BMS total score.

5.4.2 'Fit' analysis

‘Goodness of fit’ analysis produces an extreme infit and outfit for test item 1. Each subject has a maximum score. It is possible that younger or less competent children would show a score differentiation. Test item 1 does not contribute to differentiation between subjects and has therefore been withdrawn from the BMS. The remaining test items show a good infit. All test items measure the 'level of postural control' unidimensionally within their range of measurement. This underlines the unidimensionality of the BMS.

Five test items have deviant scores which occur in the border area of the range of measurement (outfit). Outfit values are sensitive to fortuitous events which occur during testing or scoring and are less important than infit values. Table 5.7 illustrates that for the test items 6 and 9 (rolling over from prone to supine; rolling from supine to prone) the scores of subjects 36 and 40 are largely responsible for the outfit measure being too high. Both children scored lower than the PCM expected of them and so gave evidence of inadequate trunk rotation. This led to high residuals and, partly because of the relatively small sample, to an outfit outside the perimeter of the established misfit criterion of -2 to 2. The scores focus attention on the subjects concerned. Due to the fact that restricted trunk motor ability is a feature of DS children, and in view of the outfit values (2.75 and 2.15), the test items were retained.

The scores of the 42 subjects on test item 5 (raise legs when supine) gave almost perfect outfit values (table 5.7). Only the score of subject 23 deviates greatly from the estimated value (residual: -9). In view of the small sample, this brings the outfit to 2.44. Partly in view of the arguments expressed in the previous section, this gives inadequate indication for removal of the test item.

Test items 7 and 8 show a large group of subjects (16 and 23 children respectively) with deviating scores. On test item 7 (supporting on hands when prone) the scores were lower than anticipated in the PCM. Score category 3, in particular, (supporting on hands when prone and stretching out one arm) did not occur very often. During administration of the BMS, it turned out that this level of performance was very difficult for children. It required a relatively great amount of strength and stability of trunk and shoulder girdle, demanded perseverance and, consequently, co-operative behaviour. In addition to postural control, it seemed that other aspects were also playing a role. Test item 7 was removed from the BMS.

On test item 8 (extension when prone), 23 of the 42 children have a deviant score (table 5.7). There is a lack of higher scores here too. Stretching the trunk and hips when prone and reaching out with two arms is evidently difficult. Aspects such as strength and co-operation probably play a role. Furthermore, each test item has been constructed in such a way that the required motor behaviour has an intentional and random character. Children are coaxed to demonstrate intentional and functional motor skills. Stretching of arms, trunk and hips, however, is observed, particularly in young children, as an expression of a developing extension, but not as much as intentional motor behaviour.

This is illustrated by motor behaviour observed in the course of testing the Landau reaction (posture of head and trunk during prone suspension). It is known from research studies (Cowie, 1970) that DS children demonstrate deviant behaviour in the first year of life in terms of inadequate development of extension in the trunk, arms and legs. Young children are possibly not in an adequate state to take test item 8. For older children, on the other hand, it is a relatively difficult test item, but what is particularly missing is the interpretation of the behaviour demanded in relation to the situation presented. Test item 8 was removed from the BMS; 15 test items remained.

Fit analysis of the remaining 15 test items (table 5.9) now also focuses attention on test item 3 (elbow support when prone). Further analysis shows that the too high outfit can be attributed to subject 39. This child, highly competent in motor ability, refused the low competence test item 3, thereby having a strong influence on the outfit. It is striking that test item 18 now has an infit value of -2.4 (table 5.9). By removing the comparatively difficult test items 7 and 8, the relatively high categorical 3 scores of subjects 38 and 39 are emphasized to a greater extent.

The atypical fit values of 15 test items can be satisfactorily explained. The fact is that the misfit criterion -2 to +2 is sharp and that an atypical outfit is relatively less important. The results confirm the unidimensionality of the test items. The decision was made to retain the 15 test items in the BMS.

Fit analysis of subjects revealed only four children with atypical scores. Children scored evenly, such that their motor behaviour could be charted homogeneously with the BMS.

5.4.3 Hypothesis 1: sequence of test items

In the comparative classification of competence of the 15 test items (table 5.9), one group stands out from below to above with the test items 5, 2, 4 and 3. This group represents the development of motor skills in a horizontal original posture during early development. The second group of test items (6, 9, 10, 11) represents the beginning of the development of disassociated motor ability against gravity. The development of trunk dissociation and trunk stability plays a role in this respect. The third group (15, 12, 14) represents the development of standing and walking with support, while group four (16, 17 and 18) relates to standing and walking without support. With respect to each other, the groups are in a sequence corresponding to normal motor development. As postulated, the mean measure (level of postural control) of Group A is smaller than that of Group B, that of Group B smaller than that of Group C and that of Group C smaller than that of Group D (table 5.10).

The 15 test items are not in the exact sequence reported in the literature (motor milestones for healthy children). This may have something to do with the difference between a motor milestone (development moment) and a test item (development period). It is also possible that the specific character of the motor development of DS children is apparent. In the first group, test items in the prone position require a greater competence than those in the supine position (table 5.9). This is in accordance with the literature. DS children have problems with the development of stretching the trunk and thus with trunk motor skills (Haley, 1987; Lydic & Steele, 1979). This is also evident in the high position of test item 13 (sitting up) (table 5). The maximum score for this is particularly illustrative for the acquisition of competent trunk motor ability.

Standing with support and walking with support (test items 12 and 15) are estimated at the same level (table 5.9). The development of standing with support is, of course, expected earlier. Possibly this is connected with the maximum level described for 'standing with support'. To do this, the child brings his weight over on to one leg, while the trunk and the supporting leg move in a dissociated and controlled fashion. In fact, these are important conditions for being able to walk successfully with support.

In summary, hypothesis 1 is confirmed by the results. The classification of the test item groups from A to D, as established, underlines the construct validity of the BMS.

5.4.4 Hypothesis 2: sequence of subsections per test item

One important question is whether the categorized subsections per test item are actually in the postulated sequence of 0, 1, 2 and 3. Figure 5.11 displays the level of postural control which is necessary for motor behaviour, as defined in the subsections (categorized 0, 1, 2, 3), making the classification between them evident.

The subsections (categorized) of all 15 test items turn out to be in the postulated sequence and are all displayed. That would be different if, for example, the motor behaviour that contributed to the categorical score 3 of test item 5 (raising the legs when supine) demanded a lower level of competence than behaviour which is assessed with the categorical score 2. In that case, the sequence 1, 3, 2, would be displayed horizontally from left to right. Whenever a categorical score is not displayed in the graph, that means that the score concerned never applies as the most probable response.

Hypothesis 2 is confirmed by this result and thus the construct validity of the BMS is endorsed. The categorized subsections are in the expected sequence and each have a certain degree of probability.

5.4.5 Hypothesis 3: correlation between BMS score and age

The confirmation of hypotheses 1 and 2 is the key to testing hypothesis 3 (correlation age and BMS score). There appears to be a strong correlation between age and level of postural control. Hypothesis 3 is confirmed in that the BMS registers motor development.

The instrument turns out to be appropriate for differentiating between DS children from 0 to 3 years. Children of 3 and 4 years are also distinguished, but this distinction is not statistically significant. This is because of the restrictions of the range of measurement of the BMS. From the age of 3 onwards, more and more children master the 15 test items. To an increasing extent, children show a complete score series. The administration of the BMS is still worthwhile for 3 and 4 year-old children of low competence. In accordance with the earlier results of Carr (1970), the sample shows no significant difference in BMS scores between boys and girls.

5.5 Conclusion

In summary, the following can be concluded. The BMS has a high degree of reliability. The test items contribute homogeneously to the realization of the total score. ‘Goodness of fit’ analysis demonstrates that the postulated variable is measured unidimensionally and that DS children perform homogeneously on the BMS.
The three hypotheses are confirmed. In the ordering of test items at the level of postural control, the postulated sequence is apparent. The postulated sequence of scale steps per test item is confirmed. In addition, there is a significant correlation between age and BMS score. The construct validity of the measuring instrument is endorsed and the underlying theoretical framework is thus supported.
From data obtained clinically, a motor test has been constructed using the PCM with which both children and test items can be ranked. The BMS turns out to be able to differentiate, in a statistically significant manner, the motor performance of DS children from 0 to 3 years of age. Its administration to older DS children is appropriate as long as the children come within the range of measurement of the test from a motor point of view. The BMS is a measuring instrument with which the level of postural control of basic motor skills of DS children from 0 to 3 years of age can be registered. Further research into aspects of validity are recommended.

5.6 Summary

In the case of the obvious problems in the motor development of children with Down’s syndrome (DS), the positive effect of motor intervention has not been established. A major reason for this is the lack of a specific motor measuring instrument. To meet this need, the test ’Basic motor skills of children with Down’s syndrome’ (BMS) has been developed.
The BMS measures the achievements of DS children in 15 basic motor skills. The 15 skills are in a developmental sequence and form an ordinal scale. Each of the skills has a specific development. There is a description of this development per skill in defined subdivisions. The subdivisions are in a developmental sequence and also form an ordinal scale.

Psychometric research has been carried out with the BMS. This research was aimed at the construction of a uni-dimensional variable with which the level of posture regulation in the period of development of basic motor skills of a DS child could be measured. In addition, the instrument has been tested for aspects of reliability and construct validity.
The BMS was carried out on 42 DS subjects living at home, aged from 0 to 4 years, with an average age of 2 years and 7 months. The test was taken under standard conditions according to fixed procedures and recorded on video. Each video was assessed by two observers independently (inter-rater reliability). After 3 months, 10 tests were chosen randomly and assessed once more (intra-rater reliability). The data were analysed using Wright & Linacre's (1992) Partial Credit Model and SPSS.

The BMS has a high degree of inter- and intra-rater reliability (Cohen's kappa), respectively .85 and .89; Cronbach's alpha is .94. In the classification of test parts at the level of posture regulation the postulated sequence was outlined. The hypothesised sequence of scale steps per test section was also confirmed. In addition, there is a significant correlation between age and BMS score ($r=.81$; $p<.001$).
The research proves that the BMS is a measuring instrument with which the level of posture regulation of basic motor skills of DS children from 0 to 3 years can be recorded. The test can be used in research into the effect of physiotherapy on the development of basic motor skills of DS children.

5.7 Literature

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6. The effect of physiotherapy on the development of basic motor skills of children with Down's syndrome

The development of basic motor skills in children with Down's syndrome (DS) is restricted. (Lauteslager, 1991; 1995). Research carried out to into the effect of intervention on this motor development has not shown any uniform and definitive result. However, studies carried out have shown gaps in the field of theory formation and of the evaluation of the outcome (Lauteslager, Vermeer & Helders, 1995; 1996). The theoretical framework 'Disturbances in the system of postural control', formulated recently by Lauteslager, Vermeer and Helders (1994; 1998), provides more insight into the manifest motor problems of DS children during the development of basic motor skills. It is hypothesized that conditional elements in the field of postural regulation, such as joint stability and balance, are insufficiently goal-oriented, as a result of which the development of motor skills continues in a manner adapted accordingly. On the basis of this premise, a physiotherapy treatment concept, adapted for these problems, was developed specifically for this target group ('Physiotherapy for young children with Down's syndrome'; Lauteslager, 1996). Missing conditional elements in the field of postural control could thereby be stimulated by suitable exercise therapy.

It is apparent from the literature that there is no provision for the evaluation of the outcome for DS children (Lauteslager et al., 1995; 1996). Several researchers concluded that a specific motor measuring instrument should be developed for this purpose (Harris, 1981a; 1981b; Sharav & Shlomo, 1986).

Recently, therefore, the test 'Basic motor skills of children with Down's

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Chapter 6 is based on

Lauteslager P.E.M., Vermeer A., Helders P.J.M., Hart H, 't & Klugkist I.G. (2000) Het effect van fysiotherapie op de ontwikkeling van basis-motorische vaardigheden van kinderen met het syndroom van Down (The effect of physiotherapy on the development of basic motor skills of children with Down's syndrome). *Nederlands Tijdschrift voor Fysiotherapie,* 110, 12-21.

syndrome' (BMS) (Lauteslager, 1997), was developed and evaluated on psychometric qualities with positive results (Lauteslager, Pennings, Vermeer & Helders, 1996; Lauteslager, Pennings, Vermeer, Helders & 't Hart, 1998). The BMS measures the level of postural control of 15 basic motor skills and makes it possible to record the motor level of DS children aged from 0 to 3 years.
In the period from September 1996 to April 1998, intervention research using the above-named physiotherapy concept was carried out, with 22 young DS children as subjects. The effect measurement was done with the BMS. Since the literature suggests a link between children's motor and mental development (Griffith, 1976; Henderson, 1985; Touwen, 1989), the mental scale of the BOS 2-30 (der Meulen & Smrkovsky, 1983) was also administered for the interpretation of the results. The aim of this investigation was to research the link between the treatment provided and the development of basic motor skills of DS children. The research was assessed for ethical aspects by the Stichting Steunfonds Vereniging 's Heeren Loo ('s Heeren Loo Support Society Foundation). The results of the research will be presented in this article.

The study has a quasi-experimental research design (simple time series), each child being treated periodically (Baarda & en de Goede 1990). By alternating periods without intervention, it was possible to compare the motor development per child between the treatment and rest periods. It was decided to adopt a quasi-experimental research design because intervention research carried out to date has been characterised by problems arising from the composition of control groups in the context of pure experimental research (Lauteslager et al., 1995; 1996). On the one hand, it appeared that there was resistance, on ethical grounds, to withholding intervention from the control group. However, standardised norms for the motor development of DS children are not available (Gibson & Fields, 1984), neither is there a well-founded therapeutic alternative which is appropriate to their problems in motor development. On the other hand, there are indications that the complexity of the motor problems of DS children plays a role.
Factors such as the degree of hypotonia, individual differences in the distribution of tonus, the mental level, social background and general health problems (e.g. heart defects and respiratory disorders) guarantee a multiplicity of variables which can influence the nature and development of the motor restrictions experienced by the DS child.
Arising from this individual-specific motor predisposition and the variation in psycho-social and biological factors, motor behaviour and

its development is unique in each child (Block, 1991). Harris (1980) also advised against pure experimental research in which use is made of an experimental and a control group because of the impossibility of comparing the subjects. Harris recommended the use of a quasi-experimental research design. A simple time series offers the possibility of treating each subject and of letting him/her serve as his/her own control. In order to achieve this repeated measurements per subject, controlled manipulation of the experimental variable and the control of possible external factors are essential.

6.1 Method

6.1.1 Subjects

In order to recruit the subjects, and the physiotherapists to treat them, contact was made with all the practising qualified physiotherapists registered with the Netherlands Association for Physiotherapy for Child and Adolescent Health Care (N=960). From this group, 164 paediatric physiotherapists notified us of their willingness to take part in the research if a DS child was presented in their practice. Subsequently, in a period of four months, 26 children were presented, 22 of whom were enrolled for the research. Participating children were selected on the basis of age, with a balanced distribution between the sexes and on the expectation that they would be able to participate for the duration of the entire study. Four of the 22 children had to terminate their participation in the study prematurely. Medical factors were the reason for this in two of the cases (heart operation, leukaemia) and for two of the children there were social factors (family circumstances). The remaining 18 children had an intake age (corrected from 4 weeks premature) from 9 to 47 weeks (average 26.3 weeks, standard deviation 13.1 weeks). They all lived at home in various parts of the Netherlands (the provinces of Noord-Holland, Zuid-Holland, Brabant, Overijssel and Gelderland). The intake data of the 18 children are recorded in table 6.1. These children took part during the entire research period and the complete data series of these children were statistically analysed. Treatment of the 18 children in the context of the research was carried out by 16 general and specialised paediatric physiotherapists who were registered in the Netherlands. Parents gave their informed consent to the research. Prior to the intake, no physiotherapy treatment was given to the children.

Sex	9 boys	9 girls
Age in weeks (chronological)	range mean standard deviation	13 to 47 weeks 27.2 weeks 12.9 weeks
Age in weeks (corrected	range mean standard deviation	9 to 47 weeks 26.3 weeks 13.1 weeks
Educational level parents	LBO[2] MBO[2] HBO[2,] WO[5]	n= 2 n= 9 n= 7
Size of family	3 family members 4 family members 5 family members 6 family members	n= 8 n= 7 n= 2 n= 1
Health	DS premature birth, more than 4 weeks congenital heart defect resperatory disorder stomach/intestinal disorder thyroid disorder auditory impairment visual impairment	n= 18 n= 3 n= 4 n= 1 n= 3 n= 1 n= 1 n= 1
BMS intake level (maximum 45)	range mean standard deviation	3 to 17 7.8 4.0
BOS 2-30 intake level in months (BSID)	range mean standard deviation	2.5 to 10.5 5.2 2.3

Tabel 6.1
[2]LBO : lower secondary vocational education
[3]MBO : upper secondary vocational education
[4]HBO : higher professional education
[5]WO : university education

6.1.2 Measuring instruments

The test, 'Basic motor skills of children with Down's syndrome' (BMS), has been specifically constructed for DS children and measures the 'level of postural control' of 15 basic motor skills, operationalised into 15 test items (table 6.2).

1. Raising legs when supine	9. Walking with support
2. Reaching when supine	10. Standing with support
3. Raising head when supine	11. Standing up with support
4. Elbow support when prone	12. Standing without support
5. Rolling from prone to supine	13. Sitting up
6. Rolling from supine to prone	14. Walking without support
7. Sitting	15. Standing up without support
8. Moving forward over the floor	

Tabel 6.2 Fifteen BMS test items

The 15 skills, which cover the period of development of basic motor skills (lying, sitting, standing, walking) are in a developmental sequence and together constitute a rising scale. Each of the skills has a specific development course. To support such development an increasing 'level of postural control' is necessary. Motor development is specified in defined scale steps per test item. The scale steps per skill are in a developmental sequence and also constitute a rising scale. Table 6.3 provides an example of the scale distribution of test item 7 ('Postural control in sitting').
The instrument was tested for reliability and validity concept (the extent to which the BMS fulfils expectations which have been drawn up on the basis of the underlying theoretical framework) (Lauteslager et al., 1996; Lauteslager et al., 1998). To this end, the BMS was applied on 42 subjects with DS from 0 to 4 years of age with an average age of 2 years 7 months. The data were analysed using the Partial Credit Model of Wright & Linacre (PCM; 1992). On the basis of this data, a unidimensional variable was constructed using the PCM so that the 'level of postural control' of subjects, test items and scale steps per test item could be expressed in a value. A fit analysis of test items and of subjects was also carried out.
The BMS has a high degree of inter-reliability and intra-reliability,

Execution The child is placed in the sitting-without-support position on a horizontal surface and is encouraged to stretch from the trunk by eliciting reaching upwards with the arms and to transfer weight laterally by eliciting sideways reaching out with the arms.
Scale 0. The test item has been correctly administered, however the child shows no motor behaviour that is described in any of the stage specifications below. 1. The child sits independently during stimulation for at least 5 seconds while supporting the position with two hands. 2. The child sits independently during stimulation for at least 5 seconds while supporting the position with one hand. 3. The child sits independently during stimulation for at least 2 seconds without support from the arms and with a bent back. 4. The child sits independently during stimulation for at least 2 seconds without support from the arms with a straight back without lumbar lordosis. 5. The child sits independently during stimulation without support from the arms. When stretching the back, a clear lumbar lordosis can be observed for at least 2 seconds. 6. The child sits independently during stimulation without support from the arms. When stretching the back and transferring weight to the lateral a clear lumbar lordosis and a clearly lateral flexed trunk can be observed for at least 2 seconds.

Table 6.3 Level classification of test item 7, ‘Postural control in sitting’

Cohen's kappa is .85 and .89 respectively; Cronbach's alpha is .94. The PCM analysis demonstrates that the test items measure the variable 'level of postural control' unidimensionally. The construct validity of the BMS is supported because the postulated sequence is outlined in the classification of test items at the level of postural control. There is also confirmation of the hypothesized sequence of scale steps per test item. In addition, there is a significant correlation

between age and the BMS score (r = .81; p < .001). In view of the construction of the BMS and the hypothesized correlation with motor development, the hypothesis that the BMS registers motor development is upheld.
In addition to the BMS, use was made of the mental scales of the Bayley Scales of Infant Development (BOS 2-30; van der Meulen & Smrkovsky, 1983). At present, the BOS 2-30 is one of the most frequently used instruments for recording the motor and mental development of DS children. The reliability (Cronbach's alpha) per age group of the mental scale is between .73 and .93, mean: .89. The reliability of the motor scale is between .62 and .90, average: .81.

6.1.3 Design and procedure

The research has a quasi-experimental research design (simple time series; Baarda & de Goede, 1990); all the children are given physiotherapy, each child serves as his/her own control. In order to carry this out the research period was divided into 5 periods (table 6.4), one baseline period of 4 weeks (P1), two treatment periods, each of 13 weeks (P2 and P4) and two rest periods, each of 13 weeks (P3 and P5). In the first and second treatment period, P2 and P4, each child was given physiotherapy treatment once a week. Period 3 and period 5 were rest periods, during which there was no treatment. Prior to the first treatment period (P2) the child's natural development was recorded (P1; baseline period). The child did not have physiotherapy treatment during the baseline period. Before the first treatment period, P2, parental advice may have been provided by a paediatric physiotherapist. Advice given to parents in this respect related to the care and handling of the child, for example, the method of lifting and carrying.

T1	P1 Baseline period 4 weeks	T2	P2 First treatment period 13 weeks	T3	P3 First rest period 13 weeks	T4	P4 Second treatment period 13 weeks	T5	P5 Second rest period 13 weeks	T6

Table 6.4 Research design: test moments (T1 to T6), baseline period (P1), treatment periods (P2 and P4) and rest periods (P3 and P5)

As we were researching the correlation between the application of the specified treatment and a child's motor development, operationalised in the BMS, we tested to see whether the increase in the BMS score of the children in the two treatment periods (P2 and P2) was significantly greater than the increase in the BMS score in the two rest periods (P3 and P5). To this end, the development of the children participating was recorded for each period. The BMS was applied 6 times in total (T1 to T6) by one researcher (physiotherapist). T1 was applied at the intake, then T2 to T6 were applied at the conclusion of the 5 periods (table 6.4). Each BMS measurement was recorded on videotape. Motor behaviour on the videotapes was then scored by one observer (physiotherapist) according to protocol. The observer was not aware of the test moment and therefore did not know which period was being evaluated. In order to obtain measurements, a test week was introduced, prior to the baseline period and at the conclusion of each period. During this week, in addition to the BMS, the mental scale of the Bayley Scales of Infant Development (BOS 2-30; van der Meulen & Smrkovsky, 1983) was applied by one researcher (human movement scientist). Scores were displayed as 'test age'.
At the time of intake, data were recorded relating to the age, sex and health status of the child, the size of the family, the number of hours the parents worked outside the home, the educational level of the parents (socio-economic environment), care facilities and the daily routine of the child. During the research period, variables were recorded on the test moments T2 to T6 relating to the previous period, which might differ per period and which could influence the motor and mental development of the child in that period (vitality, development stimulation, daily routine and the degree to which parents applied motor stimulation to their child). In addition, during the two treatment periods, the parents filled in a list of questions every two weeks, concerning the intensity of motor stimulation at home. After each session, the paediatric physiotherapist treating the children recorded the data on the treatment on a specially developed form. The use of 'list of questions for parents' and the 'evaluation of treatment' form are described in a protocol.

The treatment was carried out by general and specialised paediatric physiotherapists. Physiotherapists who took part were trained in the application of the treatment programme and in the research methods before T1, but did not have the measuring instrument at their disposal. Prior to the two treatment periods of 3 months they were given a description, made on the basis of the BMS, of the actual development level of the 15 basic motor skills of the child. This BMS report also includes individual motor treatment objectives based on the BMS stipulations. During the two intervention periods, children were treated once a week (2 x 13 weeks). One treatment lasted from 30 to 45 minutes. Every week, the paediatric physiotherapist stipulated the performance of the treatment and the transfer of aspects of the treatment to the parents. This was done on the basis of the test results and the treatment recommendations, the treatment programme and the expertise of the physiotherapist.

6.1.4 Physiotherapy treatment

The physiotherapy treatment was based on the therapy concept which was developed specifically for the target group on the basis of the above-mentioned theoretical framework (Appendix 2 Lauteslager, 1996). The concept described the motor problems of DS children and the appropriate physiotherapy treatment objectives and instructions to the parents during the period of the development of basic motor skills. One major concern in this treatment concept is that this period is influenced by disturbances in the system of postural control leading to the development of specific motor behaviour being adjusted accordingly. Generally speaking, DS children show a preference for symmetrical postures and movements. Their motor behaviour is characterised by a lack of movement dissociation, of balance reactions and of movement variation. It is inadequate both in terms of function and of appropriateness.

The reduced postural tonus of the DS child increases in time and with it the level of postural control. The development of basic motor skills, however, takes place under the influence of a relatively reduced postural control. In a general sense, the physiotherapy treatment is intended to stimulate inadequate, conditional elements in the field of postural control, to govern the specific development of basic motor skills, thereby rendering motor behaviour more functional. In principle, the increasing postural tonus ensures a better basis for the corrected motor patterns.

More specifically, this treatment aims to improve the development of posture in every motor phase, such as the crawling posture, sitting posture or standing posture. What is important here is the provision of adequate stability by stimulating the production of sufficient co-contractions (stabilising, myogenous contractions of groups of muscles round a joint). As is usual in motor development, this occurs initially in symmetrical postures, if necessary with support. Subsequently, motor behaviour is stimulated at each motor phase in which the child is without support and starts to move away from the previously mentioned symmetrical postures. The child is stimulated, for example when sitting or standing, to transfer body weight sideways, thus exercising trunk motor ability (trunk rotation and trunk lateral flexion), postural reactions (balance), movement dissociation and variation in movement. It is important that motor skills have a developmental coherence. Present skills influence the development of future skills and are developed under the influence of previous skills. If possible, meaningful situations should be provided which are associated with the child's world of experience, thereby stimulating the desired motor behaviour in a functional context. Obviously, each child develops in a different manner. The physiotherapy treatment takes place on the basis of individual objectives. The treatment programme, therefore, does not provide the prescription but the framework for therapy.

Parental assignment and participation are seen as actual components of the treatment. The parents' stimulation of motor behaviour as an integrated part of play and childcare effects the implementation of a new pattern in the motor behaviour of the child. The physiotherapist treating the child assigns certain aspects of the treatment to the parents. To make the procedure unambiguous, the protocol 'instructions to parents' has been set up. Each skill which is delegated to the parents is explained and demonstrated during the treatment. The parents are then given the opportunity of practising this under supervision during the session. A short description of the skill is available for home use. Standard parental assignments have been developed. Parents are encouraged to integrate the skills in the course of daily routine (play and childcare).

6.1.5 Statistical analysis

The data were analysed using SPSS, with p-values smaller than .05 considered to be statistically significant. The recorded variables can be divided into three groups. The first group is the independent variables, the BMS and the BOS 2-30 scores, measured on T1 to T6. This displays the motor and the mental development per period (T2-T1, T3-T2, T4-T3, T5-T4, T6-T5) and the motor and mental development during the entire research period (T6-T1). Group 2 are the control variables which were recorded at intake on T1. In the course of the study they formed a constant factor from which a possible influence is hypothesized on the mental and motor development of the children (BMS intake score, BOS 2-30 intake score, corrected for age, sex, family size, number of hours per week parents work outside the home, educational level of parents, intake health aspects and the degree of parental advice before the beginning of the first treatment period). As the third group of variables at the five moments of measurement (T2, T3, T4, T5 and T6), the periods prior to this are evaluated on (period) control variables (degree of reduced vitality of a child in any period, for example through illness, degree of motor stimulation by parents in a period, degree of development stimulation in a period [SPD and speech therapy], degree of daily routine in a period [day nursery, parent/child group, swimming]). These variables may vary during the research per period and could be of influence per period on the mental and motor development of the child during such period.

With the independent variables from group 1, the BMS and BOS scores on T1 to T6, the motor and mental development is specified per period. Using multivariate variant analysis (MANOVA), the degree of motor and mental development during the five different periods can be compared. Since the period between T1 and T2 lasted 5 weeks and the remaining periods 14 weeks, the data were corrected for the length of the duration of the periods. For example, motor development during the intake period P1 (T2-T1) was compared with the motor development during the first treatment period P2 (T3-T2) using the contrast formula (14[T2-T1] = 5[T3-T2]). In addition, the significance of the contrast (difference) between these periods was tested.
Next, we looked at whether the differences between children in the BMS and BOS 2-30 intake level (T1) and the motor and mental development during the entire research period (T6-T1) could be explained by differences in the constant control variables from group 2. To this end, the correlation (Pearson's product-moment correlation coefficient) was tested with the intake age (corrected), the BMS score at T1, the BOS 2-30 score at T1, the size of the family, the numbers of hours per week that the parents worked outside the home and the degree of parental advice before the first treatment period. In addition, we established by means of a 2-sided t-test whether the differences between children was caused by differences in sex or health. Furthermore, we checked whether differences between children could be traced back to the educational level of the parents (ANOVA).

Finally, we tested whether (period) control variables from group 3 had any influence on the significant BMS contrasts between periods. The contrast formulas, which were used to determine the significance of the difference between the BMS and BOS 2-30 development of periods, were then used to express this contrast between periods in a certain value, the contrast value. These contrast values were also to be calculated by means of the contrast formula for the (period) control variables from group 3. The contrast value stands for the difference between periods for the recorded (period) control variables.
In order to be able to find out the influence of (period) contrast variables on significant BMS contrasts, the correlation between the BMS contrast values and the appropriate contrast values of vitality, motor stimulation by the parents, development stimulation and daily routine were tested. In addition, the influence of intake age (corrected) and of sex was recorded on the significant BMS contrasts. Kendall's tau b was used as a correlation measure on 'age' because of the non-linear correlation and the linked classification.
As an illustration of the above, the contrast between P2 and P3 can be defined with the contrast formula T3-T2=T4-T3. This formula can be reduced to -T2+2T3-T4. Contrast values can thus be determined. Contrast values can now be calculated both for the difference in the BMS development between P2 and P3 and for the difference in the change of the control variables between P2 and P3. Next, the correlation of the contrast between P2 and P3 for motor growth measured by the BMS and the contrast between P2 and P3 for the change of a control variable were tested using these contrast values.

6.2 Results

6.2.1 Motor development per child

The children in the experimental group showed a variation per period in the tempo of motor development measured by the BMS (table 6.5). In order to consider this, the average BMS development for each child per period was determined per week. Next, the relative progress over five periods for each individual child was recorded. 14 of the 18 children in the first treatment period P2 showed an acceleration in the tempo of motor development compared with the baseline period P1. Four children showed a delay (table 6.6). In the first rest period P3 a delay in motor development was observed in 17 of the children compared to the first treatment period P2. One child continued the developmental tempo of the first treatment period P2. Seventeen of the 18 children showed an acceleration of motor development in the second treatment period P4 compared to the first rest period P3, with one child showing retarded development. Sixteen of the 18 children showed a delay in motor development in the second rest period P5, compared to the second treatment period P4. One child showed an acceleration in the rest period and one child continued the developmental tempo of the treatment period P4. In the light of the hypothesis, a clear tendency can be observed of the children showing a faster motor development in the treatment periods P2 and P4 compared to the intake period P1 and the two rest periods P3 and P5.

Subjects (pp) and intake age (corrected) in weeks		BMS scores on 6 tests moments (T)					
		T1	T2	T3	T4	T5	T6
pp 1	9	5	5	11	12	16	16
pp 2	13	3	5	15	16	26	30
pp 3	13	6	8	15	14	20	21
pp 4	16	5	6	14	14	18	17
pp 5	17	5	5	10	12	18	22
pp 6	17	4	9	17	18	28	35
pp 7	18	7	7	13	14	21	20
pp 8	19	6	5	10	13	20	27
pp 9	19	6	7	13	14	17	23
pp 10	21	9	10	16	18	30	34
pp 11	23	5	6	13	19	26	31
pp 12	31	8	9	17	19	23	24
pp 13	35	4	6	13	17	25	25
pp 14	43	11	13	23	27	34	35
pp 15	44	14	15	21	23	37	40
pp 16	45	13	16	22	26	32	36
pp 17	45	12	16	19	22	33	34
pp 17	46	17	21	32	35	37	35

Subjects (pp) and intake age (corrected) in weeks		BOS 2-30 scores (months) on 6 tests moments (T)					
		T1	T2	T3	T4	T5	T6
pp 1	9	2,5	4	5	9	10	12
pp 2	13	3	5	5,5	10	12	16
pp 3	13	4	4,5	7	11	14	16
pp 4	16	3	4	5,5	8	8	10
pp 5	17	3,5	4,5	7	9	12	15
pp 6	17	3,5	5	8	10	11	14
pp 7	18	3	4,5	6	9	12	16
pp 8	19	4	4	8	11	13	16
pp 9	19	4	4,5	7	10	12	13
pp 10	21	4,5	6	9	11	12	15
pp 11	23	4	5	8	12	14	16
pp 12	31	7	8	9	12	14	16
pp 13	35	6	7	9	10	12	15
pp 14	43	8	10	13	16	16	18
pp 15	44	8	9	11	13	15	16
pp 16	45	10,5	10	13	15	16	18
pp 17	45	7	9	11	14	16	16
pp 17	46	8	8	13	15	16	18

Table 6.5 Subjects (pp), intake age (corrected), BMS and BOS 2-30 scores on 6 test moments (T)

Period comparison	P1/P2	P2/P3	P3/P4	P4/P5
Acceleration	n=14	n= 0	n=17	n=1
Delay	n= 4	n=17	n= 1	n=16
The same	n= 0	n= 1	n= 0	n= 1

Tabel 6.6 Course of the extent of BMS development of 18 children during 5 periods.

6.2.2 Motor and mental development of the experimental group

The average BMS development per week of the experimental group as a whole was calculated for the intake period (P1), the first treatment period (P2), the first rest period (P3), the second treatment period (P4) and the second rest period (P5). The maximum BMS score was 45 points. On average, the experimental group gained 0.32 BMS points per week in the intake period, 0.50 points in the first treatment period and 0.15 points in the first rest period, 0.51 points in the second treatment period and 0.18 points in the second rest period (figure 6.1).

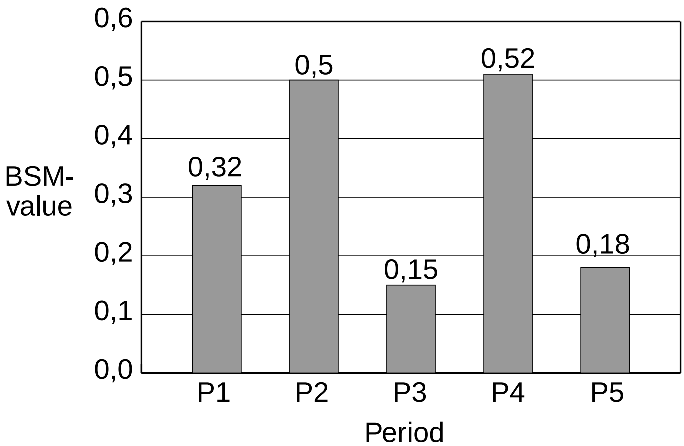

Figure 6.1 Mean BMS development per week per period P (n= 18; P1= baseline period, P2= first treatment period, P3= first rest period, P4= second treatment period, P5= second rest period)

On average, it is apparent that there is a clear difference in the degree of motor development in favour of the treatment periods P2 and P4 compared to the intake period P1 and the two rest periods P3 and P5. In addition, the average BOS 2-30 developmental tempo per week was calculated for the experimental group as a whole for the 5 periods. On average, the experimental group gained 0.21 per week in the intake period, 0.17 in the first treatment period, 0.20 in the first rest period, 0.12 per week in the second treatment period and 0.16 in the second rest period (figure 6.2).

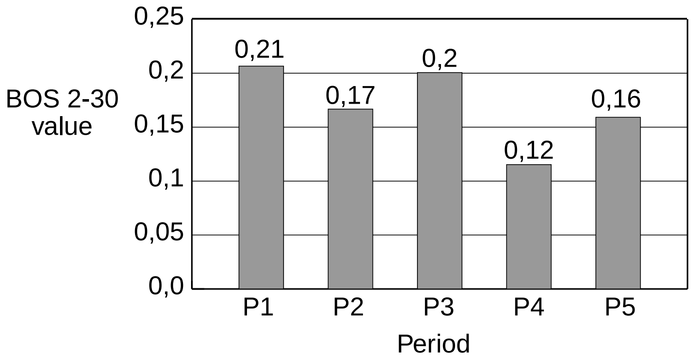

Figure 6.2 Mean BMS 2-30 development per week per period P (n= 18) P1= baseline period, P2= first treatment period, P3= first rest period, P4= second treatment period, P5= rest period)

6.2.3 Differences in motor and mental development between periods

It was then calculated whether there was a significant difference in motor development between periods (table 6.7). Motor development in the first treatment period P2 turned out to be significantly greater than in the first rest period P3 ($F(1:17)=59.65$; $p =.000$). Motor development in the second treatment period P4 turned out to be significantly greater than in the second rest period P5 ($F(1:17)=31.14$; $P=.000$). Compared to the baseline period P1, motor development in the first and second treatment periods P2 and P4 was significantly greater ($F(1:17)=5.93$; $p=.026$ and $F(1:17)=4.70$; $p=.045$ respectively). Compared to the baseline period P1, the motor development of the first rest period P3 was significantly smaller ($F(1:17)= 4.72$; $p=.044$), while that of the second rest period P5 is not applicable (F(1:17)=2.65; p=.122). Motor development in P2 combined with P3 does not vary significantly from that in P4 combined with P5, motor development in P1 did not vary significantly from the development in the combined periods P2, P3, P4 and P5. Motor development in the first treatment period P2 in statistical terms is the same as that in the second treatment period P4, the development in the first rest period P3 being the same as that in the second rest period P5. To summarize, in the light of the central hypothesis, motor development in the two treatment periods was shown to proceed significantly more quickly than in the two rest periods, and also significantly faster than in the baseline period.

Period comparison	Contrast formula corrected for length of period	Period contrasts BMS	Period contrasts BOS 2-30
P2 /P3	T3-T2=T4-T3	F(1:17)=59.65*	F(1:17)= .96
P4 /P5	T5-T4=T6-T5	F(1:17)=31.14*	F(1:17)= 4.35
P1 /P2	14(T2-T1)=5(T3-T2)	F(1:17)= 5.93*	F(1:17)= .56
P1 /P4	14(T2-T1)=5(T5-T4)	F(1:17)= 4.70*	F(1:17)= 5.15*
P1 /P3	14(T2-T1)=5(T4-T3)	F(1:17)= 4.72*	F(1:17)= .05
P1 /P5	14(T2-T1)=5(T6-T5)	F(1:17)= 2.65	F(1:17)= 1.40
P23/P45	T4-T2=T6-T4	F(1:17)= .10	F(1:17)= 7.13*
P1 /P2345	56(T2-T1)=5(T6-T2)	F(1:17)= .02	F(1:17)= 1.43
P2 /P4	T3-T2=T5-T4	F(1:17)= .03	F(1:17)= 3.88
P3 /P5	T4-T3=T6-T5	F(1:17)= .15	F(1:17)= 2.39

*Tabel 6.7 Period comparison (n=18; *= P<.05)*

The same periods were compared to measure mental growth per period (table 6.7). Mental development in P1 (baseline period) was shown to be significantly greater than in the second treatment period P4 (F(1:17) = 5.15; p=.037). Mental development in the first treatment period P2 and first rest period P3 together was significantly greater than the mental development in the second treatment period P4 and second rest period P5 together (F(1:17)=7.13; p=.016). Other differences between periods compared are not significant. To summarise, in this study there was a declining growth of mental development in time. This result corresponds with the declining mental developmental growth of DS children on the BOS 2-30 mentioned in the literature (Carr, 1970).

6.2.4 Correlation between (intake) control variables and motor development

There is a significant correlation (pmc) between the (corrected) age of the children at the moment of intake on the one hand and the intake scores on the BMS and the BOS 2-30 on the other ($r=.84$, $p<.01$ and $r=.94$, $p<.01$ respectively, table 6.8). According to expectations, children gain higher intake scores on the BMS and BOS 2-30 as they get older. The correlation between the intake scores on the BMS and BOS 2-30 is evidently also significant ($r=.82$, $p<.01$); in fact, both instruments measure development. Finally, there is a significant negative correlation between BOS 2-30 intake score and the BOS 2-30 development between T1 and T6 ($r=-.53$, $p<.05$) and between the intake (corrected) age and the BOS 2-30 development between T1 and T6 ($r=-.50$, $p<.05$). As indicated, older children perform better at the moment of intake on the mental scale of the BOS 2-30, but they then develop relatively more slowly during the research period. This result confirms the conclusion of the previous section and agrees with findings from the literature.

The difference in the BMS and the BOS 2-30 intake scores and in the BMS and the BOS 2-30 development between T1 and T6 was monitored for the (intake) control variables of sex, size of family, the number of hours that the parents work outside the home, the educational level of the parents and health aspects (premature birth, congenital heart defect, health) (table 6.8; table 6.9). There was no significant difference noted. Before T2 a number of parents were given parental advice on handling their child. This advice had no significant effect on the motor development in the baseline period P1 or in the intervention period P2345 (table 6.8).

(Intake) control variables	BMS T1	BOS 2-30 T1	BMS T6-T1	BOS 2-30 T6-T1
Age (corrected)	r= .84*	r= .94*	r= .30	r= -.50*
BMS T1	-	r= .82*	r= .10	r= -.40
BOS 2-30 T1	r= .82*	-	r= .27	r= -.53*
Size of familv	r= .25	r= .22	r= -.21	r= -.05
Volume of work mother	r= -.05	r= -.18	r= .12	r= -.20
Volume of work father	r= .18	r= .27	r= .19	r= .32
Parent advice	r= .12	-	r= .27	-

*Tabel 6.8 Correlation between (intake) control variables and BMS and BOS 2-30 intake (T1) and development (T6-T1) (n=18; * = p<.05)*

(Intake)control variables	BVK T1	BOS 2-30 T1	BVK T6-T1	BOS 2-30 T6-T1
Sex	t= -.30	t= -.54	t= -.78	t= .19
Educational level parents	F= 1.05	F= .04	F= 1.26	F= .44
Health	t=-1.02	t= -.77	t= .17	t= .53
Premature birth	t= .83	t= .69	t= .41	t= .48
Congenital heart defect	t= -.40	t=-1.73	t=-1.66	t= .95

*Tabel 6.9 Differences in BMS and BOS 2-30 intake (T1) and development (T6-T1) through (intake) control variables (n=18; * = p<.05)*

6.2.5 Correlation between (period) control variables and motor development

The (corrected) age was shown to be a significant influence on the BMS contrast value P1-P2 (tau b=-.35, p<.05). The older the child, the smaller the difference between the development in the baseline period and in the first treatment period. The significance was possibly due to the fact that a number of older children from the experimental group showed a relatively strong development in the baseline period P1. The correlation was not found with the remaining significant BMS contrast values.

The speech therapy contrast value P1-P3 has a significant correlation with the BMS contrast value P1-P3 (r_s=.49, p<.05). In the course of the research, it became apparent that there was a clear trend that children

undergoing treatment were having speech therapy. In the baseline period P1, 3 children were receiving speech therapy, in the first rest period P3, there were 10, in the second rest period P5, finally, there were 11. The difference between P1 and P3 is such that a significant correlation was found in the decrease of motor development in P3 as compared to P1. It is possible that the parents' attention in this rest period was more focused on stimulating the introduction of oral motor abilities and the development of speech and language. This correlation, moreover, was not stated with the remaining significant BMS contrast values.
The period contrast values of the (period) control variables of vitality, compliance of parents, development stimulation and daily routine gave no significant differences in the appropriate, significant BMS contrast values (table 6.10). Also difference in sex gave no significant differences in BMS contrast values (table 6.11). The significant differences found between periods for motor development cannot be explained by different (period) control variables and seem to be attributable to the physiotherapy treatment introduced periodically.

(Period) control variables	**BMS contrast value P2/P3**	**BMS contrast value P4/P5**	**BMS contrast value P1/P2**	**BMS contrast value P1/P4**	**BMS contrast value P1/P3**
Intake age corrected	tau b= -.35	tau b= .13	tau b= -.35	tau b= -.16	tau b= -13
Contrast value vitality	r= .31	r= .01	r= -.05	r= .38	r= .20
Contrast value compliance parents	r_s= .25	r_s= .11	r_s= .20	r_s= .26	r_s= .28
Contrast value SPD (see footnote 1)	r_s= .24	r_s= -.13	r_s= .18	r_s= -.26	r_s= -.31
Contrast value speech training	r_s= .12	r_s= .17	r_s= .30	r_s= .40	r_s= .49
Contrast value day care nursery			r_s= .09	r_s= -.02	r_s= .00
Contrast value swimming	r_s= -.03		r_s= .09	r_s= -.07	r_s= -.03
Contrast value parent/child group		r_s= .26	r_s= .09	r_s= .17	r_s= -.21

*Table 6.10 Correlation between significant BMS contaxt values on the one hand and the contrast values appropriate to the period of the (period) control variables and of (corrected) age on the other hand (n=18; * = p<.05)*

control variables	BMS contrast value P2/P3	BMS contrast value P4/P5	BMS contrast value P1/P2	BMS contrast value P1/P4	BMS contrast value P1/P3
Sex (intake)	t= .35	t= .00	t= 1.31	t= .00	t= .98

*Table 6.11 Difference in significant BMS contrast values through sex (n=18; * = p<.05)*

6.3 Discussion and conclusions

What is needed to interpret the results of this research is a motor development profile of young DS children. On the basis of the present literature, however, it is not yet possible to lay down a general motor development profile. Several researchers have noted a declining growth of motor development in the course of the first two years of life (Carr, 1970; Cowie, 1970; Gath, 1978; Henderson, 1986; Sharav et al., 1986). This declining growth, however, was attributed to characteristics of psychometric development tests standardised on non-disabled children and not on the development profile of the children themselves (Henderson, 1985; Sharav et al., 1986; Guralnick, 1995). Other researchers, in contrast, recorded a slow progressive and uniform development (Share, Koch, Web & Graliker, 1964; Berry, Gunn & Andrews, 1984). Gibson & Fields (1984) concluded that no uniform development norms standardised for the target group were available. In this research, motor development in the two treatment periods was compared with that in the two rest periods. In order to contribute to standardisation, the natural progression of the motor development of each child in the baseline period was also determined. Baseline standardisation implies a linear connection between motor development, measured by the BMS and age. It must be assumed that prior to this not enough was known about the developmental profile of DS children on the BMS. The BMS was developed in order to be able to evaluate the effect of intervention and has not been standardised for the target group. There are possibilities here for follow-up research.

Motor development, measured by the BMS, was shown during the entire intervention period (P2345) per week to be somewhat higher on average, but in terms of statistics equal to the increase in the baseline period P1. On the basis of a linear development, this means that the children from this research did not register any progress for motor development by having had two periods of 3 months' physiotherapy treatment in a period of 14 months. The motor development of the

children from the experimental group, measured by the BMS, made significantly faster progress in the two treatment periods P2 and P4 than in the baseline period P1. The question now is what the effect would be in the case of constant, instead of interrupted, treatment. There are also possibilities here for further research.
The average motor growth in the two rest periods P3 and P5 is clearly smaller than in the baseline period P1. If the BMS development in P3 and P5 represents natural motor development, this suggested a progressively declining motor development in comparison with the baseline P1. It is possible, however, that the development in the two rest periods was influenced by the accelerated growth in the previous treatment periods. It is also possible that the children use the two rest periods to integrate the newly acquired motor possibilities into their motor behaviour. What is striking is that the difference between P1 and P3 is significant, but is no longer significant between P1 and P5. This would suggest that the reduced motor developmental tempo during the intervention period is again increasing somewhat. Moreover, the differences between P3 and P5 are not significant.
There is a view that the average BMS development of 0.32 found in the baseline period P1 could be on the high side. Four of the children score so highly that they are responsible for 55% of the motor development of the entire group in this period. Development in the baseline period is possibly unintentionally influenced by the fact that, at the second test moment T2, the children are more familiar with the measuring instrument and with the examiner, but also because the parents are more aware of the motor development of their child after the intake and subconsciously pay more attention to it.

Motor development proceeds significantly faster in the first treatment period P2 than in the first rest period P3 and the baseline P1. Motor development in the second treatment period P4 proceeds significantly faster than in the second rest period P5 and the baseline P1. The measured period variables vitality, stimulation by parents (compliance), developmental stimulation and daily routine appear not to influence the above-named differences significantly. The results strongly support the hypothesis that the periodically introduced physiotherapy treatment leads to higher scores on the BMS and brings about an accelerated development of basic motor skills. It is also important to state that the motor gain of the two treatment periods is not undone in the two rest periods. It is evident that the result here is a structural (developmental) result and not a temporary learning effect. The fact that the development of basic motor skills can be periodically manipulated by targeted intervention can possibly be explained by saying that the motor skills in question could be potentially developed, but that conditional elements are not sufficiently present for this actually to happen. The hypothesis in this research is that the missing conditional elements are in the field of postural control. Through problem-specific physiotherapy treatment these conditions are introduced and trained, conditional elements in the field of postural control and added. By introducing these conditions into the field of postural control a child can use adequate motor behaviour functionally to an increasing degree, for instance in play. If, for example, a child lacks the trunk extension and the stability to be able to sit s/he obviously will not manage to develop balance reactions in that sitting posture. If the child does not learn to master adequate balance reactions in the sitting posture, s/he is not going to progress in that posture to the development of movement variations or to play. Conversely, the more frequently the child is able to use motor behaviour in meaningful situations in a focused and successful manner, the greater the effect will be on the motor development.

The methodical approach of the treatment appears to be of vital importance for these results. Based on a BMS test it is possible to specify in detail the development level of the child's basic motor skills in order to record accurately the specific problems in the field of postural control, formulating specific physiotherapy treatment systems per skill. In combination with the specified treatment concept and standard parental assignments, it makes it possible for the physiotherapists to stimulate problem-specific and targeted motor behaviour. Periodical evaluation and adjustment of treatment objectives is possible through repeated BMS measurements. It would appear to be advisable to introduce the BMS and the treatment concept into the practice of the paediatric physiotherapist, by means of training.
The results suggest that the motor progression made during an intervention period is not automatically continued in the following rest period. It is possible that the conditions developed in the field of postural control in a developmental period are not automatically relevant for successive periods. It is also possible that this illustrates the inability of the DS child to generalise acquired motor skills and to apply them to other situations. Follow-up research could indicate whether the increase in motor development as recorded in the two treatment periods continues when the treatment is not interrupted but continued. In addition, the optimal treatment frequency could be

determined. Furthermore, the question arises as to whether added conditions in the field of postural control without stimulation remain safe. Does treatment at a young age lead to a structurally improved motor potential or to reaching the motor ceiling earlier? Or it is to be recommended for young people and adults with DS to keep training conditional elements in the field of postural control in a focused way through taking part in sport, for example?
Finally, this research shows no correlation between the intake age and the BMS development between T1 and T6. Children from the experimental group did not appear to be more receptive for the motor stimulation provided at any particular age. Nor did there appear to be any connection between the mental intake level and the BMS development between T1 and T6. Thus, children who are more competent mentally do not automatically develop better in the motor area under the influence of physiotherapy. In addition, children who at the intake performed better in a motor area do not automatically proceed with a faster motor or mental development, there appearing to be no connection between the BMS intake level and the BMS or BOS 2-30 development between T1 and T6. Furthermore, parent guidance by a paediatric physiotherapist prior to the beginning of the research and during the baseline period does not appear to have a significant influence on the motor development in the baseline period or in the total experimental period. It is striking that changes per period of control variables show no correlation with the changes in the motor development of the children. For example, positive effects are expected from the health condition (vitality) of a child or from the degree to which parents are able to implement advice in daily care and games. It is possible that the experimental group is too small to measure such influence. Here too, follow-up research would provide more clarity.

6.4 Summary

Research carried out into the effect of intervention on the motor development of children with DS has encountered problems in the field of the theoretical foundation, the choice of measuring instrument, the treatment concept and the research design. In order to meet this problems, the theoretical framework 'Disturbances in the system of postural control' has been set up specifically for children with DS and the measuring instrument 'Basic motor skills of children with Down's syndrome' (BMS) and the treatment concept 'Physiotherapy for young children with Down’s syndrome' have been developed. Intervention research was carried out using the newly developed elements on 18 children with DS living at home (age range: 9-47 weeks; average age 26 weeks) for 14 months. The hypothesis is that specific stimulation by physiotherapy of aspects of postural control causes basic motor skills to develop more quickly and more completely as a result of which motor behaviour becomes increasingly functional. The study has a quasi-experimental research design (simple time series). The research period covers five consecutive periods (baseline period (P1), 4 weeks; treatment period 1 (P2), 13 weeks; rest period 1 (P3), 13 weeks; treatment period 2 (P4), 13 weeks; rest period 2 (P5), 13 weeks). At the beginning and at the end of each period children are tested using the BMS. In order to assess the effect of the mental level on motor development, the mental scale of the Baley Scales of Infant Development is also applied. In both treatment periods each child has weekly physiotherapy treatment from one of the child physiotherapists trained in the treatment concept. The aim of the research is to investigate the effect of the applied treatment in the two treatment periods on the development of the basic motor skills of the children participating, in comparison with baseline and rest periods.

Motor development in the first treatment period, P2, turned out to be significantly greater than in the first rest period, P3. Motor development in the second treatment period P4 turned out to be significantly greater than in the second rest period, P5. Both in the first and in the second treatment periods, P2 and P4, motor development as measured by the BMS were significantly greater than in the baseline period P1. Motor development in the baseline period P1 was not significantly distinguishable from motor development in the entire intervention period P2345. Registered control variables, including the Bayley Scales of Infant Development values, had no significant influence on the results.
The conclusion is that a methodical, problem-specific physiotherapy intervention would improve inadequate provisional elements in the field of postural control, such as stability and balance, as a result of which in the treatment periods a significant acceleration could be achieved in the development of the basic motor skills of young children with DS. Since not enough is known about the development profile of children with DS on the BMS, follow-up research is suggested into the development of these children on the BMS, into the effect of a more long-term applied physiotherapy treatment on motor development and into the structural results of this intervention.

6.5 Literature

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7. Final Conclusions

This study was prompted by the fact that parents of a young Down's syndrome (hereafter: DS) child in the Netherlands are increasingly appealing to paediatric physiotherapy for guidance in the motor development of their child (van der Kleij, Hoekman, Retel & van der Velden, 1994). However, the professional group provides this guidance in very disparate forms. Paediatric physiotherapy in the Netherlands does not have a clear and well-structured physiotherapy treatment method for this specific purpose. The essential aim of the present study is to contribute to the introduction of a scientifically-based method in order to provide systematic physiotherapy guidance for the motor development of the young DS child.

7.1 Theoretical construct

A number of developments in previous decades have influenced the design of this study, more particularly the construction of the constituent elements of the intervention research (theoretical framework, motor measuring instrument, physiotherapy guidance framework, research design). In the first place, there is a gradual recognition in the literature of the fact that the motor development of DS children gives rise to specific motor problems. Children appear to be even more restricted in the motor field than they are in the domain of mental development. In addition, their motor development is not merely retarded but deviates from that of non-disabled children. It is influenced negatively by obvious motor disorders, such the fact that their motor skills are not adequately efficient. DS children have their own, specific process of motor development.
This has been a defining factor for the content of the applied motor interventions in the past decades. In the eighties, limited intervention, particularly restricted initially to general forms of movement activation, led a number of researchers to recognize the specific character of the motor problems, opting for specific motor stimulation. However, what was lacking was a theoretical construct, a thought model for the established motor disorders and its implications regarding the ways in which disabilities in motor functioning develop (Henderson, 1985; Block, 1991).
In this study, the development of the theoretical construct 'Distur-

bances in the System of Postural Control' has been essential in the therapeutic approach to the motor disabilities of the children. What is important in this theoretical model, is that the emphasis is on the origin of constraint in the children's functional motor behaviour and not on the motor impairments which occur in the course of motor development. The theoretical framework is a motor development model in which the attention is focused on the effect motor impairments have on the development of motor behaviour and on the disabilities which therefore appear in the functional domain. In spite of the motor impairments, the children do have a natural need for movement. Children accommodate, as it were, to their motor impairments, compensate for motor problems and, in that way, develop adapted motor behaviour. The theoretical model was used as a basis for the development of a measuring instrument, i.e. the 'Test of Basic Motor Skills for children with Down's syndrome' (BMS) and of the therapeutic framework 'Physiotherapy for young children with Down's syndrome'.

7.2 Meaningful intervention

The focus in this research on the disabilities which occur in the functional motor behaviour of DS children is derived in the first instance from the care and support services for the mentally disabled. The disabilities which occur in the mental functioning of the mentally disabled concentrate the minds of the caregiver on meaningful and functional intervention. If the care provided is not offered in a meaningful context and does not lead to a meaningful result, then it will be difficult to motivate the child to co-operate in a worthwhile manner, with consequences arising for the result of the treatment. It goes without saying that this is relevant not only to many mentally disabled persons, but also in particular to the guidance of young children.
This way of thinking seems to concur with recent developments in physiotherapy. Attention, which for a long time had been devoted to the treatment of impairments of the postural and movement apparatus, has gradually shifted to possible disabilities which these impairments entail in the appropriateness of motor behaviour (van der Net, 1995; Visser & Ketelaar, 1997). In terms of the ICIDH (International Classification of Impairments, Disabilities and Handicaps)(WCC, 1995) it seems that the clients' questions have been formulated at the level of disabilities and of handicaps, not at the level of impairments. Partly also due to the discussion on physiotherapy, resulting from the limited

results of a impairments-oriented approach (Vermeer & Bakx, 1990), a more functional approach is apparent in physiotherapy, in which requests for help and treatment objectives are derived from disabilities in daily functioning. The treatment is focused on the (renewed) application of skills during this functioning and the success of the treatment is measured in terms of the effect on such functioning (Wimmers & de Vries, 1992).
For a child, the term 'disabilities' has an extra dimension when compared to adults. In any case, the period of childhood is primarily one of development. Children move, discover and learn through their actions and are challenged by their environment to develop this movement further. Basic motor skills and their development show a relationship to development in a broader sense. Motor behaviour must be able to support the developmental needs of a child, motor skills are particularly 'constraining' if the child is hindered in his everyday functioning and therefore in his development. The efficient, age-appropriate motor behaviour of a child is characterised by an unconditional association with exploration and development. Adequate postural control determines to a significant extent the appropriateness of the motor behaviour. Impairments in postural control, on the other hand, restrict the child in his exploration and therefore in his development.

7.3 Evaluative motor measuring instrument

The measuring instrument 'Test of Basic Motor Skills for Children with Down's syndrome' (BMS) was constructed to provide insight into the specific development of basic motor skills of children with Down's syndrome. To this end, the development of fifteen basic motor skills was defined in fifteen test items with corresponding developmental steps per test item. Test items and achievement levels per test item have a developmental coherence. The development of motor behaviour, defined in terms of achievement levels, produces appropriate and functional motor ability for the corresponding basic motor skills. The administration of a BMS test provides insight into the motor process of a child and into the appropriateness of his actual motor behaviour. As a result of administering a BMS test, actual physiotherapy objectives can be formulated for that period.
In that sense, the BMS is an evaluative instrument and is associated with the need which has arisen for measuring instruments which

provide insight into the origin of patients' disabilities, rather than establishing physical impairments (Ketelaar, Vermeer & Helders, 1998). The BMS registers the degree of constraint of the functional motor behaviour of young DS children as that is manifested in postural control impairments. Repeated measurements provide insight into the development which is taking place.

The instrument has good reliability and appears to be valid as far as the formulated expectations on the basis of the underlying theoretical construct are concerned. In order to be able to interpret simple BMS measurements, it would appear to be worthwhile, in the context of follow-up studies, to investigate the possibility of establishing a standardisation of DS children on the BMS. A motor development profile of children may be indicative in respect of choices concerning the intensity of the motor treatment. In view of the essence of this study, it has nevertheless been decided to use the BMS in the research 'The effect of physiotherapy on the development of basic motor skills of children with Down's syndrome'.

7.4 Method of treatment

This study indicates that the introduction of the physiotherapy method produces a significant acceleration in the development of basic motor skills of the DS child during the treatment periods. It is important, on the basis of the theoretical framework, that a model framework of treatment be developed which is specifically for young DS children. The framework is transferable and can be used in the physiotherapist's practice. It provides insight into the specific motor development of DS children, into the disabilities which occur and into the appropriate treatment strategy. The treatment framework is aimed at the active participation of parents and child and focuses on the application and training of motor skills in a meaningful context. By means of training and standard instructions, parents are given guidance in stimulating the motor skills of their child in the course of everyday care and during play.

For this method it is important that the treatment be provided in a structured and methodical manner. The evaluative character of the BMS makes it possible to indicate the precise level of the motor development of a child, formulating the physiotherapy treatment objectives involved for the short-term and the longer term. Results of treatment can be evaluated objectively, adjustment of treatment

objectives taking place as a result of the evaluation. The physiotherapy framework and the standard parent instructions provide clarity and direction for both the parents and the physiotherapist.
An optimal frequency of treatment should be determined on an individual basis. In the course of the intervention research, there was a frequency of once per week for three months, followed by rest periods of three months. This structure was used in the experiment. It is not yet clear, however, whether or not the frequency used was the most adequate. In the follow-up research, experience should be gained in introducing differences in the intensity of treatment from the point of view of results and with regard to the inconveniencing of the child and the family. The introduction of non-treatment periods is particularly worthy of note, since both for the parents and for the child the motor development does not always have priority. The measurement of progression by repeated BMS tests would be indicative in this respect. As previously indicated, it seems to be important to establish a standardisation or developmental profile of DS children in order to be able to evaluate simple BMS measurements.

On evaluation, it appeared that the methodical manner of treatment, as put into practice in the intervention research, was considered on the whole to be extremely positive by both parents and by paediatric physiotherapists. The parents' reaction to the testing of their child, the reports, the physiotherapy treatment and the application at home of motor stimulation, was that it was a learning experience, easy to understand, useful and, on the whole, not very onerous. Comments which have been made have referred more particularly to the frequency of treatment and to the duration of the treatment and rest periods. The paediatric physiotherapists consider that the system of BMS measurements, BMS reports, the framework of treatment and written parental instructions could be used to good effect in their daily practice. They found the framework of treatment clear and they appreciated the opportunity of adapting the treatment to the individual problems of a particular child. The BMS reports were found to be short and clear, contributing to a targeted and well-differentiated creation of the therapeutic treatment. Comments were also made relating to the gross motor character of the treatment framework. There was a suggestion that parental instructions should be further clarified with illustrations.

7.5 Follow-up research

The results of the research into the effect of physiotherapy on the development of the basic motor skills of DS children were assessed as being extremely positive. However, some reticence is appropriate at this point; the results should be interpreted with caution. The research has been of an exploratory nature, a promising investigation of the research area has been completed. The fact is that the conclusions are based on small numbers of subjects and that the research has been carried out by a small group of researchers who were directly involved. Findings from the literature have led to the use of a quasi-experimental research design. Due to the limitations involved in the research design, because of the lack of a follow-up study and because of the lack of standard values for children on the BMS, it is not clear whether these positive results are structural in nature or whether they underpin a child's further development. These first results are promising and require follow-up of the research into the motor development and the treatment of DS children. What is particularly important in the context of follow-up research, is the establishment of the above-mentioned standard values. In addition, the follow-up research can lead to the establishment of an individual and optimal intensity of treatment.

7.6 Physiotherapy in an educational perspective

The literature clearly indicates the motor problems of DS children, which are also evident in the parents' request for support in promoting their child's motor development. This request for help was also recognized and respected in the 'Introduction to the medical supervision of children with Down's syndrome' of the Down's Syndrome Workgroup of the Hereditary and Congenital Disorders Section of the Netherlands Association of Paediatrics (Borstlap, 1996). The advice given in this introduction was to have the child's motor development assessed by a professional paediatric physiotherapist from the second or third month of life in connection with any necessary further supervision and advice. At present, in view of the results, the best option seems to be to base the paediatric physiotherapy treatment of the DS child on the method as developed in this study. It seems advisable, therefore, to introduce the method in the Down's syndrome teams and in paediatric physiotherapy and to give DS children a physiotherapy examination on the basis of the method and, where necessary, to treat them.

The motor development and supervision of DS children has been the main theme in this study. This delineation was of benefit to the research. It goes without saying that children's development consists of more than motor ability and the parents' request for help with their DS children, often being concerned with matters other than merely movement. The support of the motor development of DS children should therefore form a part of an integral provision of support in which both remedial education and (para-) medical disciplines are represented. The parents' demand is very important, as parents remain responsible as the primary instructors and are the ones to carry out the recommendations (van den Brink, 1990). Physiotherapy is a component of this instruction (adapted from Vermeer, 1999): the task of the paediatric physiotherapist is to support the total objectives of the parents with specific motor (subsidiary) objectives. Support for child and family should be easily accessible and close to home. Integral early support should be demand directed, professionally tailored to individual needs and coherently provided (Leemans & Nieuwenhuizen, 1997).

7.7 Literature

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Summary

Motor development

Overview articles reveal extensive research into the motor problems of children with Down's syndrome. These children have a disorder-specific motor development profile. Their motor ability is relatively slow to develop and they are late in achieving motor milestones. In addition, there is a different sequence in which motor skills are mastered. In comparison with people otherwise mentally disabled, there are specific motor problems. In fact, the motor disturbance seems relatively greater than the mental one. Finally, specific postural and movement patterns are described which are not observed in non-disabled children.
In addition, numerous disturbances are specified which may influence the characteristic development of motor behaviour. Hypotonia, abnormal development of reflexes, instability and excess weight can play a role. Furthermore, additional medical problems, such as congenital heart abnormality or a deviant thyroid gland function may also play their part, in common with the cognitive and social limitations of these children.

Chapter 2 describes the characteristic movement patterns of children with Down's syndrome with reference to observations made during the period of basic motor skills development. Their motor behaviour is

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The summary is based on

Lauteslager, P.E.M., Vermeer, A. & Helders, P.J.M. (1996). Motorische problematiek en interventie (Motor problems and intervention). In R.M.F. Berger & L.W.A. Suijlekom-Smit van (Eds.), *Het syndroom van Down, wat is optimale zorg? (Down's syndrome: what is the best care?)* (pp.23-26). Rotterdam: Sophia kinderziekenhuis (Rotterdam: Sophia children's hospital).

Lauteslager, P.E.M., Bakker B.A., van den Heuvel, M.E. (1998). Physiotherapy for children with Down's syndrome: the development of a method. In E. de Graaf, A. Vermeer, H.S.A. Heymans & M.I.M. Schuurman (Eds.), *Down's syndrome behind the dykes* (pp. 133-141). Amsterdam: VU University Press.

analysed with reference to the relevant literature. The aim is to gain insight into the specific manner in which these children's motor behaviour develops and into the factors which obstruct such development. The conclusion is that the development of movement of the child with Down's syndrome is influenced to a large extent by an insufficiency of stabilising co-contractions around joints, possibly as a consequence of reduced muscle tension. As a result, the child develops specific motor behaviour which is characterised by an exaggeratedly symmetrical manner of moving and by a lack of variety of movement. The restricted development of a Down's syndrome child's balance reactions is one of the significant factors in the reduced appropriateness of the motor behaviour.

Motor intervention

To an increasing degree, the parents of Down's syndrome children have expressed the need for supervision of the specific motor development of their children during the first years of life. There are frequent indications in the literature of the importance of specific motor intervention. Competent motor abilities can support cognitive and social interactions. Satisfactory motor potential can offer the Down's syndrome child extended development opportunities.

The theme of Chapter 3 is the definition of a therapy strategy with a demonstrably positive effect on the motor limitations of these children. There will be a discussion of twelve studies investigating the effect of intervention on the motor development of young Down's syndrome children. The duration of the intervention varied from ten days to more than two-and-a-half years. Short-term effects were generally positive, but long-term effects, in the sense of structural development advantages in gross motor abilities, proved not to be demonstrable.
In any case, there is a significant dearth in these research studies, both in terms of the theoretical foundation of the intervention and of effect measurement: none of them interprets motor problems effectively based on a theoretical framework. As a result, a well-founded choice for a therapy method is impossible. In addition, inadequate insight is provided into the therapy methods used. Consequently the results presented only have restricted significance for the professionals involved.

In the investigations referred to previously, the effect measurement was carried out using seventeen different instruments. The Gesell Schedules of Motor Development, the Griffiths' Development Scales, the Stanford-Binet and the Bayley Scales of Infant Development were each used in three studies. In addition, thirteen other measuring instruments were used. Not one of these measuring methods was specifically developed in order to register change in the motor problems of Down's syndrome children. In addition one of the consequences of the diversity of measuring instruments was that no clear preference was indicated.
The unexpected lack of definitively positive results as a consequence of intervention meant that a number of researchers had doubts about the measuring method they were using. This was substantiated by an investigation into the practicability of using the motor scales of the Bayley Scales of Infant Development for Down's syndrome children. What emerged was that these children mastered several items of this test in a sequence which deviated from the norm. In fact, it illustrated the deviant motor development of Down's syndrome children compared with non-disabled children. This led to the conclusion that the results of testing Down's syndrome children with measuring instruments standardised for non-disabled children was less important and indicated the necessity for the development of a specific motor test.

Many research scientists prefer not to use a control group, sometimes because of ethical considerations. For reference, norms are then used from development tests, standardised for non-disabled children, or development norms which are based on a specific group of Down's syndrome children. In the comparison with non-disabled children, however, a distorted picture emerges because the specific problems are not indicated and the entire distinctive development of the Down's syndrome child is ignored. Comparison with the norms of Down's syndrome children does not work because there are no uniform, universally applicable, standardised norms available.
A second problem in the composition of control groups arises from the complexity of the motor problems experienced by Down's syndrome children. Factors such as the degree of hypotonia, individual variation in tonus distribution, mental level, social background and general health problems, such as the frequent occurrence of heart disorders and respiratory diseases, actually render impossible any composition of an equivalent control group in the context of an experimental research study. For intervention research, a time series set-up, in

which each child is treated and forms his own reference, might be a good alternative. Repeated measurements per subject, monitored manipulation of the experimental variable (motor intervention) and monitoring for possible external factors are all essential in this respect.

The obvious motor problems of Down's syndrome children require intervention, but there is inadequate insight into the appropriateness of intervention methods. This can only be determined once researchers have a reliable and valid measuring instrument, and a therapy method geared to the problems. It is important that the measuring instrument and therapy method should be based on a theoretical framework relating to the nature and the background of the specific process of the motor development of Down's syndrome children.

Theoretical framework

In Chapter 4 the theoretical framework 'Disturbances in the system of postural control' for the motor problems of Down's syndrome children is proposed, based on literature research. Two important restrictions are distinguished in the motor behaviour of these children. On the one hand, there are problems in adopting and maintaining postures against the force of gravity, and on the other hand, there is the lack of a varied development of movements in a posture, added to the inadequate development of qualitative motor elements, such as trunk motor ability and balance reactions.
The first restriction can be clearly explained by considering the problems as resulting from a number of manifest disturbances in the system of postural control. Postural control signifies the coordination of the entire system of specific body processes, which are responsible for the adoption of posture during motor behaviour. It is clear that each Down's syndrome child suffers from hypotonia to a greater or lesser degree. Reduced postural tonus results in an insufficiency of co-contractions, inadequate balance reactions, a defective proprioceptive feedback on posture and movement, and in the hypermobility of joints. Arising from these disturbances, problems arise in the adoption and maintenance of positions in posture and in movement.
The second restriction in motor behaviour, clearly due to problems in postural control, can be placed in a developmental perspective. As a result of the problems in adopting and maintaining positions during posture and movement, qualitative elements of motor skills are

insufficiently developed, such as trunk rotation, balance and variety of movement. Problems which occur in stabilising posture and movement lead to compensatory movement strategies, to static and symmetrical motor skills, thereby resulting in a defective development of qualitative motor elements. This reduces the efficiency of the motor skills. The problems arising during a phase of motor development are not isolated, but have consequences for successive phases, having evolved in previous phases of the motor development.

Motor measuring instrument

Influencing motor development should preferably take place during the period of the development of basic motor skills. This is the period in which the foundations are laid for future motor development. In intervention research, therefore, an instrument is needed to measure the level of postural control in this period. Based on the theoretical framework 'Disturbances in the system of postural control', the 'Test of Basic Motor Skills for children with Down's syndrome' (BMS) was developed.
The BMS is an evaluative instrument which measures the performances of Down's syndrome children on fifteen basic motor skills based on fifteen corresponding test items. The fifteen skills are in developmental sequence and form a rising scale. Each of the basic motor skills has a specific development. This development is described in defined levels of competence. The levels of competence are in developmental sequence and likewise form a rising scale.

Chapter 5 describes psychometric research, carried out using the BMS. The intention of this research is the construction of a unidimensional variable which can measure the level of a Down's syndrome child's postural control in the period of the development of basic motor skills. In addition, the instrument was tested for reliability and construct validity.
The BMS was administered to 42 subjects with Down's syndrome, aged from zero to four years, with an average age of two years seven months. The test was carried out under standard conditions by one test leader, according to the procedure indicated in the test. Each test was recorded on video. Each videotape was scored by two observers independently of each other. After three months, ten tests, chosen at random, were evaluated once again. The data were analysed by

means of the Partial Credit Model of Wright & Linacre.
The BMS has a high degree of inter-rater and intra-rater reliability, .85 and .89 (Cohen's kappa) respectively; Cronbach's alpha was .94. Fit analysis indicated that the test items measure the variable 'level of postural control' unidimensionally. The postulated sequence was displayed in the classification of test items at the level of postural control. The hypothesized sequence of scale steps per test item was also confirmed. In addition, there was a significant correlation between age and the BMS score ($r=.81$; $p<.001$).
It was concluded that the BMS is an instrument which can measure the level of postural control of basic motor skills of Down’s syndrome children aged from zero to three years.

Intervention research

Chapter 6 describes the research into the effect of physiotherapy on the development of basic motor skills of Down’s syndrome children. The research group consisted initially of 22 children living at home; four children dropped out because of illness (age at intake nine to 47 weeks, average age 26.3 weeks). Participating children were selected on the basis of age, sex and on the expectation that co-operation would continue throughout the entire research period.
The research has a quasi-experimental research design (simple time series). All the children had physiotherapy treatment, the data of each child were also used in order to monitor the results of the intervention. The research period consisted of four periods of three months (thirteen weeks). In the first and third period of three months, the children received physiotherapy treatment once a week and parental guidance took place. Periods 2 and 4 were rest periods. During this time there was no treatment and no parental guidance. Before the first treatment period, the physical development of the child was registered (baseline specification). The baseline period lasted one month. In this period there was no physiotherapy treatment, but advice was given to the parents in some cases. The investigation was as to whether the applied physiotherapy treatment given in the two treatment periods had a positive influence on the development of the basic motor skills of the children participating, compared with baseline and rest periods. The data was analysed using SPSS.
The development of the child participants was measured a total of six times with the BMS. Since the literature assumed a correlation

between motor development and a child's mental ability, the mental scale of the Bayley Scales of Infant Development (BOS 2-30) was also administered six times. During the entire research period, possible external variables, such as health, care, daily activities and parental compliance, were all monitored.
After registration, a child's motor and mental abilities were tested and the baseline period began. After one month, this period was concluded with a second test (BMS and BOS 2-30, mental scale). Subsequently, the first treatment period began, according to the schedule given above. Each period of three months (both treatment and rest period) was concluded by administering the BMS and the BOS 2-30.

The physiotherapy treatment was based on a therapy concept derived from the theoretical framework previously mentioned, which had been specifically developed for Down's syndrome children. The concept describes the motor problems of these children and the corresponding physiotherapy treatment together with the parental assignment in the period of development of basic motor skills. A basic assumption in this concept is that this period is influenced by disturbances in the system of postural control, and that this leads to the development of specific motor behaviour. Generally speaking, Down's syndrome children demonstrate a preference for symmetrical patterns of posture and movement. Their motor behaviour is characterised by a lack of movement dissociation, of balance reactions and of movement variation. It is inadequate both in terms of function and appropriateness.
The postural tonus of Down's syndrome children does in fact increase in time and, with it, the level of postural control, but the development of basic motor skills, however, takes place under the influence of a reduced postural tonus. In a general sense, the physiotherapy treatment is intended to correct the specific development of basic motor skills and thereby to render motor behaviour more functional. The increasing postural tonus ensures, in principle, a better basis of corrected motor patterns.
More specifically, this treatment aims to improve the development of posture in every motor phase. What is important in this respect is the provision of adequate stability by stimulating the production of sufficient co-contractions. As usual in the case of motor development, this first takes place symmetrically and, if necessary, with support. Subsequently, in each motor phase the aim is to achieve motor behaviour in which the child, preferably without support, can move

away from the symmetrical postures referred to previously. The children are stimulated to transfer body weight sidewards, trunk motor ability, postural reactions (balance) and movement dissociation also being practised, in addition to movement variation and functionality. What is important in this respect is that motor skills should have a developmental coherence. Obviously, each child develops in a different manner. The physiotherapy treatment takes place on the basis of individual objectives. The treatment programme therefore, does not provide the prescription but the framework for therapy.
The treatment was administered by paediatric physiotherapists in private practices and in hospitals. Participating physiotherapists had been trained in the application of the treatment programme and in the research methods. Prior to the two treatment periods of three months, they were given the results of motor tests and individual therapy objectives specified on the basis of the test. During both intervention periods, the children were treated once a week (two periods of thirteen weeks). Each treatment session lasted from thirty to forty-five minutes. Each week the paediatric physiotherapist defined the content of the treatment and parental assignment based on the test results, the treatment recommendations and the treatment programme.
Parental assignment and participation are seen as an actual component of the treatment. Exercise therapy is only meaningful if parents can integrate the correction of motor patterns in the course of play and child care, thereby implementing it in their child's motor behaviour. For that reason the physiotherapist in attendance assigns aspects of the treatment to the parents. Each skill which is delegated to the parents is explained and demonstrated during treatment. The parents are given the opportunity to practise this in the course of the session. A short description of the skill is available for home use. Parents are encouraged to stimulate the skills in everyday activities (play and child care).

The results of the physiotherapy treatment in the treatment periods P2 and P4 are definitely positive. Motor development in the first treatment period P2 turned out to be significantly greater than in the first rest period P3 and the motor development in the second treatment period P4 turned out to be significantly greater than in the second rest period P5. Both in the first and second treatment periods (P2 and P4) the motor development measured by the BMS turned out to be significantly greater than in the baseline period P1. Motor development in the baseline period P1 however was not significantly distinguishable from motor development in the entire intervention period P2345. Registered

control variables did not influence these results significantly.
The conclusion was that the methodical problem-specific physiotherapy treatment administered improved inadequate conditional elements in the area of postural control, such as stability and balance. As a result of this, a significant acceleration was achieved during the treatment periods in the development of basic motor skills of young Down's syndrome children. Since not enough is known about the development profile of young Down's syndrome children on the BMS, follow-up research is recommended into the development of these children on the BMS, into the effect of long-term physiotherapy treatment on motor development and into the structural results of such intervention.

Curriculum Vitae

Peter Lauteslager was born in Utrecht (The Netherlands) on 29 September 1958. After obtaining the Atheneum-B diploma[1] in 1976 at the Bonifatius Lyceum[2] in Utrecht, he trained as a physiotherapist at the 'Stichting Academie voor Fysiotherapie' (SAFA) in Amsterdam. Following the completion of various courses in the field of Paediatric Physiotherapy, he was registered as a Paediatric Physiotherapist in 1997. From 1981 onwards, the author has worked as a physiotherapist at 's Heeren Loo Midden Nederland in Ermelo, a centre for care, innovation and advice for people with a mental disability. In addition the author is head of the department of paramedics.

As a result of a first publication in 1991 on the motor development of children with Down's syndrome, the author obtained a research budget from the Stichting Steunfonds 's Heeren Loo (Foundation for research support). After concluding a supervision agreement with Utrecht University, he has worked part-time in an official capacity as a scientific researcher since May 1993. In 2000 he has got his PhD.
In the course of the research period he has participated in activities at the Faculty of Social Sciences at Utrecht University and at the national research centre ISED (Institute for the Study of Education and Human Development). ISED awarded the publication "Test of Basic Motor Skills of Children with Down's syndrome: research into reliability and construct-validity" the 1998 ISED article prize. The author has presented his research in guest lectures at universities and post-HBO[3] courses in Paediatric Physiotherapy, and has given lectures at symposia, conferences and workshops.

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[1] Atheneum: pre-university secondary education. Atheneum-B diploma: final school certificate with science subjects option.

[2] Lyceum: pre-university secondary school

[3] HBO - Hoger Beroepsonderwijs - higher professional education

Test of Basic Motor Skills of children with Down's syndrome

Appendix 1

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1. Disturbances in the system of postural control and the development of basic motor skills

Children with Down's syndrome (hereafter DS children) display obvious motor problems and a specific motor development profile. The development of DS children is clearly slower in comparison with that of non-disabled children. Moreover, the development of their motor skills proceeds in an abnormal sequence. One of the most noticeable neuromotor disturbances is reduced postural tonus. All DS children are, to a greater or lesser extent, hypotonic. Associated with this, there are inadequate balance responses, insufficiently stabilising co-contractions of joints, a deficient proprioceptive feedback on posture and movement and an increased joint mobility. As a result, the motor development of these children has a characteristic profile. They have a reduced ability to assume and maintain postures. This leads to problems with motility in a posture; their motor behaviour is static and has a symmetrical nature. The entire development picture is indicated in the theoretical construct 'Disturbances in the system of postural control' (Table 1).

Primary	- reduced postural tonus
Secondary	- insufficiency of co-contractions - insufficiency of balance reactions - reduced propriocepsis - increased joint mobility
Consequences	- problems in achieving and maintaining positions in posture and movement - inadequate development of qualitative aspects of motor ability - inadequate appropriate motor ability

Table 1 Disturbances in the system of postural control

Postural control means 'the coordination of one's own body processes which are responsible for maintaining posture in motor behaviour'. Disturbances in postural control are particularly evident when a child is

mastering a posture and movement against the force of gravity. Overcoming gravity is inherent in movement; the consequences of disturbances in postural control are thus particularly noticeable in the motor behaviour of these children. Since the various motor phases have a developmental coherence, motor problems in a particular phase will influence the development of motor abilities in subsequent phases.
Normal motor development can be divided into four stages: the stage of reflexive movements (prenatal and first year of life), the stage of rudimentary movements or basic motor skills (first two years of life), the stage of fundamental movements (second to seventh year of life) and the stage of specialised movements (from the tenth year onwards). The undisturbed process of the stage of development of basic motor skills is very important for motor development, since in this stage the foundation is laid for the development of the stages of fundamental and specialised movements.
In the stage of the development of basic motor skills, certain skills can be distinguished in which there is a specific aspect of motor behaviour against gravity. The development of these particular skills in DS children is negatively influenced by disturbances in the system of postural control. As a result, their development has an extremely idiosyncratic nature. As the postural control of a DS child increases in time, the ability to control the posture also increases. However, the ability to control posture is initially insufficient for the child to be able to assume an adequate posture and to stabilise it. The child is nevertheless ready for the development of certain motor skills and, for the time being, integrates adequate compensation mechanisms in motor skills. The postural support that the DS child uses in the course of motor behaviour is characteristic. For example, the posture of the trunk in sitting is supported by the hands and in crawling the child slides the legs instead of raising them.
Asymmetrical motor activities require a more adequate system of postural control than symmetrical motor behaviour. DS children compensate their disturbances in postural control by symmetrical motor activities. Balance reactions, by definition, require asymmetrical movements (lateral trunk flexion and rotation of the trunk). The DS child's balance responses are insufficient and inadequately developed. The child compensates for this by enlarging the supporting surface of the posture and by moving within this extended supporting area. For example, he[1] sits with legs wide apart and does not move the trunk outside the extended supporting surface. This has a negative effect on the dynamics of motor behaviour. Motility and variation of movement

[1] 'He', and 'him' and 'his' refer equally to male and female DS children

require adequate postural control. The level of postural control of a DS child is inadequate; his motor behaviour develops in a static and uniform manner. Table 2 gives an example of the development of the basic motor skill of 'sitting' when influenced by disturbances in postural control.

As a result of a deficient level of postural control, a DS child will initially not be in an adequate position to stabilise the posture of sitting. The development commences the moment the child can sit without support, but he supports the position of the trunk with his arms by putting his hands in front of him on the ground or on his legs. With increasing ability to control the posture, the necessary arm support decreases; after a phase of supporting with one arm, sitting without support from the arms becomes possible. Initially, the child sits with a bent back and with the pelvis tilted backwards. Subsequently, it becomes increasingly possible to extend the back. This becomes visible when the child starts sitting with a mainly straight, flat back without evident kyphosis or lordosis; the pelvis is now in a mid-position for tilting forwards and backwards. Ultimately, the child will extend the back in such a way that he is sitting with a straight back, with a lumbar lordosis and with the pelvis tilted forwards. The position is then chiefly vertical. Initially, dissociation of the assumed position, for example by rotating the shoulder girdle in relation to the pelvis, is not possible, the child's sitting having a static character. With an increasing ability to control posture, symmetry is no longer a condition for being able to maintain the posture. The child is now in a position to rotate the shoulder girdle and the pelvic girdle in relation to one another and to flex the trunk laterally while the unsupported, assumed posture continues to be maintained in combination with a lumbar lordosis. Ultimately, the child has enough balance to be able to sit on one buttock with a laterally tilted pelvis and a laterally flexed trunk. He can sit sideways without losing the sitting posture.

Table 2 Specific motor development of 'sitting'

2 Measuring instrument

The measuring instrument, ‘A test of Basic Motor Skills for Children with Down’s syndrome’ (BMS) is a test of motor skills specifically designed to test young DS children and is based on the theoretical framework ‘Disturbances in the system of postural control’. The BMS has been submitted to psychometric investigation. There is a report of the results of this investigation in Chapter 4 of this book. With the BMS, the level of postural control of motor behaviour can be measured in the period of the development of basic motor skills. The BMS can be used from the moment that the development of voluntary movement begins, to the period in which independent standing, standing up and walking are possible. In general, the test can be used from the age of three months to three years.
The BMS measures the level of postural control of fifteen basic motor skills (see Table 3). Skills have been selected on the explicit manifestations of disturbances in postural control and as a group they are representative of the motor problems of DS children in the period of development of basic motor skills. The fifteen skills are placed in developmental order and together form a rising scale.

1. Raising legs in the supine position
2. Reaching out in the supine position
3. Raising head in the supine position
4. Propping up on elbows in the prone position
5. Rolling over from the prone to the supine position
6. Rolling over from the supine to the prone position
7. Sitting
8. Moving forward over the ground
9. Walking with support
10. Standing with support
11. Standing up with support
12. Standing without support
13. Adopting the sitting position
14. Walking without support
15. Standing up without support

Table 3 Fifteen basic motor skills

Each motor skill shows a characteristic development, influenced by disturbances in postural control. In the BMS there is a description of this development for each skill. The description is subdivided into explicitly defined stage levels. The stage levels for each skill are placed in developmental sequence and jointly form a rising scale per skill. The BMS has fifteen scales; with each scale relating to one motor skill, there is an increasing level in the ability of postural control to be recorded (see Table 4). By being able to compare the motor behaviour of a DS child with the defined stage levels, it is then possible to make a stage definition.

Execution The child is placed in the sitting-without-support position on a horizontal surface and is encouraged to stretch from the trunk by eliciting reaching upwards with the arms and to transfer weight laterally by eliciting sideways reaching out with the arms.
Scale 0. The test item has been correctly administered, however the child shows no motor behaviour that is described in any of the stage specifications below. 1. The child sits independently during stimulation for at least 5 seconds while supporting the position with two hands. 2. The child sits independently during stimulation for at least 5 seconds while supporting the position with one hand. 3. The child sits independently during stimulation for at least 2 seconds without support from the arms and with a bent back. 4. The child sits independently during stimulation for at least 2 seconds without support from the arms with a straight back with no lumbar lordosis. 5. The child sits independently during stimulation without support from the arms. When stretching the back, a clear lumbar lordosis can be observed for at least 2 seconds. 6. The child sits independently during stimulation without support from the arms. When stretching the back and transferring weight to the lateral a clear lumbar lordosis and a clearly laterally flexed trunk can be observed for at least 2 seconds.

Table 4 Example of a stage subdivision. Test item 7: Postural control when sitting

In order to be able to use the fifteen basic motor skills and corresponding scales as a measuring instrument, fifteen test items have been made. The aspects below have been elaborated per test item.

- A short description of the objective and the operational system of the test item.
- A description of the specific development of the basic motor skill in relation to postural control.
- An explanation, which includes the indicative developmental points recorded and a description of the testing procedure.
- The camera position in relation to the child.
- A stage subdivision.
- Test instructions.
- Instructions for scoring.

The development of motor behaviour of a basic motor skill is an extremely complex matter. Its representation in a stage subdivision is, by definition, a simplification. The development of each basic motor skill can be subdivided in principle into the development of subsidiary motor skills, which can each be influenced by the disturbances in the system of postural control. Per basic motor skill it is possible to make several stage subdivisions, each of which records the development of a subsidiary aspect. As this would make the BMS far too complex, it was decided to make one stage subdivision per basic motor skill. With these stage divisions, those aspects of motor behaviour can be assessed which are the most indicative of the development of motor skills influenced by disturbances in the system of postural control. Stage level 1 represents the first observable expression of motor behaviour of a motor skill. The last description of a stage level per skill represents motor behaviour with a functional level of postural control. The basic motor skill can be applied in the course of posture and movement. The interim stage levels represent the course of development as manifested under the influence of an increasing ability to control posture. In this, the general lines can be observed, in the first instance in the field of increasing possibilities regarding symmetrical posture and stability. Subsequently, increasing postural control makes asymmetrical movement possible. As a result, in the third place, the development of postural reactions is set in motion. The increasing development of postural reactions results in an increasing ability to move in a posture. The increase in the variation of movement leads to an increase in the functionality of motor behaviour. In addition, the occurrence of compensatory movement strategies is processed. The stage description 0 means that the test item concerned has been

correctly administered, but that the motor behaviour displayed cannot be allocated to any one of the stage levels concerned. Incorrectly administered test items cannot be assessed.
As far as possible, the stage subdivisions are uniform in construction. As soon as the child has shown the ability to stabilise an assumed posture, time registration is administered. The ability to stabilise an assumed posture during a particular period is an objective measure to differentiate in the level of postural control. A stopwatch can be used to determine whether a posture can be maintained for a minimum of 2 or 5 seconds. An increasing level of postural control is evident from the fact that a child is capable of moving in the assumed posture. There is an increasing capacity for disassociated movement in a posture and therefore of an increasing functionality. Comparison of the motor behaviour of a child with the stage level description is enough to make a stage specification.
There is a great variety of motor behaviour in the development of motor skills. In the stage subdivisions, naming the normative elements in such behaviour has reduced the number. That makes it possible to assess a variety of motor behaviour with one stage level subdivision. However, not all variations that appear can be classified in that. The basic motor skills of test item 8 (Moving forward over the ground) and 13 (Sitting up) both have two variously proceeding developmental paths. Both paths lead ultimately to one identical motor skill. With a view to the assessment of behaviour, both development paths have been incorporated in the appropriate stage level subdivision. Moreover, several skills have stage level classifications in which various kinds of motor behaviour of an identical level are assessed. The descriptions of the kinds of motor behaviour in those cases are connected at one level in parallel. For example, the basic motor skills 3 (raising head in the supine position), 8 (Moving forward over the ground) and 15 (Standing up without support) in the first stage specification, cover various forms of motor behaviour. This behaviour can be observed in each case as the beginning of the development of the motor skill concerned and can also be assessed at an identical level.

The BMS is an ordinal measuring instrument. Both the fifteen basic motor skills and the stage levels per skill are in developmental sequence and have an ordinal coherence. Together they provide insight into the process of motor development. In contrast to an indicative or a psychometric instrument, the BMS has not been standardised. Each stage level description has an independent value

since there is a hierarchical developmental coherence with preceding and succeeding stage level descriptions. The coherence of the hierarchically arranged developmental stages is indicative for the assessment of the motor development. In the hands of a trained paediatric physiotherapist, the BMS is an extremely practical and refined measuring instrument. After administration, a precise report can be made of the level of a child relating to the development of the motor skills tested. On the basis of the ordinal coherence of the skills and on the basis of the developmental coherence between the stage levels per test item, a precise indication can be given as to which following stages come into consideration for stimulation in terms of physiotherapy. By repeating the measurements at a particular interval the process of development can be evaluated and intervention, if necessary, can be adjusted.
The fact that functional developmental motor ability is being measured and the specific character of ordinal measuring instruments makes the BMS particularly appropriate for testing young children with a mental disability. In fact, the administrative procedure of ordinal scales when compared to psychometric instruments, is very flexible.
Psychometric tests have standardisation of test procedure and test materials; the examiner has a passive role and has the task of presenting the prescribed instructions in the correct manner. With ordinal scales, on the other hand, the examiner has an active role. His task is to present the test in such a way that the child can react optimally. The examiner is, after all, interested in the appropriateness of a child's motor behaviour and not in that child's reaction to a standardised situation. The intention of each test item of the BMS has been laid down and is described per item. The method of stimulation, also described, is generally effective in eliciting the desired motor skill. In spite of the fact that the manner of stimulation may vary, the examiner should be vigilant that justice is done to the intention of the test item and that the motor behaviour performed by the child comes into being through the child's efforts alone.

3 General guidelines for administering the BMS

The BMS is to be administered by an experienced paediatric physiotherapist. Training in administering the test should take place. The test is to be recorded on video in order to evaluate motor behaviour. The examiner should be familiar with the description of the test sections and with the administration of the test. Testing should take place in a flexible and routine manner so that the child can maintain interest in the test. In order to promote the uniformity and the structure of the test administration, brief instructions per test item are included for the examiner, in which step by step the objective, execution, manner of stimulation and the position of the camera are stated (see Table 5). A consistent test structure is extremely beneficial for the evaluation of the video.

Objective
- Registration of the stage at which the child is capable of sitting unsupported.

Execution
- Initial posture: independent sitting position.
- Stimulate the child to maintain the sitting position for 5 seconds with as little arm support as possible.
- Stimulate the child to extend the trunk for 5 seconds by reaching out forwards and upwards.
- Stimulate the child to show lumbar lordosis of the trunk for 2 seconds by reaching out forwards and upwards.
- Stimulate the child to lordosis and lateral flexion of the trunk for 2 seconds by reaching out upwards and sideways.

Stimulation
- Offer the motivating toy in front of, and somewhat above the child.
- Move the toy forward and above, just out of the child's reach.
- Move the toy sideways and above, just out of the child's reach.
- If necessary, position the trunk passively.
- If necessary, position the arms passively.

Camera position
- Obliquely behind the child at an angle of about 45° with respect to the sagittal plane.

Table 5 Test instructions. Test item 7: Postural control when sitting

A test item should be worked out in a completely clear and adequate manner to the extent that there is full differentiation in the motor ability of the child. The examiner should make visible the maximum attainable level of a child in a test item. With a view to the evaluation of the video, it is a good idea to establish this maximum level twice. It is not necessary to do this more than twice as it would make the test unnecessarily long. The examiner should name a test item at the point at which the testing of this item has been completed. Spontaneous motor behaviour of children is not scored, unless the examiner modifies the situation to the extent that it complies with the test description and the test item is also named as such. For example, in test item 4 (Elbow support in prone position), if a child spontaneously assumes the correct initial posture, this is not a hindrance to proceeding with the test. Both the examiner and the observer will have to check each time whether the test item to be evaluated has been correctly administered. Should this not be the case, the score is meaningless. The position of the child with respect to the video camera is described both in the information and in the test instructions per test item. In the interests of clarity, movement of the camera and zooming in and out are kept to a minimum. Unless the motor behaviour to be filmed requires the opposite, for example in unsupported walking (test item 14), the recording is kept as static as possible. In principle, the filming is done with the child filling the picture. The examiner does not need to be visible in the picture and should be careful not to obstruct the view of the observers. However, the manner of stimulation and the motivating toy should be in the picture. After completing a test item, the camera can be turned off, if necessary, before proceeding with the following item.
As stated above, the test items are numbered from 1 to 15 and have an ordinal sequence. With a view to administering the test in practice, the test items are grouped according to the initial posture. Test item 4 is administered in the prone position, items 1, 2 and 3 in the supine position, while 5 and 6 test rolling over from the prone to supine position and vice versa. In the test items 7, 8 and 13 the posture is sitting, 9, 10 and 11 relate to standing and walking with support, while test items 12, 14 and 15 deal with standing and walking without support. Twelve of the fifteen test items are administered on an exercise mat, with 12, 14 and 15 just on the floor. Dependent on the level of motor ability and the interest shown by the child, the examiner may start administering the BMS with any group of test items. It is not important to have a fixed sequence of test items to be administered

and in practice it may not even be desirable. As previously mentioned, each test is recorded on video. Scoring the test takes place subsequently from the videotape from which more complex motor behaviour can be optimally evaluated. Physiotherapists who have had training in the specific motor problems of DS children and in the BMS are responsible for the scoring. Score instructions (Table 6) are available for the observers. Contained in these instructions there is a description per test item of the characteristic elements that have a stage subdivision and per stage description the constituent characteristic elements are named. To evaluate motor behaviour the complete stage subdivision with relevant information is always the most appropriate, but the score instructions can be of value in order to ascertain the differences between the stage descriptions for each stage subdivision.

Characteristic elements of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Lumbar lordosis.
c, Trunk lateral flexion.

Posture
d. Supports position with two hands.
e. Supports position with one hand.
f. No arm support.
g. Back is bent.
h. Back is straight without lumbar lordosis.

Period
i. At least 2 seconds.
j. At least 5 seconds.

Stage description	Elements
0.	a.
1.	a,d,j.
2.	a,e,j,
3.	a,f,g,i.
4.	a,f,h,i.
5.	a,b,f,i.
6.	a,b,c,f,i.

Table 6 Scoring. Test item 7: Postural control when raising the head in the prone position

In administering the test, care should be taken to ensure that the child is not distracted by external factors. The child, the parents, the examiner and, if necessary, a cameraman should be the only persons in the test room. The room and its furnishings should be such that the child can concentrate on participating in the test. There should be an exercise mat and two adjustable tables in the room. The stimulation material is within reach of the examiner, but out of sight of the child. For the test item ‘standing up with support’ (Item 14) a standard table edge has been developed. It is necessary to have a video camera there, but it should be set up in such a way as to avoid distraction as far as possible. The child is undressed, but pants and if necessary a nappy may be retained. The latter is based on practical considerations and in spite of the fact that a nappy may impede motor behaviour.
The test procedure as described per test item is carried out in such a way that the child is given the optimal opportunity to react. It is important that the examiner is convinced that the toy actually interests the child and that it induces him to perform motor behaviour. Nevertheless, if the child does not display any motor behaviour that is specified in any of the corresponding stage subdivisions, the examiner should round off that test item. The total test duration is restricted to not more than thirty to forty-five minutes. The administration of the test should be perceived by the child to be a play situation.
The intention of the test item can be made clear to young children by having the examiner make use of positioning. For example, it is more or less impossible to keep a child that can sit independently in the prone situation, unless this is made clear by the positioning hand of the examiner on the pelvis. However, one hand on the pelvis can produce stability, for example for the child reaching out in the prone position, whereby he gains unintentional assistance in the motor behaviour to be performed. The examiner should be aware of this fact and may use positioning in an explanatory manner, but should avoid giving unintentional assistance. The observer should assume that positioning is applied with the correct intention. A position can be further clarified by marking out the space available for the child. For example, test items in prone and supine positions can be administered on a Bobath table. A child then has fewer opportunities to withdraw from the test situation.
The examiner can also indicate a desired posture or movement by demonstrating it or by letting the child feel what is expected. The desired motor behaviour can be carried out passively on the child or offered to the child. For example, if the child has to raise his legs in the

supine position (test item 1) in the first instance the examiner can bring the legs and feet passively into the field of vision of the child. It must be clear that there is only a score when the child carries out the motor behaviour independently. The legs will ultimately have to be raised from the ground by the child himself. In a situation like this, the examiner will give the child the opportunity to assume and carry out a posture or movement independently.

A child scores positively at a particular stage specification if he complies at least once with the described motor behaviour. That means that the examiner should administer the test in a focused and expert manner in order to arrive at the required differentiation. The various stage specifications are mutually exclusive. A child that is tested for a motor skill therefore scores one stage specification. If a child shows various kinds of motor behaviour which could be scored, as a result of the administration of one test item, the behaviour that scores the highest is the one to be rated. The examiner should safeguard against the child having a sense of failure if he cannot comply with a movement assignment.

A number of specifications of levels define motor behaviour that is applicable to related joints. Reaching out in the supine position with one arm (test item 2), for example, can take place either to the left or the right. We have chosen to exclude the left/right differentiation from the test, unless otherwise specified in the test item information. For example, with test item 12, relating to the knee position in the course of standing unsupported, the child scores positively if he can show the motor behaviour described with either of his knees. As a result of left/right differences it may thus occur that the child complies with various specifications of stages with regard to the knees. The premise in such a situation is that the highest scoring description of level is counted. Likewise, with test items 5 and 6 (rolling over) it is possible that rolling over is from the left or the right side and that differences in level can be observed. The rule here is also that the highest scoring specification of stage level is counted. With several stage specifications, in which primarily symmetrical postures are described, it is important to establish the duration of the period in which the posture can be maintained. The observer uses a stopwatch for this. A period begins once a posture has been adopted and stops at the moment that the posture is disturbed. There is no need to time the period taken to adopt the posture, nor the motor behaviour following the discontinuation of that posture.

For the optimal execution of the test it is important that the child feel

comfortable. To this end, the timing on the day of testing is chosen in consultation with the parents and organised in such a way that any eating or sleeping times are taken into consideration. Parents should be present in the background, but may, if they wish, be involved by the test leader in the administration of the test. In test item 14 for example (walking without support), the child can be encouraged to walk towards one of his parents. In order to put the parents at their ease, information can first be given about the course of the test. In that case, the child is not immediately approached and has the opportunity to get used to the examiner and the situation. As mentioned earlier, it is well-advised to start with items in which the child is expected to take part without reservation. The test can be further administered from that point. It is less relevant to have a fixed test sequence.
Whenever it happens during testing that certain test items are clearly below or above the level of the child, in view of the ordinal nature of the test, it should be assumed that these items are either mastered or are not possible. A child that can sit up independently, for example, will usually not be inclined to demonstrate arm motor abilities in the supine position. Yet the examiner should be aware that, in view of the fact that the children being tested have a mental disability, incongruities are possible in the motor development. It might also be that the development of a motor skill has not been completely mastered. In any case, there is an overlap in the development of motor skills. In case of doubt, a test item can be taken again at a later stage of the test. All in all, there is a preference for administering the entire test, but with a child that, for example, cannot stand with support, it is unnecessary to test walking without support.

Motor skills can be elicited with toys. It is important that the child's attention is attracted by the toy and that the interest is maintained throughout the administration of a test item. With mentally disabled children in particular, it is important to find out whether the child is not reacting because he has not mastered the motor behaviour required or because he is simply not stimulated by the toy. For that reason it is a good thing to have available a wide range of toys suitable for various ages and levels of development, and also with several functions. The form of the stimulation may be varied so long as the essence of the test remains the same. Obviously, toys suitable for babies are needed, but toddlers and young children also need to be stimulated. Toys should be nice to look at, but also to hear, to feel, to put in the mouth and to sit on. Material should be challenging and must be exciting. A child may have a definite preference for particular playthings. It is a good idea to find out from the parents about such preference and actually to make use of the favourite toys from the start. If required by the test item, the plaything must have specific properties. Reaching out with one hand in the prone position, for example, must be stimulated with a plaything that can be grasped with one hand and not a toy that requires two hands. Playthings must be safe. In the choice of playthings one should be alert to the danger of small, loose components, or sharp corners. It is important to offer toys one at a time and to keep the remaining playthings out of sight of the child. A zipped bag or a box with a lid would be a solution. Some tact is needed when exchanging the toys.

4. BMS score and BMS reporting

BMS score sheet	SC 0	SC 1			SC 2			SC 3			Score
1. Raise legs in supine position	0	1	2	3	4	5		6	7	8	
2. Reach out in supine position	0	1	2	3	4	5		6	7		
3. Raise head in supine position	0	1	2		3	4		5			
4. Prop up on elbows in prone position	0	1	2		3	4		5	6		
5. Roll over from stomach to back	0	1	2		3			4	5	6	
6. Roll over from back to stomach	0	1	2		3			4	5	6	
7. Sitting	0	1	2	3	4	5		6			
8. Move forward over the ground	0	1	2		3	4		5			
9. Walk with support	0	1			2	3		4	5	6	
10. Stand with support	0	1	2	3	4	5	6	7	8		
11. Stand up with support	0	1			2	3		4	5		
12. Stand without support	0	1			2	3		4	5		
13. Adopt sitting position	0	1			2			3			
14. Walk without support	0	1	2		3			4	5		
15. Stand up without support	0	1			2			3	4		
									BMS total score		

Table 7 BMS score sheet. Division of score categories (SC) per test item

A child's scores are noted on a score sheet (Table 7). In order to establish the BMS total score, the subdivisions per test item are divided into 4 score categories (SC 0, SC1, SC2 and SC3). In fact, the number of subdivisions varies from four (test item 13) to nine (test item 1). Test item 7, for example, has six subdivisions (Table 4, Table 7). The subdivisions 1, 2 and 3 of test item 7 are brought together in score category 1,

the subdivisions 4 and 5 in score category 2, while subdivision 6 represents score category 3. The division into score categories is visible on the score sheet and also in the grouping of the subdivisions in the stage subdivisions (Table 4). A maximum of three points can be obtained per test item. Per test item, score category 1 provides one point, score category 2 two points and score category 3 three points. The maximum BMS score is therefore fifteen times three, making forty-five points.
Not every BMS administration will lead to scores on all fifteen of the test items. Non-completed scores are inherent in the use of measuring instruments with which a development field with a particular range is being evaluated. Non-completed scores occur predominantly in three different situations. In the first place, they occur in higher test items with children who do not have the motor competence to display the behaviour demanded. In the second place, it occurs in children in the toddler age group who can assume the sitting position independently. These children indicate clearly their current development area, but are insufficiently cooperative to carry out the test items in the supine and prone positions; they adopt a sitting position. A case in point is that rolling over from the supine to the prone position (test item 6) can be administered in such cases (the child proceeds to the sitting position), but rolling over from the prone to the supine position cannot (test item 5). In the third place, in conclusion, the scores of children who can stand, walk and stand up without support are not completed. The corresponding test items with support are not administered (3-scores).

Group 1 1. Raise legs in supine position 2. Reach out in supine position 3. Raise head in supine position 4. Prop on elbows in prone position	**Group 3** 9. Walk with support 10. Stand with support 11. Stand up with support
Group 2 5. Roll over from stomach to back 6. Roll over from back to stomach 7. Sit 8. Move forward over the ground	**Group 4** 12. Stand without support 13. Adopt the sitting position 14. Walk without support 15. Stand up without support

Table 8 Supplement to non-completed scores; 4 groups of test items

In order to arrive at a BMS total score, in the case of non-completed scores we proceed to fill in these scores. This is done by integrating more basic motor skills in more complex motor skills. In order to proceed to fill in non-completed scores, the fifteen test items are divided into the four linked groups of motor skills (Table 8). The fifteen test items are classified in ordinal sequence. Group 1 represents the development of motor skills in a horizontal initial posture during early development. Group 2 consists of skills for which axial motor ability and trunk disassociation are increasingly necessary. Group 3 consists of skills relating to standing and walking, performed with support, and group 4 consists of skills relating to standing and walking without support.

A score is considered to be non-completed if it complies with three conditions. In the first place, the child does not take part in the test item. In the second place, case history indicates that the child has mastered the non-completed motor behaviour. In the third place, the group of test items following the group in which the non-completed score occurs, includes at least two test items with a categorical score assessed at higher than 0.

The non-completed score is then determined by calculating the average of the scores that were obtained in the group of test items in which the non-completed score occurs. It is rounded off to the categorical score of 0, 1, 2 or 3. Each calculated value in which the number after the decimal point is lower than 0.5 is rounded off downwards (e.g. a group average of 2.33 will result in an additional score of 2). If two or three scores in a group of test items have not been completed, the average is calculated of those scores obtained in the group in which the non-completed scores occur. After rounding off, the calculated average score is used to supplement the non-completed scores. If all the scores from one group are missing and the three criteria of non-completed scores quoted above have been complied with, each test item from the group concerned obtains the supplementary categorical score 3.

A BMS report can be made in a straightforward manner on the basis of a BMS administration. On the basis of a child's stage scores the current developmental level of the fifteen basic motor skills can be described quite precisely. The description of the stage specification can be used as a guideline. As the fifteen test items and the subdivisions per test item have an ordinal coherence, it is also possible to specify individual motor therapy objectives. The descriptions of the stage subdivisions can also serve as a basis for this.

5 Test equipment

In order to be able to administer the BMS test the examiner requires an exercise mat (200 x 125 cm), two tables adjustable in height, one standard table edge, one exercise stick (100 centimetre) and an assortment of toys. The play material should attract the child's attention, stimulating him to look at it, to grasp it and to move towards it. The toys should encourage the child to play because they have striking colours, make noises in one way or another or move and are pleasant or exciting to touch. The assortment of playthings includes an unbreakable mirror, rattle cubes, a musical box, 2 strings of bells, squeaky animals and key-ring rattle. In addition, use is made of a Little Tikes toy bus with removable passengers, robust plastic farm animals, a number of dolls/cuddly toys including Bert and Ernie, stacking beakers and two wind-up frogs. Finally, all sorts of balls are used (foam ball, juggling balls, rattle ball (Ball with holes) and bean bags. For the video recording, a video camera with a stand (Table 9) is required.

Video camera and stand	
Exercise mat	
Two tables adjustable in height	
Standard table edge	
Exercise stick	
Assortment of playthings	
- Unbreakable mirror	- Rattle cubes
- Musical box	- Key ring rattle
- Two strings of bells	- Squeaky animals
- Dolls	- Stacking beakers
- Soft toys	- Wind-up frogs
- Balls	- Farm animals
- Toy bus with passengers (Little Tikes)	

Table 9 Test equipment

6 Test sections

6.1 Test item 1: Postural control when raising the legs in the supine position

Objective and method

The objective of this test item is to register the stage at which the child is able to raise the legs in the supine position. To this end, the child is put in the supine position and encouraged to raise his legs.

Motor development in relation to postural control

As a result of an unsatisfactory level of postural control, the DS child is initially not capable of raising the legs from the floor. The legs often lie totally supported by the ground in a bent position (‘frog posture’) and in the first instance hardly move at all. The development of raising the legs in the supine position as regards this test item begins at the moment that the child reacts to stimulation by moving the legs in the horizontal plane. However, this does not result in the child raising the legs from the ground.

With increasing postural control, the child is more and more capable of raising the legs. In the first instance, only the knees will be raised, with the feet remaining supported on the ground. Later, the whole leg will be raised from the ground. In doing this, the contralateral leg initially remains on the ground to stabilise the trunk, but subsequently, the child will raise both legs together. A functional level of postural control has been reached when the child is in a position to play a hands-and-feet game for example. At first, the lumbar column flattens out and the pelvis is somewhat tilted backwards as a manifestation of the flexion activity of the trunk. Ultimately, raising the legs is accompanied by forceful flexing of the trunk. The pelvis is tilted backwards and the sacrum comes free from the ground.

Information on the administration and evaluation of the test item

In administering this test item it is important to establish whether the child is capable of raising the legs in a supine position. Should it be accompanied by a stabilising flexion activity of the trunk it should be registered whether the pelvis is tilted backwards and whether the sacrum can be raised from the floor when required.

You should generate so much interest in the child’s own feet that he wants to bring his hands and feet together, or his mouth and hands and feet. The examiner can bring the feet passively into the child's vision or to his hands and mouth. The feet can be made especially interesting by having an attractive toy attached to them. From a practical point of view, the motivating toy should not drop from the feet to the lower legs. Should that happen, the child can reach it earlier and does not have to raise the legs as far. During the final test situation, the child should be able to manage to raise his legs independently. The examiner should ensure that in the initial phase the child is lying with his legs flat on the floor. The leader should prevent the child from supporting the raised leg position with his hands.

Once the child assumes a raised position with one or with both legs, or with the knee, the duration of the action is determined by further differentiation (short-lasting or minimum two seconds). The time registration starts from the moment that the knee, the leg or the legs concerned are raised from the floor without support. As far as stage levels 4, 5 and 6 are concerned, this is the moment at which the second leg comes free from the floor. It ends at the moment that the child loses the adopted position. The duration of the lumbar lordosis does not have to be recorded.

Increasing flexion activity of the trunk is apparent from the extent of backward tilting of the pelvis in the course of raising the legs and stabilising the leg position. The stabilising contraction of the stomach muscles is apparent because the pelvis tilts backwards and the lumbar spinal column then flattens. Finally, one can observe that the pelvis is tilted to such an extent that the sacrum comes free from the ground.

Nota bene

It is important to distinguish whether the legs are raised one after the other, or more or less simultaneously. Whenever legs are clearly raised one after the other, at the moment that the upper leg has passed the vertical position, the first leg raised will provide a counter weight for the leg still to be raised. This is a way of compensating for a lack of trunk stabilising ability. Synchronous or almost synchronous raising of the legs makes a maximum demand on the stabilising ability of the trunk. The second leg should be raised no later than when the first raised leg has achieved the vertical position.

When both legs are raised simultaneously it should be possible to observe pelvic tilting before the hips have achieved their position of maximum flexion. In that case, pelvic tilting can be attributed to trunk stabilisation. Beyond this position, it is possible that the force of gravity is responsible for the tilting of the pelvis. It may occur that the pelvis tilts because the child pulls the feet further with his hands, for example towards the mouth. Since this is not tilting caused by trunk activity the tilting is not scored. Furthermore, it may be observed that the child rolls on to his side to raise his legs. This is also not scored, as raising the legs should take place in the supine position against the force of gravity.

Position of the camera

The camera is placed at the side of the child, filming almost horizontally at an angle of 90° with respect to the sagittal plane.

Stage classification

Execution The child is placed in the supine position with the legs flat on a horizontal surface and is encouraged to raise the legs.
Scale 0. The test item has been correctly administered. However, the child shows no motor behaviour that is described in any of the stage specifications below. 1. The child moves one or both legs over the floor in the horizontal plane. The legs remain totally supported by the floor, raising them is not possible. 2. The child raises one or both knees from the ground. The raised position is stabilised for at least 2 seconds, the feet remain supported by the ground and are not moved. 3. The child moves one or both legs with one knee raised from the ground. The feet move but are still supported by the ground. 4. In the supine position, the child has one leg or both legs off the ground for a moment. 5. In the supine position, the child has clearly raised both legs one after the other from the ground and keeps them raised from the ground for at least 2 seconds. 6. In the supine position the child has raised both legs from the ground almost simultaneously, holding them there for at least 2 seconds. 7. In the supine position, the child has raised both legs from the ground almost simultaneously. Flexion activity in the trunk is clear because the lumbar spinal column flattens out when the legs are raised and the pelvis is tilted somewhat backwards. 8. In the supine position, the child has raised both legs from the ground almost simultaneously. He flexes the trunk when raising the legs to the extent that the pelvis tilts backwards and the sacrum clearly comes off the ground.

Test instructions

Objective
- Registration of the level at which the child is capable of raising the legs in the supine position.

Execution
- Initial posture: supine position, legs flat on the floor.
- Encourage the child to raise both legs simultaneously.
- Encourage the child to stabilise the raised leg position for 2 seconds.
- Motivate the child to flex the trunk.

Stimulation
- Attach a motivating toy to the feet.
- If necessary, position the legs passively.

Camera position
- At the side of the child, at an angle of 90° with respect to the sagittal plane.

Scoring

Characteristic features of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Moves one or both legs.
c. Moves feet.
d. Raises one or both legs.
e. Clearly raises legs one after the other.
f. Raises legs almost at the same time.
g. Flattens out lumbar spinal column, tilts pelvis somewhat backwards.
h. Tilts pelvis backwards, sacrum comes free.

Posture
i. Legs entirely supported by the ground.
j. Knees raised, feet supported by the ground.
k. Legs raised.

Period
l. Short duration.
m. Minimum 2 seconds.

Stage specification	Elements
0.	a.
1.	a,b,i.
2.	a,j,m.
3.	a,b,c,j.
4.	a,d,l.
5.	a,e,k,m.
6.	a,f,k,m.
7.	a,f,g.
8.	a,f,h.

6.2 Test item 2: Postural control when reaching out with the arms in the supine position

Objective and method

The objective of this test item is to register the stage at which the child is in a position to reach out with the arms in the supine position. To this end, the child, in an unsupported supine position on the ground with the arms beside the body, is encouraged to reach upwards with one or both arms. Subsequently, he is encouraged to reach out sideways with one or both arms to follow a motivating toy.

Motor development in relation to postural control

As a result of an unsatisfactory level of postural control, the DS child is initially not able to raise the arms from the ground. The arms often lie in a bent position next to the body ("hooray" position) completely supported by the ground and are hardly moved at all. The development of motor behaviour that is registered in the context of this test item commences when the child reacts to a motivating toy by moving the arms in the horizontal plane. The arms are still supported by the ground. A stage further is when the hands, supported by the body or the chest, are moved towards each other or towards the mouth. In the first instance, the arms are not raised, but dragged along the ground and over the body towards each other.
Children are then in a position to raise the arms from the ground for short intervals. However, purposefully stretching upwards to reach a toy is not yet possible. One group of children stretches up by raising the forearms from the chest in the direction of the toy, with the upper arms supported by the chest. At the following stage of development the whole arm is used to reach out. A functional motor level has come into being when the child is capable of reaching out with the whole arm and is also in a position to follow a toy sideways. The child can now play in a supine position. It is essential that the arms be moved sideways in relation to the trunk. When the child follows the toy sideways by rotating the trunk, the level of postural control of the shoulder girdle is insufficient to make disassociated movement possible. The child compensates for this by rotating the trunk.

Information about administration and evaluation of the test item

In administering this test item, it is important to determine whether the child can raise the arms in the supine position and whether a reaching-out arm position can be stabilised for two seconds. Finally, the child must be able to follow a toy sideways with arms reaching out. The toy should be offered in such a way that the attention of the child is roused, that he remains interested in the toy and wants to reach out to it. The stimulation must be such that an almost vertical extended arm position is elicited. If necessary, the examiner may passively indicate the reaching out position to the child. In the initial posture, the child's arms should lie on the ground next to the trunk.

Once the child reaches out it is important that it is clear whether or not he can reach out with the entire arm. The toy should be offered in such a way that this can be differentiated. If the child reaches out toward a toy with the entire arm, or with the forearm, it is important to determine whether the posture can be stabilised for two seconds.

When the arms remain lying next to the body during the stimulation, the raising of one or of both forearms or hands, without leading to the voluntary reaching out to the toy, should be interpreted as moving the arms with support (level stage 1 or 2) and not as the raising of one or both arms (level stage 3a) or as reaching out with one or both forearms (level stage 3b). A number of children try to reach out extra high by extending the cervical spinal column in the course of reaching. The child pushes with the head against the floor and in this way raises the shoulder girdle a little, as it were. This motor behaviour does not lead to further score differentiations.

A functional level of postural control has been reached when the child in the reaching out position turns out to be able to follow the toy with one or with both arms sideways in relation to the trunk. To this end, the toy is moved in circles laterally around the child's head, just out of the child's reach. Following the toy sideways by rotating must be interpreted as compensation, resulting from an inadequate level of postural control around the shoulder girdle. It is important to differentiate between tracking the toy sideways intentionally and the arm falling sideways through a lack of postural control.

Nota bene

"Reaching out" in this context means focussed raising of the arm or forearm in the direction of a toy to a more or less vertical position. With a reaching out arm position, it is not necessary that the elbow be fully extended. Time registration is started at the moment that the arm or forearm, which is being raised or reaching out, is free from the ground, terminating at the moment that the child loses the raised or reaching out posture.

Camera position
The camera is placed at the side of the child’s feet, filming more or less horizontally at an angle of about 45º in relation to the sagittal plane.

Stage classification

Execution
The child is placed in a supine position on a horizontal surface with the arms beside his body and is stimulated to reach out with one or both arms and to follow the motivating toy sideways.

Scale

0. The test item has been correctly administered. However, the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child moves one or both arms besides his body over the ground. It is not possible to raise the arms, which remain supported on the ground.
2. The child moves one or both arms over the ground and over his body. The arms are not raised, but remain supported on the ground and on his body.

3a. For a short time, the child raises one or both arms completely from the ground.

3b. The child reaches out to the motivating toy with one or with both forearms for at least 2 seconds. The arm used for reaching out remains supported on the chest.

4. For a short period, the child reaches out with one or both arms towards the motivating toy.
5. The child reaches out towards the motivating toy with one or with both arms for at least 2 seconds.

6. The child reaches out and tracks the toy sideways with one or both arms. To do this, he rotates the trunk; the arms are hardly moved in relation to the trunk.
7. The child reaches out and tracks the toy sideways with one or both arms in relation to the trunk.

Test instructions

Objective
- Registration of the level at which the child in the supine position is capable of reaching upwards with the arms.

Execution
- Initial posture: supine position, arms besides the body flat on the ground.
- Encourage the child to reach upwards with one or both arms.
- Encourage the child to stabilise the raised arm position for 2 seconds.
- Encourage the child, after reaching out, to track sideways with one or both arms.

Stimulation
- Offer the toy just out of the child's reach above his face.
- Move the toy just out of the child's reach in a circular movement to the side of his head.
- Position the arms passively if necessary.

Camera position
- At the side of the child's feet, at an angle of about 45º in relation to the sagittal plane.

Scoring

Characteristic features of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Moves one or both arms.
c. Raises one or both arms.
d. Reaches out with one or both forearms.
e Reaches out with one or both arms.
f. Tracks sideways with one or both arms.
g. Rotates the trunk, arms not moved in relation to the trunk.
h. Moves arms in relation to the trunk.

Posture
i. Arms supported on the ground.
j. Arms supported on the chest.

Period
k. Short duration.
l. At least 2 seconds.

Stage specification	Elements
0.	a.
1.	a, b, i.
2.	a, b, i, j.
3a.	a, c, k.
3b.	a, d, j, l.
4.	a, e, k.
5.	a, e, l.
6.	a, e, f, g.
7.	a, e, f, h.

6.3 Test item 3: Postural control when raising the head in the supine position

Objective and method

The objective of this test item is to register the level at which the child is capable of raising the head in the supine position. To this end, the child is stimulated to raise the head from the ground in the supine position by passively providing a light trunk flexion.

Motor development in relation to postural control

As a result of an inadequate level of postural control, the DS child is not initially able to raise the head in the supine position, to stabilise the raised position and to flex the trunk. As far as this test item is concerned, the start of the development of raising the head can be twofold. On the one hand, it can be observed that the child is capable of stabilising the head in respect to the trunk whenever the examiner passively flexes the trunk a little. As a result, the head comes off the ground. In the first instance, however, the child does this by stabilising the head with a cervical extension. On the other hand, it can be observed that the child raises the head from the ground for a short time without being able to stabilise the raised head position and without the cervical spinal column following the flexed curve of the trunk.
Once the ability to control the posture intensifies, the cervical flexors will increasingly take part in raising and stabilising the position of the head. Initially, the head is still stabilised in a middle position as regards flexion and extension, the chin can then be drawn in (atlanto-occipital flexion). Subsequently, the head is increasingly stabilised in a flexion position and the line of the cervical spinal column follows the flexed curve of the trunk. Ultimately, an active arm and trunk rotation is observed as the child pulls himself upwards on the arms of the examiner.

Information on administration and evaluation of the test item

In administering this test item, it is important to determine to what extent the child is capable of raising the head from the ground in the supine position and whether the child can at the same time stabilise the trunk adequately in a flexed posture. To this end, in the supine position, by means of a light traction of the arms, causing some trunk flexion, the child is encouraged to raise the head. The examiner sits in front of the child and encourages him to raise the head with a motivating toy, which

should interest the child. Where necessary, the examiner may take the child through the raised head position passively. The light traction on the arms is intended to give direction to the movement and should be seen as a gesture of invitation to the child. The examiner should wait for the child's reaction and not continue the traction until the head is raised from the ground passively. Since some trunk flexion is provided, the head will come away from the ground if the child stabilises the head position in any way. It is not the intention of the test item to have the child come to a sitting position; it is not a traction test. Raising the head in the supine position takes place in a more or less horizontal position and gives an indication of the development of flexion and of postural control of the head and the trunk in the supine position. If the child raises his head in the supine position without traction from the examiner, this also results in a score.
Sometimes, children are quite late in reacting to the toy. It has also been observed that children first pull themselves up to a half-sitting or sitting position and only then flex the cervical spinal column. However, no differentiation is made in the tempo and the sequence of reaction, as observers may score a relatively late reaction, for example.
It is essential to make a distinction between the head being raised because the child is stabilising the cervical spinal column, either by extension or with some flexion and the head being actively raised and some flexion of the cervical spinal column being observed. When the child just stabilises the head, the head comes away from the ground with the help of the examiner. It is the trunk flexion, caused by traction to the arms, in combination with the stabilising of the head position that causes the head to come away from the ground and not due to a cervical flexion activity of the child. If there is stabilising of a position, the duration of this is determined (at least two seconds).
At stage 5, traction to the arms by the examiner is no longer necessary in order to bring about trunk flexion, as the child actively flexes the trunk and pulls himself upwards by the arms. It is important to give the child the opportunity to pull himself upwards. To make this clear the examiner should avoid pulling the child up to a half-sitting position. By not moving the hands, it is clear whether the child is pulling himself up or not. In that case, through the flexion movement, the child overtakes the examiner's hands as it were.

Camera position
The camera is at the side of the child, filming more or less horizontally at an angle of 90º in relation to the sagittal plane.

Stage classification

Execution The child is placed on a horizontal surface in a supine position. The examiner takes the child by the wrists and gives some traction as a result of which the trunk flexes a little. In the meantime, the child is stimulated to raise his head.
Scale 0. The test item has been correctly administered but the child does not demonstrate any motor behaviour that is specified in any of the stage specifications below. 1a. The child raises the head for a short period, but does not bring it in line with the curve of the trunk. 1b. The child stabilises the position of the head by cervical extension. The head comes away from the ground through the traction of the examiner. The child stabilises the raised position for at least 2 seconds. 2. The child stabilises the head in a mid-position regarding flexion and extension. The head comes away from the ground through the traction of the examiner. The child stabilises the raised position for at least 2 seconds. 3. The child raises the head for a short period and brings it in line with the curve of the trunk by flexing the cervical spinal column. 4. The child raises the head and brings it in line with the curve of the trunk by flexing the cervical spinal column. The child stabilises the raised position for at least 2 seconds. 5. The child raises the head and brings it in line with the curve of the trunk by flexing the cervical spinal column. In addition, the child pulls himself up on the arms of the examiner by flexing the trunk and the arms.

Test instructions

Objective
- Registration of the level at which the child is capable of raising the head in the supine position.

Execution
- Initial posture: supine position, through some traction via the wrists the trunk is a little flexed.
- Stimulate the child to raise the head.
- Stimulate the child to stabilise the raised head position for 2 seconds.
- Stimulate the child to flex the trunk and arms.
- Nota bene: it is not a traction test

Stimulation
- Provide a motivating toy in the child's range of vision.
- If necessary, position the child's head passively.

Camera position
- At the side of the child, at an angle of 90º with regard to the sagittal plane.

Scoring

Characteristic elements of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Raises the head
c. Extension of the cervical spinal column.
d. Mid-position concerning flexion and extension.
e. Cervical spinal column flexion.
f. Flexes trunk and arms.

Posture
g. Head not in line with curve of trunk.
h. Head off the ground.
i. Head in line with curve of trunk.

Period
j. Short duration.
k. At least 2 seconds.

Stage description	**Elements**
0.	a.
1a.	a,b,g,j.
1b.	a,c,h,k.
2.	a,d,h,k.
3.	a,b,e,i,j.
4.	a,b,e,i,k.
5.	a,b,e,i,f.

6.4 Test item 4: Postural control when propping on the elbows in the prone position

Objective and method

The objective of this test item is to register the level at which the child is capable of propping himself on his elbows in the prone position.
To this end, the child is placed in the prone position with a raised head, supporting himself on his elbows and is encouraged to transfer weight sideways to one arm and then to reach out with the contralateral arm.

Motor development in relation to postural control

As a result of an inadequate level of postural control, the DS child is initially not able to support himself on his elbows in the prone position. As far as this test item is concerned, the development of this begins when the child, in the prone position, supports the position adopted by head and trunk with the arms lying bent under the chest.
With an increasing level of postural control a functional position of the arms emerges for supporting the elbows. In this, the position of the upper arms can vary from an angle of about 90º in relation to trunk, to an angle of 90º in relation to the ground (side view). The symmetrical distribution of weight over both elbows is essential for the ability to maintain the posture.
Subsequently, symmetry is less important as the child is going to transfer the weight to one arm without that 90º position of the upper arm disappearing. A functional level of postural control has been achieved when the child can transfer the weight to one arm and then reach out with the other arm to grasp a toy, for example. Dependent on the level of stretching out, in the trunk there will be an increasing demand for extension and rotation and in the shoulder girdle an increasing degree of stability. Initially, the shoulder on which the child is supporting himself can be adducted in such a way that the chest and the upper arm touch and support their reciprocal positions. Ultimately, this mutual support is no longer necessary. In any case, adduction of the shoulder is barely observable. A functional situation has arisen. The child is in a position to reach out with one arm, the contralateral shoulder is stabilised in the central position regarding abduction and adduction.

Information on administration and evaluation of the test item

In administering this test item it is important to determine whether, in

the prone position, the child is supporting the assumed position of head and trunk with bent arms under the chest (stage level 1), or whether there is functional support on the elbows (stage levels 2 to 6). In the latter case the position of the upper arms as described can vary from an angle of about 90º in relation to the trunk, to an angle of about 90º in relation to the ground (side view). When there is no effective support on the elbows, the arms support the raised position of the head and trunk, but are lying with the elbows more bent under the chest. The position of the upper arm varies from an angle of about 90º in relation to the ground to a position against the trunk. In that case, stage level 1 is scored. A certain amount of abduction in the shoulder joint does not detract from the effectiveness of the support. When there is too much abduction the elbows lose their supporting function. Both postures should be stabilised for at least two seconds.
Subsequently, the necessity of symmetry for the functional supporting on the elbows should be determined by stimulating the transfer of weight sideways. This entails the trunk moving from the midline to the lateral and an increase in load on the ipsilateral shoulder. The sideways transfer of weight must be clearly discernible.
The effectiveness of the stage of postural control is ultimately apparent when the child, after having transferred the weight to one arm, is encouraged to reach out with the contralateral arm for at least two seconds. Here too, it is important that the functional elbow support is maintained as the initial posture. Rolling sideways in order to be able to reach out, for example, is not counted as reaching out. The examiner should make sure that the child, after reaching out with his hand, does not support himself on the motivating toy in order to stabilise the reaching out position in that way. The level of postural control of the shoulder on which the child is leaning is furthermore apparent from whether or not the joint is adducted during reaching out with the other arm. It may turn out to be necessary for the chest and the upper arm to support their reciprocal positions.
For the success of the test item, it is important that the test be administered consistently from a correct initial posture. In placing him in the initial posture, therefore, the examiner places the child on the ground supporting himself on his elbows. It should be clear the child is in the prone position with a raised head. The angle of the upper arm in relation to the trunk and the ground should be such that functional support is possible. A certain amount of abduction is permitted, but with too much abduction the effective position of the elbow disappears. As the posture must be actively stabilised by the child, the examiner

should give the child the opportunity to actually take over this action. Once the child has actively assumed the specified initial posture correctly, the test item can be administered normally.
The child should be interested in the toy, which should be offered in front of the child within his range of vision and in such a way that grasping it is a reasonable possibility. The examiner should be careful that the child, after reaching out with his hand, does not support himself on the toy and in that way stabilise the reaching out position. If the toy is offered too far to the side of the child this will lead to unnecessary loss of posture.
Without the child reaching out, the examiner can stimulate him to transfer weight by moving the toy in a horizontal line in a circular movement around the head to the left or to the right. The child should then follow the object visually and rotate the head as far as possible (looking backwards). If necessary, the examiner can demonstrate the transfer of weight passively and the reaching out with one arm. The transfer of weight must be clearly discernible.

Nota bene
In the course of reaching out with one arm it may be observed that the child bends the ipsilateral hip in order to stabilise the prone position. Since this is a physiological movement pattern and in fact a variant on the prone position it does not lead to a different score. One should be on the lookout for the stomach and pelvis coming away from the ground. At that moment the prone position is lost as an initial posture. When transferring weight laterally it may be that the child goes to hand support with the contralateral arm. In that case the child scores level 4.

Camera position
The camera is placed obliquely in front of the child, filming more or less horizontally at an angle of about 45º in relation to the length axis of the child.

Execution
The child is placed on a horizontal surface in the prone position, functionally supporting himself on his elbows. The head is raised. He is encouraged to transfer weight sideways to one arm and then to reach out with the contralateral arm.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is specified in any of the stage specifications below.

1. In the prone position the child supports himself, mainly symmetrically, on his elbows for at least 2 seconds. The position of the upper arm varies from an angle of about 90º in relation to the ground, to a position against the trunk (side view).
2. In the prone position the child supports himself, mainly symmetrically, on his elbows for at least 2 seconds. The position of the upper arm varies from an angle of about 90º in relation to the trunk, to an angle of about 90º in relation to the ground (side view).

3. In the prone position the child supports himself, mainly symmetrically, on his elbows for at least 5 seconds. The position of the upper arm varies from an angle of about 90º in relation to the trunk, to an angle of about 90º in relation to the ground (side view).
4. From functional elbow support in the prone position the child transfers weight sideways to the left or to the right. The position of the upper arm varies from an angle of about 90º in relation to the trunk, to an angle of about 90º in relation to the ground (side view).

5. From a functional elbow support in the prone position the child reaches out with one arm for at least 2 seconds. The position of the upper arm on which the child is supporting himself varies from an angle of about 90º in relation to the trunk, to an angle of about 90º in relation to the ground (side view). The shoulder on which the child is leaning is clearly adducted, the chest and the upper arm touch each other and support their reciprocal positions.
6. From a functional elbow support in the prone position the child reaches out with one arm for at least 2 seconds. The position of the upper arm on which the child is supporting himself varies from an angle of about 90º in relation to the trunk, to an angle of about 90º in relation to the ground (side view). The shoulder on which the child is leaning is hardly adducted at all.

Test instructions

Objective

- Registration of the level at which the child is capable of supporting himself on his elbows.

Execution

- Initial posture: prone position supporting on the elbows. Raised head position.
- The position of the upper arms varies from an angle of 90º in relation to the ground, to an angle of 90º to the trunk (side view).
- Stimulate the child to stabilise the posture for 2 or 5 seconds.
- Stimulate the child to transfer weight sideways, for example, by having him look round.
- Stimulate the child to reach out with one arm for 2 seconds.
- Nota bene: consistently place the child back in the initial posture.

Stimulation

- Offer the motivating toy in front of the child.
- Move the motivating toy in a horizontal line and in a circular movement around the head to the left or to the right.
- If necessary give a passive demonstration of transferring the weight to the lateral.
- Move the motivating toy just out of reach and a little above the outstretched arm.
- If necessary, position the arm passively.

Camera position

- Obliquely in front of the child, at an angle of about 45º in relation to the length axis.

Scoring

Characteristic elements of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Supports mainly symmetrically on the elbows.
c. Transfers weight sideways.
d. Reaches out with one arm.

Posture
e. Position of the upper arm varies from an angle of about 90º in relation to the ground, to a position against the trunk (side view).
f. Position of the upper arm varies from an angle of about 90º in relation to the trunk, to an angle of about 90º to the ground (side view).
g. Chest and upper arm touch each other and support their mutual positions.

Period
h. At least 2 seconds.
i. At least 5 seconds.

Stage specification	Elements
0.	a.
1.	a,b,e,h
2.	a,b,f,h.
3.	a,b,f,i.
4.	a,c,f.
5.	a,d,g,h.
6.	a,d,f,h.

6.5 Test item 5: Postural control when rolling over from the prone to supine position

Objective and method

The aim of this test item is to register the level at which the child is capable of rolling over from the prone to supine position. To this end, the child in the prone position is encouraged to roll over to the supine position.

Motor development in relation to postural control

When DS children roll over from the prone to the supine position disturbances in the system of postural control can be observed in the motor function of the head, the trunk and the limbs. These disturbances have an influence on subsidiary functions of rolling over but also on the motor function of rolling over as a whole. The way in which a DS child develops rolling over is determined by the individual-specific distribution of the extent of postural control problems over the body and by the development that occurs in this. A manifestly reduced level of postural control, for example in the trunk, will put the emphasis in rolling over on the head, arm and leg motor abilities. Compensatory movement can then be observed in the trunk motor abilities, such as a lack of movement disassociation, (rotation in itself, but also in combination with flexion and extension) for example.
As a result of an inadequate level of postural control, the DS child will initially not be able to raise the head in order to roll over from the prone position. The development of the motor ability of the head in the context of this test item starts when the head is extended in an effort to roll over. The child falls over, as it were, to lying on his side because the head is moving outside the supporting surface area and brings him out of balance. The child can also use this extension more actively and then does come to the supine position. Subsequently, enough dissociation comes about in order to flex the head. Once the child can combine the flexion with rotation a functional onset to rolling over is possible.
An inadequate level of postural control can lead to a restricted role of the arms in rolling over. In the framework of this test item the development of arm motor activity begins with symmetrical arm function. This is combined with symmetrical trunk motor activity, but trunk rotation is not observed. Next, the contralateral arm is moved to dorso-medial, the arm is not raised, but remains supported by the trunk. Finally, a

functional level of postural control comes into being; the contralateral arm is raised and in rolling over comes free of the trunk. The development of asymmetrical arm motor activity is combined with the development of trunk rotation.
As a result of inadequate postural control, the role of the legs in rolling over from the prone to the supine will be restricted. In the context of this test item, the development of leg motor activity begins at the moment that the legs are bent, more or less symmetrically, in order to roll over. This is combined with symmetrical trunk motor activity. With an increasing level of postural control, the contralateral leg is bent at the hip or extended, in order to be bent backwards subsequently, so that the ipsilateral leg is crossed. In this, the contralateral leg is not initially raised, but is supported on the ipsilateral leg. A functional level of postural control is finally achieved when the contralateral leg is raised in the onset to rolling over. The development of asymmetrical leg motor activity is combined with the development of trunk rotation.
Trunk motor activity develops with a rising level of postural control through increasing dissociation possibilities. Initially, shoulder girdle and pelvic girdle do not move in relation to one another but rolling over takes place as an entity. Trunk flexion in the prone position during the onset of rolling over is not observed, in some cases the trunk is actually extended. Finally, with trunk rotation, rolling over is achieved and a distinct difference can be observed at the moment the shoulder girdle and pelvic girdle begin the rotation. In combination with trunk rotation, in the prone position during the onset of rolling over, the trunk is flexed together with hip flexion in the contralateral leg, or actually in combination with hip extension in the extended contralateral leg.

Information on administration and evaluation of the test item
The quality and functionality of this motor skill can be most accurately registered by making separate stage classifications for the development of subsidiary motor activity relating to rolling over from the prone to the supine position. For practical reasons we have decided to make one combined stage specification. The development of trunk motor activity is given a key position here because this development is seen as the most indicative for the development of rolling from the prone to the supine position, which is disturbed due to problems of postural control.
To evaluate the test item it is important to place the child in a flat initial posture. For example, if the examiner places the child propping up on his elbows in the prone position, the child may come to lie on his side

because he has lost his balance. This has nothing to do with rolling over. The examiner should also beware of trying to combine test items 5 and 6 to facilitate rolling over from the prone to supine to prone. Evaluation is then especially difficult since the movements overlap each other and influence each other.
In administering this test item it is important to determine whether the head is extended or flexed as the child rolls over. It must be determined whether the child extends or flexes the trunk in the prone position as he begins to roll over. It is important to evaluate whether the shoulder girdle and the pelvic girdle move more or less together, or whether clear rotation in relation to each other can be observed. Trunk rotation must be clearly recognisable and should be named as such in order to proceed with the scoring. Finally, it must be registered whether both arms and both legs are more or less simultaneously active or not, and whether, during the activity, they are supported or raised. The final result must also be taken into consideration. If the child only comes to side-lying, this is evaluated as a lower motor level than when he can actively continue to roll to the supine position.
Rolling over from the prone to the supine position can be stimulated by offering a motivating toy that is attractive to the child, obliquely in front of him and somewhat above the child. The child will look at it and possibly want to grasp it. The toy is then moved in a circle round the head just out of the child's reach. When the child follows the toy with his head or with his arm, rolling over is elicited and brought into action. The examiner will have to be careful not to elicit too much head and trunk extension by the manner of stimulation. As far as this is concerned, the toy must be offered in a neutral manner. If necessary, the objective of the test item can be made clear by the examiner when she[2] facilitates the child rolling over manually.
However, it is more or less impossible to stimulate the child who can sit up independently, to roll over from the prone to the supine position. From the prone position, the child will go to a sitting position. If correctly administered, the test item is evaluated as not having been completed.

Nota bene
'Rolling over' means active participation in the whole rolling process. The entire rolling movement is supported. 'Start to roll over', on the other hand, means that the rolling over has begun or is being commenced and has a distinctly different meaning in this context. Whether or not trunk rotation is present is evaluated during the first 90º

[2] 'she' end 'her' are used to refer to both male and female physiotherapist

of rolling over; that is to say in the course of rolling over from the prone to the supine position. Possible rotation then takes place against the force of gravity. Rotations, observable in the second 90º of the rolling over, i.e. from side-lying to the supine position, can come into being as a result of the force of gravity and are therefore not evaluated. Motor activity of the arms and legs, on the other hand, are evaluated over the total movement path.
Some children raise the trunk and come via a sort of half-sitting position and half side-sitting position to the supine position. As long as the angle between trunk and ground is not greater than 45º and the motor activities of trunk, arms and legs can still be evaluated on the basis of the stage specification, the behaviour can still be evaluated as rolling over. However, if the child demonstrates a sitting posture, a side-sitting posture or a crawling posture, the motor behaviour can no longer be considered to be rolling over. A check should be made as to whether this is a non-completed score or a 0 score.

Camera position
The camera is placed at the side of the child, filming more or less horizontally at an angle of about 90º in relation to the sagittal plane.

Stage classification

Execution
The child is placed in the prone position on a horizontal surface with the arms flat on the ground and is encouraged to roll over to a supine position.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour specified in any of the stage specifications below.

1. The child rolls over to side-lying.
2. The child extends the head and/or the trunk in an effort to roll over to the supine position. Trunk rotation is hardly observed at all.

3. The child flexes the trunk and shows mainly symmetrical arm and leg motor activities in the course of rolling over to the supine position. Trunk rotation is hardly observed at all.

4. The child clearly rotates the trunk and shows mainly symmetrical arm and leg motor activities in the course of rolling over to the supine position.
5. The child clearly rotates the trunk and shows mainly asymmetrical arm and/or leg motor activities in the course of rolling over to the supine position. The contralateral arm and the contralateral leg are not raised, but remain supported.
6. The child clearly rotates the trunk and shows mainly asymmetrical arm and/or leg motor activities and also raising the contralateral arm and/or the contralateral leg in the course of rolling over.

Test instructions

Objective
- Registration of the level at which the child is capable of rolling over from the prone to the supine position.

Execution
- Initial posture: prone position, arms flat on the ground.
- Stimulate the child to roll over to the supine position.

Stimulation
- Offer the motivating toy obliquely above the child's face.
- Move the motivating toy just out of reach of the child in a circular movement above the head.
- If necessary, provide passive rolling over.
- Nota bene: take into account the fact that excessive cervical and/or thoracic extension can be stimulated.

Camera position
- At the side of the child, at an angle of about 90º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage subdivision

Administration

a. Test item correctly administered.

Movement

b. Extends the head and/or trunk.
c. Scarcely any trunk rotation at all.
d. Flexes the trunk.
e. Symmetrical arm and leg motor activity.
f. With clear trunk rotation.
g. Asymmetrical arm and/or leg motor activity.
h. Raising of the contralateral arm and/or leg.

Posture

i. Comes to side-lying.
j. Comes to supine position.
k. Supported contralateral arm and/or leg.

Stage specification	**Elements**
0.	a.
1.	a, i.
2.	a, b, c, j.
3.	a, c, d, e, j.
4.	a, e, f, j.
5.	a, f, g, j, k.
6.	a, f, g, h, j.

6.6 Test item 6: Postural control when rolling over from the supine to prone position

Objective and method

The objective of this test item is to register the level at which the child is capable of rolling over from the supine to prone position. To this end, the child is stimulated in the supine position to roll over to the prone position.

Motor development in relation to postural control

When DS children roll over from the supine to prone position, disturbances in the system of postural control can be identified in the motor activity of the head, of the trunk and of the limbs. These disturbances are of influence not only on the subsidiary functions of rolling over but also on the motor activity of rolling over as a whole. The manner in which rolling over develops in a DS child is determined by the individual specific degree of postural control problems over the body, as well as the development which takes place in it. With a child who has distinct hypotonia in the cervico-thoracic area, for instance, the motor activity contribution of the head will be relatively minor. The impulse to roll over, for example, is mainly provided by the legs, while compensatory movement can be observed in the motor activity of the head.
As a result of an inadequate level of postural control, the DS child will not initially be able to raise the head. The movement impulse to roll over by flexing the head is not then possible. In the context of this test item, the development of the motor activity of the head begins when the child pushes himself off with his head against the ground by cervical extension. With an increasing ability in dissociated movement, the head is then first flexed and then flexed and rotated without being raised from the ground. Finally, in the course of rotating and flexing, the head is also raised and can make a functional contribution in rolling over.
In the case of an inadequate level of postural control, the arms initially have no part in rolling over. In the context of this test item, the development of arm motor activity starts when the arms are used more or less symmetrically to initiate rolling over. A distinguishing feature of this stage of development is the absence of trunk rotation, the trunk possibly being flexed. In the course of increasing development the contralateral arm reaches out to the ipsilateral side. The arm crosses the trunk, however it is not raised, but remains supported by the trunk.

Ultimately, a functional level of postural control comes into being, the arm now being raised when reaching out as an impulse to rolling over. The development of asymmetrical arm motor activity is combined with the development of trunk rotation.
In the case of an inadequate level of postural control, the leg motor activity will not initially contribute to rolling over. In the context of this test item the development of the leg motor activity commences at the moment that a more or less symmetrical hip flexion is observed in the impulse to roll over. The trunk is then also flexed, but trunk rotation does not take place. Once the level of postural control increases the contralateral leg is bent at the hip in the impulse to roll over, but in crossing the ipsilateral leg remains supported by this leg. Ultimately, the contralateral leg is raised when crossing. However, the contralateral leg can also be used to push off in order to roll over. The hip is then extended and the foot pushes against the ground behind the body. The occurrence of these asymmetrical forms of leg motor activity is combined with the occurrence of trunk rotation a functional level of leg motor activity being achieved.
In combination with the development of the function of head and limbs, the ability of trunk flexion, trunk extension and trunk rotation also come into being. Initially, shoulder girdle and pelvic girdle do not have inter-related rotation, but are rolled over as a whole, for example by extending the head and the trunk. Furthermore, trunk flexion in the supine position and trunk extension in the prone position is not adequately feasible. Combined with the development of the dissociation of head, arm and leg motor activities, the child finally rolls over with trunk rotation. A clear distinction can be observed at the moment that the shoulder girdle and pelvic girdle start the rotation. During rolling over, trunk flexion can be observed in the supine position and after rolling over trunk extension in the prone position. The trunk motor activity contributes at a functional level to rolling over from the supine to the prone position. Flexion activity in the trunk can be deduced from the fact that the head, the arms and/or the legs are raised. However, an initial flexion activity in the trunk can also lead to a passive manner of rolling over to side-lying. In this case the legs are raised, then the child falls, as it were, to side-lying because the legs are moving outside the supporting surface and he has brought himself out of balance. The child can also use this flexion more actively and he rolls on to the prone position.
In this test item, children whose development is such that they can reach a sitting position independently, will be inclined to proceed to a hands-knees position and/or to sitting instead of to the prone position.

Information on administration and evaluation of the test item

By making separate stage classifications for the development of subsidiary motor activities relating to rolling over from the supine to the prone position, the quality and functionality of this motor skill can be registered the most accurately. For practical reasons we have chosen to make one combined stage classification. In this, the development of trunk motor ability is used as the starting point because this development is seen as the most indicative for the disturbed development of rolling over from the supine to prone position due to problems of postural control.

To evaluate this test item it is important to place the child in a flat initial posture. If the child is placed by the examiner with bent legs in the supine position, for example, he may come to side-lying because of losing his balance. This has nothing to do with rolling over. The examiner should also not be tempted to combine the test items 5 and 6 to facilitate the testing of rolling over from the prone to supine to prone position. That would make evaluation much more difficult as movements overlap and influence each other.

In administering this test item it is important to determine whether the head is extended or flexed in the impulse to roll over. It should be determined whether the child extends or flexes the trunk in the supine position at the start of rolling over. Furthermore, it should be registered whether the arms and the legs are symmetrically or asymmetrically active and whether they are supported or raised during the activity. Finally, it is important to evaluate whether the shoulder girdle and the pelvic girdle move more or less at the same time, or whether a clear rotation can be observed in the relation of one to the other. The presence of rotation must be adjudged without reservation in order to score it as such. The final result should also be considered. If the child only comes to side-lying, this is evaluated as a lower motor level than when he actively rolls to the prone position. If the child does not come to the prone position, but goes to a hands-knees position or to sitting, the examiner must consider whether rolling over from the supine to prone position should be evaluated as level 0 or as a non-completed score.

Rolling over from the supine to prone position can be stimulated by offering an interesting toy to the child, obliquely and a little above his head. The child will look at it and may want to grasp it. The motivating toy is then moved out of reach of the child in a circular movement around his head. Once the child follows the toy with his head or with his arm, rolling over has been set in motion and elicited. The examiner should be aware of the fact that too much head and trunk extension can be elicited by the manner of presenting the toy. In this respect, the toy should be offered in as neutral a way possible. Where necessary, the examiner can make the objective of the test item clear by manually facilitating the child's rolling over.

Nota bene

The concept of 'rolling over' implies active participation in rolling over. The total rolling movement is supported. 'Starting to role over' on the other hand means that the rolling over has begun or is being undertaken and has another meaning in this context.
Whether or not trunk rotation is present is evaluated during the first 90º of rolling over, i.e. during rolling over from the supine to side-lying position. Any rotation then takes place against the force of gravity. Rotations observed in the second 90º of the rolling over, thus from side-lying to the prone position can occur as a result of the force of gravity and are therefore not counted. Arm and leg motor activity, on the other hand, are evaluated over the whole movement path.
Some children raise the trunk and come to the prone position via a sort of half-sitting and half-side-sitting position. So long as the angle between trunk and ground is not greater than 45º and the trunk, arm and leg motor activities can still be evaluated on the basis of the stage classification, the behaviour can be rated as rolling over. However, if the child shows a sitting, side-sitting or crawling posture the motor behaviour can no longer be counted as rolling over. The examiner should check whether it is a case of a non-completed score or a 0 score. In the prone position, if one leg finally remains bent under the trunk this may still be counted as the prone position.

Camera position

The camera is at the side of the child, filming more or less horizontally at an angle of about 90º in relation to the sagittal plane.

Stage classification

Execution
The child is placed in the supine position on a horizontal surface with the arms and legs flat on the ground and is encouraged to roll over to the prone position.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is specified in one of the stage specifications below.

1. The child rolls to side-lying.
2. The child extends the head and/or the trunk in the supine position as an impulse to rolling over to the prone position. Trunk rotation is scarcely observed at all.

3. The child flexes the trunk, e.g. by raising the head, the arms or the legs and shows mainly symmetrical arm and leg motor activities when starting to roll over to the prone position. Trunk rotation is scarcely observed at all.

4. The child clearly rotates the trunk and shows mainly symmetrical arm and leg motor activities while rolling over to the prone position.
5. The child clearly rotates the trunk and shows mainly asymmetrical arm and/or leg motor activities while rolling over. The contralateral arm and the contralateral leg are not raised but remain supported.
6. The child clearly rotates the trunk and shows mainly asymmetric arm and/or leg motor activity and raises the contralateral arm and/or the contralateral leg while rolling over to the prone position.

Test instructions

Objective
- Registration of the level at which the child is capable of rolling over from the supine to prone position.

Execution
- Initial posture: supine position, arms and legs flat on the ground.
- Stimulate the child to roll over to the prone position.

Stimulation
- Offer the motivating toy obliquely above the child's face.
- Move the motivating toy just out of reach of the child in a circular movement around his head, to the side and towards the cranium.
- If necessary, roll the child over passively.
- Nota bene: take into account the fact that excessive cervical and/or thoracic extension can be stimulated.

Camera position
- At the side of the child, at an angle of about 90º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage classification

Administration

a. Test item correctly administered.

Movement

b. Extends head and/or trunk.
c. Scarcely any trunk rotation.
d. Flexes the trunk.
e. Symmetrical arm and leg motor activities.
f. With clear trunk rotation.
g. Asymmetrical arm and/or leg motor activities.
h. Raises the contralateral arm and/or leg.

Posture

i. Comes to side-lying.
j. Comes to the prone position.
k. Supported contralateral arm and leg.

Stage specification	**Elements**
0.	a.
1.	a,i.
2.	a,b,c,j.
3.	a,c,d,e,j.
4.	a,e,f,j.
5.	a,f,g,j,k.
6.	a,f,g,h,j.

6.7 Test item 7: Postural control when sitting

Objective and method

The objective of this test item is to register the level at which the child is capable of sitting unsupported. To this end, the child is encouraged, in an unsupported sitting position, to reach forwards and sideways with one or both arms.

Motor development in relation to postural control

As a result of an inadequate level of postural control, the DS child will initially not be able to stabilise the sitting posture. The development in the context of this test item commences at the moment that the child can sit without support, but supports the position of the trunk with the arms by placing the hands in front on the ground or on his legs. With an increasing ability to control the posture the need to support with the arms decreases; after a phase of supporting with one arm, sitting without the support of the arms becomes possible. Initially, the child sits with a bent back and the pelvis tilted backwards. Then it becomes increasingly possible to extend the back. This becomes visible when the child sits more often with a mainly straight, flat back without obvious kyphosis or lordosis; the pelvis is then in a mid-position as regards tilting forwards and backwards. Ultimately, the child stretches the back to such an extent that sitting takes place with a straight back, a lumbar lordosis and the pelvis tilted forwards. The position is then mainly vertical. Initially, dissociation of the assumed position by rotating the shoulder girdle, for example in relation to the pelvis, is not possible; the sitting position has a static nature. With an increasing ability to control the posture, symmetry is no longer a condition for maintaining it. The child is in a position to rotate the shoulder girdle and the pelvic girdle in relation of one to the other and to flex the trunk laterally while the unsupported, assumed posture continues to be maintained in combination with the lumbar lordosis. Ultimately, the child has such a degree of balance that he can sit on one buttock with a laterally tilted pelvis and a laterally flexed trunk. He can sit with his legs to the side without losing the sitting posture.

Information on administration and evaluation of the test item

In the course of unsupported sitting, disturbances in the system of postural control can be identified in the DS child in the development of motor activity of the head, of the trunk and of the limbs. By registering the specific development of these subsidiary functions it is possible to make a complete profile of sitting. For practical reasons it was decided to make a combined stage classification. In this, the development of the trunk motor abilities had a key position because this is seen as the most indicative for the development of postural control during sitting. In the stage specifications, postures and movements are described that are assumed by the child as a result of stimulation to reach upwards, forwards and sideways with the arms. In administering this test item it is important to determine whether the child can sit independently with or without the support of the arms. Furthermore, it is to be registered whether the child is sitting with a bent or a straight back. Differentiation in this respect can be achieved by stimulating reaching out with the arms. The position of the pelvis is important in this. It is to be determined whether the child is sitting with a bent back and the pelvis tilting backwards, with the pelvis in the middle position, or with the pelvis tilted somewhat forward in combination with a lumbar lordosis. As soon as the child is capable of stabilising the sitting posture, the length of duration of sitting is determined for the purpose of differentiation. Incidentally, the examiner does not have to let the child fall in order to make clear the inability to sit independently.

Subsequently, it is important to determine whether trunk motor activity is possible in the course of sitting. It is evaluated whether the child is capable, after stimulation, of extending the trunk and of lateral flexing it in an unsupported sitting position when reaching out with one or both arms. When the child extends the back it is important to determine whether or not lordosis occurs in the lumbar area whereby the pelvis tilts slightly forward. If the child does appear to be capable of sitting with a lumbar lordosis and a pelvis tilted slightly forward it is to be investigated whether this lordosis is still maintained in the course of lateral flexing of the trunk. In the course of lateral flexing the trunk, finally, the child can transfer his body weight in such a way that the pelvis is tilted laterally and sitting on one buttock occurs. A side-sitting posture can be adopted at this point. Whenever the child turns out to be capable of adopting a particular posture, for the purpose of differentiation its length of duration should be determined. It is important that the sitting posture described is maintained as such. Children who in their enthusiasm proceed to sitting on their heels or kneeling must be corrected. In order to stretch and to flex the back, the sitting child's attention should be drawn in such a way that it makes the child want to reach upwards and to the side with one or both arms. To this end, the motivating toy should be offered to the child, just out of reach, both to the upper/front and to the upper/side of the child. The examiner is to ensure that when the child reaches out forwards for the toy it is not too far from the child, since he can lose the vertical trunk position by reaching forwards excessively. In the same way, a toy offered too high would lead to excessive stretching of the cervical and thoracic spinal column. In reaching out sideways the child must be stimulated to transfer his weight laterally. As far as possible he should attain this with the trunk outside the supporting surface. If the toy is offered too high and not enough to the side, a trunk lateral flexion will be observable without the trunk coming out of the supporting surface; this does not provide any information about the child's ability to transfer weight laterally. If necessary, reaching out can be passively demonstrated to the child by the examiner. The final motor behaviour to be evaluated, however, must be performed independently by the child.

Nota bene

A lumbar lordosis is always accompanied by a pelvis tilted slightly forward and is compensated by the thorax in such a way that it results in a mainly vertical trunk position during sitting. If the child turns out not to be sufficiently capable of stabilising the trunk position, it is possible that the lumbar lordosis continues during reaching out forwards. The child then hangs face down, as it were, with complete lordosis in the back and loses the sitting position. This posture may not be confused with the lordosis that is restricted to the lumbar region and leads to a mainly vertical trunk position when sitting.

The back is considered straight (level 4) when a mainly vertical unsupported trunk position occurs with an absence of lumbar lordosis and a neutral pelvic position in relation to tilting forwards and backwards.

When the child reaches out sideways with the contralateral hand and then touches the ground or his own body on the contralateral side, it should not necessarily be interpreted as taking support. It is not possible to obtain effective support in this manner. However, the child is capable of getting support in this manner when inadequate reaching sideways is elicited and the toy is offered, as it were, above the child.

'Side-sitting' is understood to mean an asymmetrical sitting posture, in which the body weight rests mainly on one buttock and the trunk is laterally flexed on the contralateral side. The ipsilateral leg is rotated outwards at the hip and the contralateral leg is rotated inwards. However, the legs may also be held symmetrically, for example, sitting cross-legged. In a conditional sense side-sitting requires an adequate level of posture-controlling functions.

Camera position
The camera is placed obliquely behind the child, filming more or less horizontally at an angle of about 45º in relation to the sagittal plane.

Stage classification

Execution
The child is placed in the sitting-without-support position on a horizontal surface and is encouraged to stretch from the trunk by eliciting reaching upwards with the arms and to transfer weight laterally by eliciting sideways reaching out with the arms.

Scale

0. The test item has been correctly administered, however the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child sits independently during stimulation for at least 5 seconds while supporting the position with two hands.
2. The child sits independently during stimulation for at least 5 seconds while supporting the position with one hand.
3. The child sits independently during stimulation for at least 2 seconds without support from the arms and with a bent back.

4. The child sits independently during stimulation for at least 2 seconds without support from the arms with a straight back without lumbar lordosis.
5. The child sits independently during stimulation without support from the arms. When stretching the back, a clear lumbar lordosis can be observed for at least 2 seconds.

6. The child sits independently during stimulation without support from the arms. When stretching the back and transferring weight to the lateral a clear lumbar lordosis and a clearly lateral flexed trunk can be observed for at least 2 seconds.

Test instructions

Objective
- Registration of the stage at which the child is capable of sitting unsupported.

Execution
- Initial posture: independent sitting position.
- Stimulate the child to maintain the sitting position for 5 seconds with as little arm support as possible.
- Stimulate the child to extend the trunk for 5 seconds by reaching out forwards and upwards.
- Stimulate the child to show lumbar lordosis of the trunk for 2 seconds by reaching out forwards and upwards.
- Stimulate the child to lordosis and lateral flexion of the trunk for 2 seconds by reaching out upwards and sideways.

Stimulation
- Offer the motivating toy in front of, and somewhat above the child.
- Move the toy forward and above, just out of the child's reach.
- Move the toy sideways and above, just out of the child's reach.
- If necessary, position the trunk passively.
- If necessary, position the arms passively.

Camera position
- Obliquely behind the child, at an angle of about 45° with respect to the sagittal plane.

Scoring

Characteristic elements of the stage classification

Administration
a. Test item correctly administered.

Movement
b. Lumbar lordosis.
c. Lateral trunk flexion.

Posture
d. Supports position with two hands.
e. Supports position with one hand.
f. No arm support.
g. Back is bent.
h. Back is straight without lumbar lordosis.

Period
i. At least 2 seconds.
j. At least 5 seconds.

Stage specification	**Elements**
0.	a.
1.	a,d,j.
2.	a,e,j.
3.	a,f,g,i.
4.	a,f,h,i.
5.	a,b,f,i.
6.	a,b,c,f,i.

6.8 Test item 8: Postural control when moving forward over the ground

Objective and method

The objective of this test item is to register the level at which the child is capable of moving forward over the ground. To this end, the child is stimulated to move forward in both the prone position and in the sitting position.

Motor development in relation to postural control

In the DS child, moving forward over the ground is influenced by the individual, specific distribution of postural control problems over the body and by the development that occurs in this. In principle, there are two developmental lines that appear, which can both be assessed on their quality. The children with relatively adequate postural control in the arms and in the trunk will move forward in the prone position. A not inconsiderable number, who do have disturbances in postural control in the trunk and in the arms choose to move forward in the sitting position.

As a result of an inadequate level of postural control, the DS child is initially not capable of moving forward. The ability to stretch and stabilise the trunk in the prone or the sitting position is lacking, as is the ability to lean on the arms and the legs and to push off with them. As far as this test item is concerned, the development begins at the moment that the child starts to move forward independently. The manner of moving forward that the child is going to use will depend on the individual specific extent of disturbances in postural control. The child compensates for any shortcomings as much as possible. In principle, there are several variants, which in the context of this test item can be interpreted as a first movement form in order to be able to move forward. The child with a lack of extension in the trunk and with relatively more postural control in the legs than in the arms, will perhaps choose to move in a supine position by pushing off symmetrically with the legs. It is also possible that the child will move about by rolling over. The child that has relatively more possibilities in the arms than in the legs and has a reasonable degree of trunk extension, will possibly move forward in the prone position. He can make use of a movement pattern that is also observed in normal motor development and move backwards, pushing symmetrically with both arms. The child with obvious problems in extending the trunk and stabilising the shoulders and the elbows and who, in terms of development, is capable of sitting, will possibly move backwards by shuffling on the buttocks. Pushing off with the arms and the legs occurs symmetrically, the movement sometimes being supported by flexing the trunk. The child keeps the trunk within the supporting surface of the legs and asymmetrical trunk motor activities, such as rotation and lateral flexion are not observed.

With an increasing development of capacity in postural control, two development lines can subsequently be observed. On the one hand, there are children who move forward in the prone position and on the other hand there are children who move forward in the sitting position. The child that is going to move forward in the prone position will initially do so symmetrically. Depending on the possibilities of extending the trunk and on the extent of postural control in the arms, the child pushes off more or less symmetrically at the same time with the elbows or with the hands (‘seal-like movements). No rotation can be observed in the trunk. Once the child has adequate trunk extension and stability to transfer weight and to support on one arm, he pushes off with alternate arms. He moves forward by ‘creeping’. Trunk rotation can be observed as the child moves forward. The extent to which the legs contribute to moving forward is dependent on the stage of development and on the level of postural control. Initially, the legs do not push forward; subsequently this occurs symmetrically and ultimately alternating. The children who move forward in the sitting position will initially also do this symmetrically. The trunk is bent and stretched; the arms and the legs push forward, mainly symmetrically. There is no question of trunk rotation. Then a form of ‘bottom shuffling’ develops which can also be observed in normal motor development as an alternative to crawling. In contrast to the manner described above, in this form of ‘bottom shuffling’ elements of qualitatively well-developed motor ability can be identified. In this case, the ‘bottom shuffling’ is not symmetrical, the child shuffles for example in a side-sitting position, and the posture in which the child shuffles is varied. A developing trunk motor activity takes place when rotation and lateral flexion can be observed. Use is made of adequate balance responses. Both children who ‘creep’ and those who ‘bottom shuffle’ can subsequently be observed moving forward in a crawling posture. The child has sufficient stability to stand on hands and knees. Initially, the child intending to move forward moves the arms and the legs symmetrically and in turn (hare leap). The legs do not come away from the ground but are pushed forwards. Then the child is in a position to transfer weight sideways and the arms and legs are moved alternately. In the first instance the hip is still not adequately stretched because the child prefers to keep the body weight above the legs. The duration of asymmetrical weight bearing is kept short, the crawling movements are short, the limbs are pushed along the ground instead of raised. Finally, the arms and legs are used alternately in crawling, the limbs come free from the ground when moving and the hips are stretched in such a manner that the knee comes past the hip joint. In addition, it can also be observed that a child moves alternately on hands and feet, the so-called elephant walk.

Information on administration and evaluation of the test item
Moving forward as a motor skill can be scored on the basis of two parallel operating stage subdivisions. Some children show movement forms from both the first and the second developmental lines named. In that case, that movement form scoring the highest is registered. In administering this test item it is important to determine whether the child is moving forward in the prone position, the supine position, in the crawling posture or in the sitting position or indeed by rolling over. Next, it is essential to register, both in moving forward in the sitting position and also in the prone position, whether the arm and leg motor activity is symmetrical or asymmetrical and whether or not rotation in the trunk and/or lateral flexion can be observed. The efficiency of the forward movement also plays a role in this. Moving forward is only scored as such when the child moves a distance of at least one metre over the ground.

When the child moves forward sitting on his heels or sitting in a TV position (with hips in endorotation and buttocks between the ankles), by moving the body weight alternately from side to side and also alternating the contralateral leg in order to push forward, it can be scored as ‘moving in the sitting position’. Only the degree of symmetry will still have to be assessed. Moreover, a child goes quickly from sitting on the heels to the crawling posture to then crawl, symmetrically or otherwise.

A child that can only crawl if he is placed in a crawling posture is not scored as crawling. For a correct administration of the test item, crawling should be started from the prone or the sitting position. It is possible that the examiner coaxes the child passively to crawl in this way. As stated previously, the test item should ultimately be administered according the specification. With a child who shows a particular manner of moving forward, but with interrupted movement, for example because of sitting down, the total distance covered may be counted. However, with the child that moves forward for a total of more than one metre, but shows various forms of movements, each of which separately is less than one metre, the lowest scoring movement form is counted. The motor skill can be coaxed by offering the child a motivating toy as he lies on his stomach or is sitting. The child should be interested in the toy to such an extent that he wants to move to it.

Nota bene

Side-sitting refers to an asymmetrical sitting posture, in which the bodyweight is mainly on one buttock and the trunk on the contralateral side is lateral flexed. The ipsilateral leg is rotated outwards at the hip and, conversely, the contralateral leg is rotated inwards at the hip. Sometimes the posture of the legs is also symmetrical, for example, as in the crossed-legged position. In a conditional sense this posture requires an adequate level of postural control functions.

The symmetry in arm-and-leg movements (‘seal-like movement’, ‘hare leap’) does not mean that the motor behaviour of the left arm is identical to that of the right arm, but that the movements take place at more or less the same time. Arms and legs moving asymmetrically move alternately. A crawling posture in which the child puts the weight on one knee and one foot is registered as a crawling posture. Motor activity movement behaviour in which alternating sitting posture and kneeling can be observed, is evaluated as ‘bottom shuffling’.

Camera position

The camera is placed obliquely in front of the child, filming more or less horizontally at an angle of about 45º in relation to the sagittal plane.

Stage classification

Execution
The child is placed successively in the prone position and in the sitting position on a horizontal surface and is coaxed in both initial postures to move forward.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child moves at least 1 metre, for example backwards in the prone position by means of rolling over, in the supine position or in the sitting position.

2a. The child moves at least 1 metre forward in the prone position. The arm motor activity takes place mainly symmetrically, for example in "seal-like movements". Absolutely no trunk rotation or lateral trunk flexion is observed.

2b. The child moves forward at least 1 metre in the sitting position. Absolutely no trunk rotation or lateral trunk flexion is observed.

3a. The child moves forward at least 1 metre in the prone position. The arm motor activity is mainly asymmetrical and alternating ('creeping'). Clear trunk rotation and/or lateral trunk flexion takes place.

3b. The child moves forward at least 1 metre in the sitting position. Clear trunk rotation and/or lateral trunk flexion is observed.

4. The child moves forward at least 1 metre on hands and knees. Arm and/or leg motor activity are mainly symmetrical. In turn, both arms and both legs are moved ('hare leap').

5. The child crawls forward for at least 1 metre alternating the hands and the knees or on the hands and the feet ('elephant walk'). Arm and leg motor activities are asymmetrical.

Test instructions

Objective

- Registration of the level at which the child is capable of moving forward over the ground.

Execution

- Initial posture: prone position and sitting.
- Coax the child to move forward more than 1 metre.

Stimulation

- In front of the child offer a motivating toy out of reach.
- If necessary, show the child passively how to move forward.

Camera position

- Obliquely in front of the child, at an angle of about 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Symmetrical arm motor activity.
c. Asymmetrical arm motor activity.
d. Symmetrical arm and/or leg motor activity.
e. Asymmetrical arm and/or leg motor activity.
f. No trunk rotation and/or lateral trunk flexion.
g. Clear trunk rotation and/or lateral trunk flexion.

Posture
h. Prone position.
i. Sitting.
j. Hands and feet.
k. Hands and knees.

Distance
l. At least 1 metre.
m. At least 1 metre forwards.

Stage specification	Elements
0.	a.
1.	a, l.
2a.	a, b, f, h, m.
2b.	a, f, i, m.
3a.	a,e,g,h,m.
3b.	a,g,i,m.
4.	a,d,k,m.
5.	a,e,j,k,m.

6.9 Test item 9: Postural control when walking with support

Objective and method

The objective of this test item is to register the level at which the child is capable of walking with support. To this end, the child is put in front of a table, at chest height, and coaxed to walk: in the first instance with the support of the table and then to cross over to another table.

Motor development in relation to postural control

As a result of an inadequate level of postural control the child will initially be able to stand with support, but not to walk alongside the table. In the context of this test item, the development begins the moment that the child, with chest level support from a table, is able to walk sideways by moving the ipsilateral leg sideways and making sequential steps with the contralateral leg. To be in a position to be able to move on, the child has to transfer the body weight to one leg in order to raise the other leg and to be able to move sideways. It is no longer sufficient merely to support symmetrically on both legs, the body-weight has to be distributed over the supporting leg and, if necessary, over the arms and the trunk.

The child can vary the amount of support provided by the table. In the first instance, the child will take maximum support from the table to compensate for the lack of postural control. The child gains a lot of support by leaning with the chest on the table and putting his arms on it. He is also leaning forwards a little. Finally, the child just maintains his balance when he holds the table with his hands as he is walking and the position is vertical.

When the child crosses over to a second table, walking is just supported by one hand or there is even a moment without support. The symmetry of the posture of the trunk is dispelled by rotation. Crossing over to another table makes a greater demand on the ability of postural control than walking alongside the table, because it requires an increasing degree of movement dissociation.

Information on administration and evaluation of the test item

The level of postural control can be adequately established by registering the amount of support that the child needs in order to walk alongside the table. The child gains maximum compensation for an insufficient level of postural control by supporting himself both with the

arms and the chest on and against the table. The examiner should state verbally whether or not the child has made use of chest support, as it is almost impossible to make a video recording of chest support. In the framework of this test item, walking sideways or walking alongside the table can be defined as soon as the child makes a sideways step at least 3 times with the appropriate sequential step. What is important is the fact that the child alternately puts weight on one leg in order to move the other leg. The sequential step does not have to be a linking step in the sense that the feet finish up next to each other.
The child displays an increasing ability to bear weight on the legs when finally he supports his balance with two hands, or even with one hand on the table as he is walking along. Body posture becomes more vertical. It is important to distinguish between arm and hand support. Hand support should be interpreted as supporting balance, but as soon as one or both arms are used for support, the legs are being supported more expressly in the course of walking and it should be scored as such. If the child supports himself in walking by holding the table with one hand, supporting himself with the other elbow on the table, for example, it should be interpreted as supporting on two arms. In fact, the most support will be derived from the arm supported on the elbow. On the other hand, a child that only supports walking with the hands is, as stated, capable of bearing unsupported weight, but compensates with the hands for the inadequate level of balance. Hand support may mean that the child holds on to the edge of the table, but also that he gains support from the hands on the table.
An extra element is added by establishing whether the child is capable of crossing over to another table at right-angles. With support, the child makes a turn of about 90º and, in spite of the dissociation necessary for this, should be able to stabilise the posture. In this respect also a distinction is made between support with the arms or with the hands. Finally, an attempt is made to see whether the child can cross over without support.
The motor skill can be elicited by placing the child with his chest against a table and by offering a motivating toy on the table, just out of reach, next to the child. In placing the child, the examiner should give him the opportunity to assume the standing position. Once the child moves, the examiner should ensure that the motivating toy remains out of reach by moving it proportionately. The examiner should make sure that the toy is not offered too far from the child, as this would elicit leaning on the table with chest and arms. Walking along with as little

support as possible can be elicited by moving the toy over the edge of the table against which the child is standing. Possibly, the examiner can bring the child's body-weight passively over the feet in order to stimulate walking along with minimal support. If necessary, the examiner can make it clear, for example via the pelvis, that walking sideways is expected. Once the child can walk alongside the table without trunk support, just by supporting with the hands, the examiner transfers the toy to a table at right-angles with the objective of coaxing the child to cross over to the second table. The distance between the two tables may be varied. In the first instance, when crossing from one to the other, the child must have continuous contact with one of the two tables. Subsequently, the tables are placed a little further from each other so that when crossing over, the child has a moment without support from either table. However, it should not be so arranged that the child has to take a step without support.
Crossing over can be coaxed by having the child reach out with one hand for the toy in the direction of the second table. The toy must be attractive enough for the child to want to move to grasp it and it will thus have to be presented in the child's line of vision.

Nota bene
The table used should be at chest height. Lower or higher tables than this stimulate adapted motor behaviour. In practice, an exercise bench, adjusted for height, serves the purpose admirably.

Camera position
The camera is place obliquely behind the child, filming more or less horizontally at an angel of 45º in relation to the sagittal plane.

Stage classification

Execution The child is placed with support in front of a table at chest height on a horizontal surface and is coaxed to walk alongside the table with as little support as possible. If possible, the child is stimulated to cross over to a second table at right-angles.
Scale 0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below. 1. The child walks at least 3 steps alongside the table and supports himself mainly with the chest against the table and one or both arms or hands on the table. 2. The child walks at least 3 steps alongside the table and supports mainly with one or both arms on the table with the chest unsupported. 3. The child walks at least 3 steps alongside the table and supports mainly by holding the table with one or both hands. 4. The child crosses over to a second table at right-angles, but with one or both arms maintains continuous contact with one of the two tables. 5. The child crosses over to a second table at right-angles, but with one or both hands maintains continuous contact with one of the two tables. 6. The child crosses over to a second table at right-angles and for a moment is without support from either of the two tables.

Test instructions

Objective

- Register the level at which the child is capable of walking with support.

Execution

- Initial posture: position in front of table at chest height.
- Coax the child to walk alongside the table with as little support as possible. At least 3 steps.
- Coax the child to cross over with as little support as possible to a second table at right-angles. Vary the distance to be covered.

Stimulation

- Offer the motivating toy next to the child but just out of reach.
- Nota bene: take into account the fact that the position of the toy on the table influences the degree of support taken by the child.
- Move the motivating toy over the table sideways out of the child's reach.
- If necessary, show the child passively how to walk alongside the table.
- If necessary, show the child passively how to walk along without trunk support.
- Nota bene: comment on whether or not there is support from the trunk.
- Offer the motivating toy, out of reach, in the direction of the second table at right-angles.
- Move the toy, out of reach, towards the second table at right-angles.
- If necessary, show the child passively the position of the arm reaching out.
- If necessary, show the child passively how to cross over.

Camera position

- Obliquely behind the child, at an angle of 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Walks along.
c. Crosses over.

Posture
d. Chest support.
e. Arm support.
f. Hand support.
g. Without support.

Distance
h. At least 3 steps.

Stage specification	Elements
0.	a.
1.	a, b, d, e/f, h.
2.	a, b, e, h.
3.	a, b, f, h.
4.	a, c, e.
5.	a, c, f.
6.	a, c, g.

6.10 Test item 10: Postural control when standing with support

Objective and method
The objective of this test item is to register the level at which the child is capable of standing with support and transferring weight laterally. To this end, the child is encouraged to stand with the support of a table and then coaxed to reach out sideways with one arm.

Motor development in relation to postural control
When standing, the DS child is confronted with the characteristic problem of maintaining the extended posture. As a consequence of disturbances in the system of postural control, problems occur in stabilising the position of the trunk, the hips, the knees and the ankles and consequently in maintaining the standing posture as a whole. As a result of an inadequate level of postural control, the DS child is initially incapable of remaining standing with support. As far as this test item is concerned, the development of supported standing starts at the moment that the child, without help, is capable of remaining standing in front of a table at chest height. At first, the child has difficulty in stabilising the position of the trunk, the hips and the knees. He will seek a great deal of support with the trunk against the table and with the arms on the table to compensate for the lack of postural control. He does not place his body weight vertically above the feet, but leans forward against the table.
With an increasing ability to stretch the trunk and the legs and to stabilise, the child has enough support to sustain the position initially with the arms, but then just with the hands, as chest and arm support become no longer necessary. The position is then also more vertical, as the child has the body weight perpendicular above the feet.
Ultimately, the child's postural control is adequate, so that he can stand with the support of one hand, reach out with the other arm, transfer weight to one leg in the direction of the motivating toy and lateral flex the trunk contralaterally. Transferring weight to one side makes an increasing demand on the system of postural control because one leg is increasingly weight-bearing, while the lateral flexion of the trunk breaks through the symmetrical extension and the child must therefore be able to remain standing with dissociation.
At first, the child controls the position of the knees by bracing the joints statically, usually in extension. In that case the knees are locked. In

this way the child can bear weight but does not dare to move the knee joints. Transferring weight is a problem for the child, together with disturbances in balance. Ultimately, the posture of the knee joint has to be maintained in a functional position regarding flexion and extension so that there is a dynamic-stable posture. The knees can be moved functionally during the transfer of weight to the side, disturbances in balance are controlled dynamically.

Information on administration and evaluation of the test item
The level of postural control of ‘standing with support’ can be adequately established by registering the amount of support the child needs in order to remain standing symmetrically. Secondly, it is necessary to determine whether the child can break through the symmetry by transferring the weight in the direction of the motivating toy to one leg, thereby lateral flexing the trunk contralaterally. In addition, the examiner registers whether or not the child is able to achieve a static or dynamic knee stabilisation in transferring the weight laterally. In administering this test item it is important to determine with what support a child is able to remain standing independently with his chest towards a table. In the course of symmetrical standing it is registered whether, in a conditional sense, trunk support against the table is necessary. Furthermore, it is established whether the child supports himself with the arms on the table or whether supporting with two hands or with one hand is sufficient. Once the child is able to stand independently with the support of only one hand on the table, it is to be determined whether the child is capable of asymmetrical movement forms. To this end, he is encouraged to transfer weight to the side in the direction of a motivating toy and to make one leg more weight-bearing. Next, it is important to determine whether this causes lateral flexion of the trunk contralaterally and in what manner the ipsilateral knee joint is stabilised. In this respect, a distinction is made between passively stabilising in a more or less stretched joint position (hardly any knee movements at all) and a dynamic manner of stabilising in a functional position of the joint regarding flexion and extension (evident knee movements). The latter level of stabilising allows functional movement in the joint. Movements that can be observed in the knee joint as a result of instability should not be evaluated as dynamically stable but as static. The child is placed in a position with his chest towards a table at chest height, after which the examiner must give him the opportunity to assume the standing position. If necessary, the examiner shows the child passively, the

standing posture without chest support and possibly with support only from the hands. As soon as there is symmetrical standing with support it is important to determine whether the posture can be stabilised for two or five seconds.
Once the child can stand with support of the hands, reaching out with one hand sideways is elicited by offering a motivating toy next to the child at shoulder height, just out of reach. If necessary, the examiner can show the child passively how to reach out with one hand. When the child reaches out, the toy is moved sideways and upwards just out of reach, in such a way that the child transfers weight in the direction of the toy to the side and if possible lateral flexes the contralateral side of the trunk. By varying the extent of reaching out, the lateral flexion of the trunk and motor activity of the ipsilateral knee joint can be elicited. The toy must be such that it interests the child and makes him want to reach out for it.

Nota bene
In this test item, the height of the table in front of which the child stands is important. If the table is too high it will encourage the child to support himself with the chest and arms against the table. If it is too low it can lead to a child putting his chest and arms on the table in order to support the position. The tabletop should be at chest height necessitating an adjustable table. When the child supports the standing position by holding the table with one hand and leans with the elbow of the other arm supported this is interpreted as supporting on two arms. In fact, the arm leaning on the elbow will give the most support. On the other hand, a child who supports the standing position only with the hands is capable of bearing unsupported weight, but compensates his inadequate level of balance with the hands.
For a correct evaluation by observers, the examiner should make a verbal report of whether or not the child is supporting with the chest against the table, as this is later difficult to ascertain from the monitor screen. When the child reaches out with one hand it is important to determine whether the standing position is supported exclusively with the other hand.

Camera position
The camera is placed obliquely behind the child, filming more or less horizontally at an angle of 45º in relation to the sagittal plane.

Execution

The child is put in a standing position on a horizontal surface in front of a table at chest height. He is encouraged to stand with as little support as possible and then to transfer weight laterally by coaxing him to reach out sideways with one arm.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child stands for at least 2 seconds with the support of the trunk against the table.
2. The child stands for at least 5 seconds with the support of the trunk against the table.
3. The child stands for at least 5 seconds with the support of both arms on the table, the trunk being unsupported.

4. The child stands for at least 5 seconds while only holding the table with two hands.
5. The child stands for at least 5 seconds while only holding the table with one hand.
6. The child stands while only holding the table with one hand. He transfers his weight laterally in the direction of the motivating toy without lateral flexion of the trunk.

7. The child stands while only holding the table with one hand. He transfers his weight laterally in the direction of the motivating toy and lateral flexes the trunk on the contralateral side. The child stabilises the position of the ipsilateral knee statically, there is scarcely any movement in the knee joint.
8. The child stands while holding the table with one hand. He transfers his weight laterally in the direction of the motivating toy and lateral flexes the trunk on the contralateral side. The child stabilises the position of the ipsilateral knee dynamically, there is clear movement in the knee joint.

Test instructions

Objective
- Registration of the level at which the child is capable of standing with support.

Execution
- Initial posture: standing in front of a table at chest height.
- Stimulate the child to stand independently for 2 or 5 seconds with as little support as possible from arms and trunk.
- Stimulate the child while standing with the support of one hand on the table to transfer his weight in the direction of a motivating toy, to lateral flex the trunk contralaterally and to stabilise the ipsilateral knee dynamically.

Stimulation
- Offer the motivating toy in front of the child on the table.
- If necessary, show the child passively how to stand supported without trunk support (support of 2 arms, 2 hands or of 1 hand).
- Nota bene: make a report of whether support is with the trunk or not.
- Offer the motivating toy to the side and a little above the child, just out of reach.
- Move the motivating toy laterally and a little higher.
- If necessary, position the arm passively.
- If necessary, show the child passively how to transfer the weight laterally.

Camera position
- Obliquely behind the child, at an angle of 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage subdivision

Administration
a. Test item correctly administered.

Movement
b. Transfers weight laterally.
c. Lateral flexes the trunk contralaterally.

Posture
d. Arm support.
e. Trunk support.
f. Hand support.
g. Support with one hand.
h. Statically stable knee.
i. Dynamically stable knee.

Period
j. At least 2 seconds.
k. At least 5 seconds.

Stage specification	Elements
0.	a.
1.	a, e, j.
2.	a, e, k.
3.	a, d, k.
4.	a, f, k.
5.	a, g, k.
6.	a, b, g.
7.	a, b, c, g, h.
8.	a, b, c, g, i.

6.11 Test item 11: Postural control when standing up with support

Objective and method

The objective of this test item is to register the level at which the child is capable of standing up independently with support. To this end, the child is stimulated to stand up from a sitting position on a horizontal surface. For support, use may be made of a table at chest level.

Motor development in relation to postural control

As a result of an inadequate level of postural control, the DS child is not initially capable of going independently from a sitting position to standing with support. The development of this, as regards this test item, starts at the moment that the child pulls himself up symmetrically with his arms on the edge of the table to a standing position. Initially, the legs make hardly any contribution to standing up. The child pulls or pushes himself upwards with his arms, with the legs functioning more or less symmetrically and passively as pivots. A case in point is when children in a kneeling position put their elbows on the table, lean the trunk forwards and push themselves up mainly with the arms. With an increasing level of postural control, the legs are more involved and the child assumes the vertical while extending the legs in a mainly symmetrical manner. The function of the arms continues to play an important part in assuming the standing position. However, the child is now using the table to pull himself up less frequently, but is using the arms to keep his balance. Next, the child can, in a mainly symmetrical manner, go to kneeling before standing up. He supports the position with his arms on the table and with his legs he pushes himself upwards by extending them in a mainly symmetrical manner. In the next stage, the child progresses to standing, whether or not from the kneeling position, via a half-kneeling posture. The emphasis for pushing upwards is clearly in the function of the legs; the arms are used to maintain balance by holding the table with the hands. To this end, in the kneeling position the child transfers weight to one leg. As a result, the contralateral leg can be raised and can be placed forwards or sideways with the foot on the ground. Since the child can then transfer weight forwards or sideways to the contralateral leg that has stepped ahead, then extending this leg, he comes to a standing position (half-kneeling posture). An increasing ability to control the posture is apparent from the reduced arm support on the table.

Initially, assuming the vertical position is supported with both arms on the table, subsequently, the hands are enough to maintain balance in the course of standing up with support.

Information on administration and evaluation of the test item
When administering this test item, it is primarily of importance to determine whether the accent in motor activity in assuming the vertical is on the arm function or the leg function. A number of children pull themselves upwards to the standing position with the arms or the hands without the legs being actively extended. In that case the child can create a fixed point that serves as a tilting point by putting the feet together, for example, or stabilising them against the table. In spite of the fact that the leg function is passive as regards pushing upwards, the child can show a kneeling position or a half-kneeling posture.
If the legs do contribute actively to assuming the standing position, they are mainly responsible for pushing upwards and the table is held with the arms to support the balance. It is to be registered whether there is a mainly symmetrical active leg function or an asymmetrical leg function. With symmetrical leg motor activity the child can show the kneeling position as the transitional posture. In the case of asymmetrical leg motor activity the half-kneeling posture can be observed as the transitional posture. The half-kneeling posture is that posture in which the child, with the trunk held mainly vertical, kneels on one knee and stands on one foot placed in front or at the side of the body. If the child shows the kneeling position or the half-kneeling posture as a transitional posture but then pulls himself up to standing mainly with the arms, this is evaluated as level 1. Finally, it should be determined whether the child needs the arms or the hands in order to maintain balance when standing up via the half-kneeling posture. The motor skill can be coaxed by offering a motivating toy on a table at chest height to the child sitting on the ground. The child must be able to see the toy and must be sufficiently interested in it to reach out for it. The examiner is responsible for ensuring that the toy remains just out of reach of the child. If necessary, the examiner may make the intention of the test item clear manually, for example by the manipulating the pelvis. The behaviour to be scored must be performed independently.

Nota bene
The table should be at chest height. Tables that are lower or higher stimulate adapted behaviour. A table that can be adjusted in height is essential. Furthermore, the level of the motor behaviour displayed is

also dependent on the manner in which the child can grasp the edge of the table. A rod that has been made for this test item is attached to the edge of the adjustable table.
When the child maintains the standing position by holding the table with one hand and supporting by the other arm with the elbow on the table, this is interpreted as supporting on two arms. In fact the arm supported by the elbow will provide the most support. On the other hand, a child who only supports standing up with the hands is capable of bearing unsupported weight, but compensates with the hands for the inadequate degree of balance.
The half-kneeling posture is that posture in which the child is raised on one knee with a trunk held mainly vertically and on one foot placed in front or at the side of the body.

Camera position
The camera is placed obliquely behind the child, filming more or less horizontally at an angle of 45º in relation to the sagittal plane.

Stage classification

Execution
The child, on a horizontal surface in the sitting position, is put in front of a table at chest height and is stimulated to stand up with support.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child pulls or pushes himself up by the arms to the standing position. In the course of assuming the standing position, the child shows mainly inactive leg function.

2. The child stands up and shows an active, mainly symmetrical leg function. The child supports the movement with the arms or with the hands on the table.
3. The child goes via the kneeling position to standing and shows an active, mainly symmetrical leg function. The child supports the movement with the arms or the hands on the table.

4. The child goes via the half-kneeling posture to standing and shows an active leg function. He supports the movement with the arms on the table.
5. The child goes via the half-kneeling posture to standing and shows an active leg function. He supports the movement with the hands on the table.

Test instructions

Objective
- Registration of the level at which the child is capable of standing up independently with support.

Execution
- Initial posture: sitting on the ground in front of a table at chest height.
- Stimulate the child to stand up with the support of the table.
- Nota bene: use a table with a standard table edge.

Stimulation
- Offer the motivating toy on the table.
- Move the motivating toy just out of the child's reach and higher than the child.
- If necessary, show the child passively how to stand up.

Camera position
- Obliquely behind the child, at an angle of 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage subdivision

Administration

a Test item correctly administered.

Movement

b. Pulls himself up on the arms or on the hands.
c. Active leg function.
d. Kneeling position as a transitional posture.
e. Half-kneeling posture as a transitional posture.

Posture

f. Symmetrical leg position.
g. Inactive leg function.
h. Support on the table with one or two arms.
i. Support on the table with one or two hands.

Stage specification	Elements
0.	a.
1.	a, b, g.
2.	a, c, f, h, i.
3.	a, c, d, f, h, i.
4.	a, c, e, h.
5.	a, c, e, i.

6.12 Test item 12: Postural control when standing without support

Objective and method

The objective of this test item is to register the level at which the child is capable of standing without support and of transferring weight laterally. To this end, the child is coaxed in an unsupported standing position to reach out sideways with one arm.

Motor development in relation to postural control

As a result of an inadequate level of postural control, the DS child is initially not capable of continuing to remain standing unsupported: he has difficulty in stabilising the position of the trunk, the hips and the knees. As far as this test item is concerned, the development of unsupported standing begins at the moment that the child is capable of continuing to stand without support for a particular period. Gradually, the period of being able to stand without support will become longer.

The unsupported standing posture becomes more dynamic and functional when the child is capable of transferring weight to one leg. Transferring weight to one side increasingly makes demands on the system of postural control because one leg is increasingly weight-bearing. Finally, the trunk motor activity is also visible; the child laterally flexes and rotates the trunk thereby breaking through the symmetrical extension of the trunk so that he can continue to stand with dissociation.

Initially, the child controls the position of the knees by locking the joints in a more or less stretched position. In this way, the child can bear the weight, but does not dare to move the knee joints. Transferring weight and experiencing balance disturbances both produce problems. Ultimately, the posture of the joint must be maintained in a functional position regarding flexion and extension in such a way that there is a dynamic-stable posture. The knees can be moved and balance disturbances are controlled dynamically.

Information on administration and evaluation of the test item

As mentioned previously, the DS child has specific problems in maintaining the extended posture. As a consequence of disturbances in the system of postural control, problems arise in stabilising the position of the trunk, the hips, the knees and the ankles and thereby in

maintaining the standing posture as a whole. The level of postural control can be adequately established by registering the period that the child can remain standing unsupported (at least two or five seconds) and then by determining whether the child can breach the symmetry by transferring weight laterally. It is important to determine whether or not the trunk is flexed laterally in so doing.
In the course of transferring weight, the ability of the ipsilateral knee to stabilise is registered. A distinction is thus made between static stabilising in a more or less stretched joint position and a dynamic manner of stabilising in a functional position of the joint, with regard to flexion and extension. This level of stabilisation ultimately allows movement in the joint. Movements that can be observed in the knee joint as a result of instability should not be evaluated as dynamically stable, but as static.
The child is placed standing on the ground, after which the examiner should give him the opportunity to assume the standing position himself. If necessary, the child can be put in the standing position with the support of a table. In that case, standing without support can be elicited by offering the child a motivating toy. If the child is capable of standing without support then reaching out with one hand is elicited by offering the child a toy at shoulder height and just out of reach. When the child reaches out, the toy is moved to the side and upward, just out of reach, with the result that the child transfers weight laterally and lateral flexes the contralateral side of the trunk. Motor activity of the ipsilateral knee joint is in fact elicited by stimulating the child to reach out horizontally to the side. A bent knee provides the possibility of reaching out further sideways. Perhaps the examiner can show the child passively how to reach out.
If necessary, and when possible, it should be made clear to the child that the foot may not be moved when reaching out sideways, for example by having one foot placed in a ring. As soon as the ipsilateral foot is raised from the ground in transferring weight laterally there is a transfer reaction in the sense of concomitant stepping. The posture ends at that moment and the time registration should be stopped. If so desired, standing without support can be encouraged once again. The toy should be something that interests the child and makes him want to reach out for it.

Camera position

The camera is placed obliquely behind the child, filming more or less horizontally at an angle of 45º in relation to the sagittal plane.

Stage classification

Execution The child is placed standing on a horizontal surface. He is encouraged to stand without support. Then he is encouraged to transfer weight laterally in combination with contralateral trunk lateral flexion by coaxing him to reach out sideways with one arm.
Scale 0. The test item has been correctly administered, but the child shows no motor ability that is described in any of the stage specifications below. 1. The child stands unsupported for at least 2 seconds. 2. The child stands unsupported for at least 5 seconds. 3. The child stands unsupported and transfers weight laterally. He hardly lateral flexes the trunk on the contralateral side at all. 4. The child stands unsupported. He transfers weight laterally and clearly lateral flexes the trunk on the contralateral side. He stabilises the position of the ipsilateral knee for the most part statically, with little or no movement in the knee joint. 5. The child stands unsupported. He transfers weight laterally and clearly lateral flexes the trunk on the contralateral side. He stabilises the position of the ipsilateral knee for the most part dynamically with movement in the knee joint.

Test instructions

Objective
- Registration of the level at which the child is capable of standing without support.

Execution
- Initial posture: unsupported standing.
- Encourage the child to stand without support for 2 or 5 seconds.
- Encourage the child to transfer weight laterally, to lateral flex the trunk contralaterally for 2 seconds and to stabilise the ipsilateral knee dynamically.
- If necessary, place one leg in a hoop.

Stimulation
- Offer a motivating toy in front of the child.
- Offer a motivating toy at the child's side at shoulder level just out of reach.
- Just out of reach, move the toy laterally and somewhat higher.
- If necessary, position the arm passively in a reaching-out position.
- If necessary, show the child passively how to transfer weight laterally.

Camera position
- Obliquely behind the child at an angle of 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage classification

Administration
a. Test item correctly administered.

Movement
b. Transfers weight laterally.
c. Lateral flexes the trunk contralaterally.

Posture
d. Statically stable knee.
e. Dynamically stable knee.

Period
f. At least 2 seconds.
g. At least 5 seconds.

Stage specification	Elements
0.	a.
1.	a, f.
2.	a, g.
3.	a, b.
4.	a, b, c, d.
5.	a, b, c, e.

6.13 Test item 13: Postural control in adopting the sitting position from prone

Objective and method

The objective of this test item is to register the level at which the child is capable of assuming the sitting position from prone. To this end, the child was placed in the prone position and encouraged to sit up.

Motor development in relation to postural control

In a particular phase of the child's motor development, the sitting posture appears emphatically as a transitional posture. In this phase the child frequently moves around the sitting posture as he goes from sitting to side-sitting and then on to the prone position or to the crawling posture and vice versa. During this phase of development, the further development of qualitatively high-ranking motor activities can normally be observed, such as balance, trunk extension, trunk rotation and trunk lateral flexion. In DS children, the development of these forms of movement is adversely affected by disturbances in the system of postural control. In the framework of this test item, the focus is on the development of assuming the sitting position from the prone. The problems that occur in this are seen as representative for the whole gamut of motor problems in this phase of development.

As a result of an inadequate level of postural control, the DS child is initially not capable of assuming the sitting position independently. As far as this test item is concerned, the development begins when the child comes to the sitting position in a mainly symmetrical manner with support of the arms. A distinctive feature is that in the course of the motor behaviour the trunk is kept as much as possible within the supporting surface and that trunk motor activity (trunk rotation and trunk lateral flexion) only has a restricted role to play in assuming the vertical. In this respect mainly four movement variants can be distinguished.

A typical manner of assuming the sitting position is that in which the trunk is pushed upwards with the arms in the prone position and the legs are brought forward by means of symmetrical wide abduction. In this, the knees can be extended, although some children keep one of the knees bent. In the second place, it can be observed that the child pulls the knees in under the trunk in a sort of hands-and-knees position and then pushes the trunk upwards with the arms and comes to a sitting position with the buttocks on or between the feet. In neither

movement variant does the trunk come outside the support surface nor does the child lose balance. The hips are moved in a mainly symmetrical manner. Side-sitting is not observed and the trunk movements are symmetrical and require little trunk motor activity.
A number of children, when in the prone position, do not pull their knees under the trunk but next to it. Subsequently, from a sort of side-lying/half side-sitting position, the trunk is first pushed with the arms as far as possible above the pelvis. As a result, the pelvis tilts to a horizontal position. Then the trunk is pushed to the vertical with the arms. A passive trunk lateral flexion can be observed, but on the side of the arms pushing upwards. Some children, with rather more ability to stabilise the spinal column, maintain the trunk in a more neutral position regarding lateral flexion and shortening. As with the first variants described, neither of these motor behaviours shows any side-sitting.
With an increasing level of postural control, the motor skill assumes a more asymmetrical character. The child’s trunk motor ability is more manifest. This is displayed in two different movement forms. In the first, the child pulls the knees upwards next to the trunk and comes via side-sitting to the sitting position. Lateral trunk flexion can be observed on the side of the arms pushing upwards. However, the contralateral lateral flexion of the trunk is still not sufficiently active and it is the pushing upwards with the arms that is the decisive factor in assuming the sitting position. In the second variant, the child in the prone position pulls the knees under the stomach and goes to a hands-and-knees position. There is evidence of developing trunk motor activity in going from side-sitting to sitting. The trunk motor activity required for this is eccentric in nature with the force of gravity contributing to the establishment of the movement pattern.
In the case of further development, a third level occurs. The contra-lateral trunk lateral flexion becomes more and more active and the role of the arms in assuming the sitting position is less important. Ultimately, arm support in the last phase of the movement is hardly essential any more. The trunk is brought above the sitting base with some arm support through an active trunk lateral flexion focussed against the force of gravity. Side-sitting as a transitional posture can be observed.

Information on administration and evaluation of the test item

In administering this test item, it is important first to classify the degree of symmetry in the movement patterns displayed. In this respect, it is essential to register whether or not the child displays side-sitting as an

indication for trunk rotation and lateral flexion. At level 1, as indicated, four movement variants can be described. A feature of all four variants is that the trunk is pushed upwards with the arms and that no clear side-sitting can be observed.
It is important to define ‘side-sitting’ as a posture. Side-sitting entails an asymmetrical sitting posture, in which the body weight rests mainly on one buttock and the trunk is lateral flexed on the contralateral side. In a complete side-sitting posture the ipsilateral leg is exorotated in the hip, and the contralateral leg on the other hand is endorotated. Frequently, however, exorotation is observed in both hips, with the legs displaying a sort of cross-legged sitting posture. This posture also counts as side-sitting. The side-sitting posture requires an adequate level of postural control functions in a conditional sense, particularly balance, and is indicative for developing trunk motor activity. In the first two movement patterns at level 1 the child does not move the trunk outside the supporting surface while the hip motor activity is largely symmetrical. On the one hand, the child pushes the trunk upwards with the arms and moves the legs forward while widely abducting the hips. He achieves the sitting position and there is no clear side-sitting to be observed. The wide abduction of the hips in this pattern is observed both with the two extended knees and with one extended and one bent knee. In the latter case there is apparently side-sitting because the buttock on the side of the bent knee is somewhat higher as a result of which the pelvis tilts somewhat sideways. Nevertheless, the child stays with the trunk above the supporting surface and the rotations in the hips are mainly symmetrical. On the other hand, the child can push up the trunk with the arms and he pulls the knees up under the trunk. He achieves the sitting posture without bringing the trunk outside the surface area, and no clear side-sitting can be observed. In this case also, it can apparently be said to be side-sitting because the legs are not entirely symmetrically weight-bearing and the pelvis is somewhat tilted to the side. The third variant displays trunk lateral flexion on the side of the arms pushing upwards. The child raises the trunk with the arms and draws in the knees next to the trunk. The trunk is first raised above the supporting surface using the arms, causing the pelvis to tilt horizontally. At the side of the arms pushing upwards as a result of this, a clear trunk lateral flexion can be observed. In variant four the trunk is rather more stabilised but the pattern of movement is further equivalent to the third variant. Just as in the first two variants, no side-sitting is displayed in variants three and four and pushing up with the arms is decisive for assuming the vertical.

Unlike stage specification 1, level 2 shows a passive form of side-sitting as a constituent of movement. The trunk is not optimally active in this and does not lateral flex actively as part of assuming the sitting position. It is pushing up with the arms that ensures that the child achieves the sitting position. On the one hand, side-sitting comes into being eccentrically as a result of force of gravity because the child, from the hands-and-knees position, places the buttocks on the ground next to the feet and lower legs in order to achieve the sitting position. On the other hand, the child pushes the trunk upwards from side-lying/ half side-sitting as a result of which a passive trunk lateral flexion also occurs. Finally, level 3 requires active trunk motor activity; side-sitting occurs particularly through an active trunk lateral flexion from side-lying/ half side-sitting and the need for hand support is restricted.
The motor skill can be elicited by offering a motivating toy to the child in the prone position obliquely above and somewhat caudally in relation to the child's head, within his line of vision but out of reach of the hands. The toy must be interesting enough for the child to want to reach out with one arm. When the child reaches out, the toy is moved a bit higher and caudally to encourage him to assume the vertical. It is obvious that the child must be encouraged to adopt the sitting position via a side-sitting position.
Moreover, it is a fact that children who can come to a sitting position independently show a strong urge actually to sit. Eliciting the motor behaviour is, in that case, completely superfluous. Some children, who go from the prone position to a crawling posture, crawl a little bit before sitting. As long as the motor behaviour can be included in a stage description, this behaviour may be evaluated as 'assuming the sitting position'.

Camera position
The camera is placed obliquely in front of the child, filming almost horizontally at an angle of 45º in relation to the sagittal plane.

Stage classification

Execution
The child is placed in the prone position on a horizontal surface and is encouraged to adopt the sitting position.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child adopts the sitting position by pushing up the trunk with the arms. He does not display any clear side-sitting.

2. The child adopts the sitting position by pushing up the trunk with the arms. He displays clear side-sitting.

3. The child assumes the sitting position by raising the trunk with an active trunk lateral flexion and some hand support. He shows clear side-sitting.

Test instructions

Objective
- Registration of the level at which the child is capable of assuming the sitting position from the prone position.

Execution
- Initial posture: prone position.
- Encourage the child to adopt a sitting position.

Stimulation
- Offer the motivating toy obliquely in front, but just out of reach of the child.
- Move the motivating toy a bit higher. Move the toy parallel to the body caudally.
- If necessary, show the child passively how to assume the sitting position.

Camera position
- Obliquely in front of the child, at an angle of 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage classification

Administration

a. Test item correctly administered.

Movement

b. Assumes sitting position.
c. Pushes trunk upward with arms.
d. Active trunk lateral flexion and some help from the arms.

Posture

e. No side-sitting.
f. Side-sitting.

Stage specification	Elements
0.	a.
1.	a, b, c, e.
2.	a, b, c, f.
3.	a, b, d, f.

6.14 Test item 14: Postural control when walking without support

Objective and method

The object of this test item is to register the level at which the child is capable of walking without support. To this end, the child is coaxed to walk without support.

Motor development in relation to postural control

It is inherent in walking that body weight is transferred to one leg in order to raise and move the other leg. By definition, therefore, walking is an asymmetrical form of motor behaviour in which extreme demands are made on the ability to control posture when moving in dissociated initial postures. When a DS child is walking, disturbances in the system of postural control can be observed in the motor activity of the head, of the trunk and of the limbs. These disturbances have an influence on the subsidiary functions of walking, but also on walking as a whole. A generally applicable reciprocal developmental sequence of these subsidiary functions cannot be given. The manner of development in walking is in any case determined by the individual specific distribution of the extent of problems of postural control over a child's body, as well as by the development that takes place in it. A child may have the tendency to compensate by locking parts of the body. For example, a manifestly reduced level of postural control in the lower extremities can lead to the static and passive stabilisation of the knees in a final extension. Compensatory balance responses can then be observed in the trunk and in the arms.

Due to an inadequate level of postural control, the DS child will not be able to walk without support. The development of walking in the context of this test item begins at the moment that the child can take a few steps without support. A growing ability to control posture is apparent from the more frequent occurrence of movement dissociation in the course of walking. Trunk rotation can occur while the shoulder girdle and the pelvic girdle do not rotate initially in relation to one another. The head and shoulders can be stabilised more dynamically and functionally, instead of being locked in retraction. The child can then look around freely, for example, as he is walking. The arms can be used more functionally when walking, instead of necessarily being fixed in the wing position.

The child initially has problems in maintaining balance. He walks with the legs wide apart, transfers weight particularly sideways and shows a Trendelenburg gait. With an increasing level of postural control there is an improvement in the ability to maintain balance when walking without support. His wide-legged gait becomes narrower and the child is better able to stabilise the weight-bearing hip and to bend the hips more selectively. The weight is also transferred more forwards instead of sideways, the knees can be dynamically weight-bearing in a light flexion instead of in a statically fixed position and in the feet an increasingly controlled development takes place. With continuing development, the walking distance will increase and walking will become more functional. The child will be able to change the direction of walking without sitting or using support. Ultimately, other forms of walking, such as running, hopping, walking backwards and so on will occur, but these are outside the parameters of this test.

Information on administration and evaluation of the test item
The level of postural control in walking without support can be deduced from the degree of functionality of walking as a whole. It may also be observed more locally in the motor activity of the head and the shoulder girdle, the position of the arms, the movement dissociation in the trunk, the stability of the hips and the knees, the manner of transferring weight and the posture and movement of the foot and ankle. The level of postural control can be adequately established by registering the distance the child can walk unsupported, by assessing whether or not the child can change the direction of walking, by establishing whether or not the child is walking with trunk rotation and by scoring the motor activity of the knees in the standing phase. Scoring the presence or absence of trunk rotation, particularly during unsupported walking, is not easy, while its occurrence is an important indication of the development of balance and functionality in walking. A child is walking with trunk rotation when the shoulder girdle and the pelvic girdle are clearly rotating in relation to each other. This rotation should also be perceptible during the major part of the walking. An observer should not have to search for moments of rotation; in such a case that would simply be scored as negative. In the walking of non-disabled children, the presence or absence of trunk rotation can immediately be clearly recognised. An aid to the recognition of trunk rotation in DS children could be that it often occurs at the same time as the development of a narrow-legged gait, a more selective bending of the hip of the leg that is moved forward and more selective weight-bearing of the hip of the standing leg.

As mentioned earlier, we also decided to register the level of postural control of the weight-bearing knee joint during the standing phase. In this, a distinction is made between statically stabilising in a more or less stretched position of the joint and a dynamic manner of stabilising the joint in a functional position, as far as flexion and extension are concerned. This latter level of stabilising finally allows scoring of movement in the joint. Static or dynamic stabilisation can be adjudged when this is observed mainly in the course of walking. Unsupported walking can be elicited by placing the child on the ground and offering a motivating toy just out of reach. The toy must be such that the child will want to move towards it, the position of the toy should be such that the child will have to move in order to reach the toy. The examiner must give the child the opportunity to assume the standing position, if necessary a supported standing position can be used as a starting position, for example in front of a table, or a standing position supported by the examiner. If necessary, the examiner can show the child passively how to walk, for example via the pelvis or the arms. The child must carry out the motor behaviour independently which is ultimately to be scored.

Nota bene

The examiner should realise that the walking pattern of the child is influenced whenever he carries a toy in his hands. Thus, carrying a ball with two hands influences the child's trunk rotation in the course of walking.

At level 1 and 2 the rule is that the number of steps taken is of decisive significance. The forward movement of one leg counts as one step. The subsequent forward movement of the contralateral leg counts as a following step.

Camera position

The camera is at an angle of 90º in relation to the direction in which the child is walking. The child's walking is filmed almost horizontally, obliquely in front, from the side and from obliquely behind.

Stage classification

Execution
The child is placed standing on a horizontal surface and is stimulated to walk without support.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child walks at least 3 steps without support.
2. The child walks at least 7 steps without support.

3. The child walks at least 7 steps without support and walks to and fro. Hardly any trunk rotation can be observed. During the standing phase the position of the knees is mainly stabilised statically.

4. The child walks at least 7 steps without support and walks to and fro. Either clear trunk rotation can be observed or the position to the knees during the standing phase is mainly stabilised dynamically.
5. The child walks at least 7 steps without support and walks to and fro. Clear trunk rotation can be observed and during the standing phase the position of the knees is mainly stabilised dynamically.

Test instructions

Objective
- Registration of the level at which the child is capable of walking without support.

Execution
- Initial posture: standing.
- Encourage the child to walk without support. 3 steps, 7 steps and to and fro.

Stimulation
- Offer the standing child a motivating toy out of reach.
- Move the toy away out of reach of the child.
- If necessary, show the child passively how to walk.

Camera position
- At an angle of 90º in relation to the direction in which the child is walking. The child's walking is filmed almost horizontally, obliquely in front, from the side and from obliquely behind.

Scoring

Characteristic elements of the stage classification

Administration
a. Test item correctly administered.

Movement
b. Walks without support.
c. Without trunk rotation.
d. Either trunk rotation or dynamically stable knee.
e. Both trunk rotation and dynamically stable knee.

Posture
f. Statically stable knee.

Distance
g. 3 steps.
h. 7 steps.
i. To and fro.

Stage specification	Elements
0.	a
1.	a, b, g.
2.	a, b, h.
3.	a, b, c, f, i.
4.	a, b, d, i.
5.	a, b, e, i.

Test item 15: Postural control during standing up without support

Objective and method

The objective of this test item is to register the level at which the child is capable of standing up without support. To this end, the child is stimulated to stand up from a sitting position on a horizontal surface.

Motor development in relation to postural control

As a result of an inadequate level of postural control, the DS child is not initially capable of standing up without support. The start of this development in the context of this test item may be twofold. The common characteristic for this first level of motor activity is that the movement patterns executed are symmetrical. On the one hand, it can be observed that a child goes symmetrically from the sitting position via the hands-and-knees position to the hands-and-feet posture. Trunk rotation and trunk lateral flexion cannot be observed. The child brings his body weight above the feet by sliding the hands towards the feet. Then he stands up by simultaneously stretching the back and the legs. On the other hand, it can be observed that a child in the sitting position places the feet on the ground and thus comes to a symmetrical squatting position. He then progresses to a symmetrical standing position, with or without the support of the hands, by stretching both legs simultaneously. Here too, some symmetrical trunk motor activity can be observed.

The motor behaviour becomes less symmetrical when, for example, the child goes from the sitting position via side-sitting to a hands-and-knees posture or from the hands-and-knees posture places the feet one by one on the ground to go to a hands-and-feet posture. To this end, weight is transferred laterally and a better-developed level of balance and stability is necessary. When the level of postural control improves further, the child stands up symmetrically from the hands-and-feet posture, but it is not necessary to move the hands to the feet first in order to stand up. An indication of increasing trunk motor possibilities of going to the hands-and-knees posture, hands-and-feet posture or the squatting position, is the fact that trunk rotation and/or lateral trunk flexion can be observed in the movement pattern. Subsequently, in finally standing up the child will use the half-kneeling posture. The half-kneeling posture is that posture in which the child with a mainly vertically held trunk stands supported on one knee and on one foot placed in front of the body. Supporting with one hand on the ground or with one or two hands on the leg with which he has stepped out facilitates, in the first instance, the maintenance of balance in standing up. A functional level of postural control has been achieved when the child stands up via the half-kneeling posture and no longer needs arm support.

Information on administration and evaluation of the test item
The level of postural control in the course of standing up without support can be deduced from the extent of symmetry in the movement pattern to go from the sitting position to the hands-and-feet posture or the squatting posture. Furthermore, it is registered whether or not use is made of the half-kneeling posture in the course of standing up and the extent of support of the movement with the arms is recorded.
As far as this test item is concerned, it is important to determine whether or not the child goes symmetrically from the sitting position to the hands-and-feet posture or to the squatting posture. The deciding factor in this is whether or not trunk rotation and/or lateral flexion can be observed. Through rotation and/or lateral flexion the child's trunk moves outside the supporting surface and thereby gives evidence of trunk dissociation. For example, he displays side-sitting when he goes from the sitting position to the hands-and-knees posture, or places the feet in front one by one when he goes from the hands-and-knees posture to hands-and-feet posture or to the squatting posture.
As soon as the child goes to the hands-and-feet posture or squatting position with clear trunk rotation and/or lateral flexion it is important to determine in what manner the child then proceeds to stand. When he makes use of the half-kneeling posture at this point it indicates an increasing ability of posture dissociation and an increasing ability to maintain balance. In the final standing up via the half-kneeling position, it should be observed whether or not the child supports the movement with the hands. A functional level of postural control has been achieved when the child reaches the standing position via the half-kneeling posture without the support of the hands.
This motor skill can be elicited by offering a motivating toy above the child sitting on the ground, just out of reach of his arms. The child that stands up from the prone position without showing sitting as a transitional posture should be corrected, as should the child that starts the movement from 'sitting on the heels'. When the child actually assumes the vertical, the examiner moves the toy proportionately higher. The toy should be so interesting that the child wants to grasp it.

If necessary, the examiner can indicate the required motor behaviour, for example via the child's hands or shoulders. With somewhat older children the movement can be demonstrated by the examiner or can be explained verbally. Only that motor behaviour which is executed independently is evaluated. When the child stands up with a toy in his hands this will influence his manner of standing up. The child should achieve a standing position with a mainly vertical trunk position.

Nota bene

It is important to define further the concept 'half-kneeling posture'. The half-kneeling posture is the posture in which the child, with the trunk held mainly vertically, supports himself on one knee and on one foot placed in front of, or next to the body. A characteristic of the half-kneeling posture is the more or less vertical trunk. One or both hands can be placed on the ground or on the legs for support. When both supporting hands are placed on the ground the trunk posture quickly becomes more horizontal and a crawling posture occurs which should in fact be evaluated as such.

Camera position

The camera is placed obliquely behind the child, filming more or less horizontally at an angle of 45º in relation to the sagittal plane.

Stage classification

Execution
The child is placed in the sitting position on a horizontal surface and is encouraged to stand up.

Scale

0. The test item has been correctly administered, but the child shows no motor behaviour that is described in any of the stage specifications below.

1. The child comes symmetrically to a hands-and-feet posture or a squatting posture. Trunk rotation and/or trunk lateral flexion are scarcely observed at all. The child then comes to a standing position by stretching the legs in a mainly symmetrical manner.

2. With a clear trunk rotation and/or trunk lateral flexion the child goes from the sitting position to the hands-and-feet posture or to the squatting posture. He then comes to the standing position by stretching the legs in a mainly symmetrical manner.

3. The child comes to the standing position via the half-kneeling posture with support of the hands.
4. The child comes to the standing position via the half-kneeling posture without support of the hands.

Test instructions

Objective
- Registration of the level at which the child is capable of standing up without support.

Execution
- Initial posture: sitting on the ground.
- Encourage the child to stand up.

Stimulation
- Offer the motivating toy above the child's head, just out of reach.
- Move the toy above the child and out of reach, proportionally to the child's standing up.
- If necessary, indicate standing up passively or demonstrate it.

Camera position
- Obliquely behind the child, at an angle of 45º in relation to the sagittal plane.

Scoring

Characteristic elements of the stage classification

Administration

a. Test correctly administered.

Movement

b. Stands up.
c. Without trunk rotation and lateral flexion.
d. Symmetrical stretching of the legs.
e. Unambiguous trunk rotation and/or trunk lateral flexion.

Posture

f. Hand-and-feet position or squatting posture.
g. Half-kneeling posture.
h. With support of hands.
i. Without support of hands.

Stage specification	Elements
0.	a.
1.	a, b, c, d, f.
2.	a, b, d, e, f.
3.	a, b, g, h.
4.	a, b, g, i.

Physiotherapy for young children with Down's syndrome

A therapeutic framework

Appendix 2

Table of contents

1 Introduction

The therapeutic framework 'Physiotherapy for young children with Down's syndrome' provides the paediatric physiotherapist with a framework for the exercise therapy of young children with Down's syndrome (hereafter DS children) in the developmental period of basic motor skills. This framework is based on the theoretical concept of 'Disturbances in the system of postural control' of DS children and outlines the motor restrictions, the therapeutic objectives, the possibilities of exercise therapy and of parental participation. The therapeutic framework is not an all-embracing programme. The idea behind this framework is to provide the paediatric physiotherapist in attendance with insight into the process that leads to the occurrence of the specific motor behaviour of DS children and into the possibilities of shaping such developmental process by means of exercise therapy tailored to these problems. Individual adaptation of the framework to the individual child is necessary, and is the responsibility of the paediatric physiotherapist.
As the exercise therapy is in this case the treatment of young children with mental limitations, the treatment objectives in the motor area are related to functionality. It is preferable that meaningful situations be provided associated with the child's experience, resulting in the required motor behaviour being stimulated in a natural context. Parental participation appears to be the most appropriate procedure regarding the generalisation of effects. Based on this framework it is possible for DS children to have paediatric physiotherapy and be instructed during the period of the development of basic motor skills.

2 Motor disturbances and limitations

Normal motor development can be divided into four phases: the stage of reflexive movements (prenatal and first year of life); the stage of rudimentary movements or basic motor skills (first two years of life); the stage of fundamental movements (second to seventh years of life) and the stage of specialised movements (from the tenth year onwards). The development of voluntary motor activity begins at the stage of basic motor skills. Basic motor skills lay the foundation for the development of the following stage of fundamental movements. Motor intervention is preferred to take place during this stage. Nine functional developmental stages can be distinguished in the phase of the development of basic motor skills: the development of motor activity in the prone position, in the supine position, rolling over, sitting, moving forward over the ground, motility around the sitting position and standing, standing up and walking. For the majority of DS children this is motor behaviour that develops in the first three to four years of life. The motor development of DS children is negatively influenced by reduced a postural tonus, by insufficiency of stabilising co-contractions of joints, by a defective proprioceptive feedback on posture and movement, by inadequate balance responses and by an enlarged motility of joints. To summarize: there are disturbances in the system that controls posture (see Table 1). From a functional point of view, these disturbances are displayed more particularly at those times in the motor development that the child masters postural and movement patterns, whereby the force of gravity is overcome and the child assumes the vertical.

Primary	- reduced postural tonus
Secondary	- insufficiency of co-contractions - insufficiency of balance reactions - reduced propriocepsis - increased joint mobility
Consequences	- problems in achieving and maintaining positions in posture and movement - inadequate development of qualitative aspects of motor ability - inadequate appropriate motor activity

Table 1 Disturbances in the system of postural control

One characteristic of the course of motor development of DS children is the initial incompetence and the increasing, yet insufficient, ability to stabilise a posture. However, the child does want to move and for that moment he[1] develops adequate compensatory mechanisms in motor behaviour. This results in symmetrical postural and movement patterns, for example, in which there is only a restricted development along the path towards asymmetry. Ultimately, idiosyncratic possibilities occur in terms of dissociation, balance, variability and motility.

[1] 'He', 'him' and 'his' are used indiscriminately for both male and female DS children

Successively, the child has problems in the first instance in assuming postures and then, with an increasing level of postural control, a posture can be assumed, but not stabilised. Subsequently, the child is able to stabilise the assumed posture but can only move in it to a restricted extent. The development of movement dissociation in the assumed posture is insufficiently viable in a functional sense. Aspects of movement, such as trunk rotation and lateral flexion, for example, and consequently the ability to maintain balance, are inadequately developed.

3 Physiotherapy treatment

The specific physiotherapy treatment during the stage of basic motor skills will be discussed in terms of the nine functional phases named above. Seven items will be examined in relation to each phase:
- general motor picture
- specific motor problems
- compensatory motor activities
- consequences for motor development
- treatment objectives
- exercise therapy
- assignment for parents

It is important, in order to be able to give problem specific physiotherapy, to have knowledge of the precise motor problems of the DS child. It is also important to place the problems in a developmental framework and to recognise their influence on motor development as a whole. For this reason there is a general motor picture of the DS child for each phase, with a list of specific problems in postural control and a description of the compensatory motor activities adopted by the child. There is then an examination of the possible consequences of such with regard to the course of development of the period of basic motor skills. Resulting from the specific motor profile sketched, the outline of a problem specific motor intervention programme has been devised. The motor activities of the children will be affected, to a varied extent, by problems of postural control. Not all the problems sketched occur in each child. Depending on the degree of problems in postural control for the individual child, there will be differences between them in a functional sense as far as the motor possibilities are concerned. It will be indicated concisely how the specific physiotherapy treatment can be given shape and how parents can participate in the treatment. The implementation of the treatment is not described in great detail. Each child develops differently and the paediatric physiotherapist in attendance will give the general objectives a specific form for each individual.

In general, a treatment will be focused on improving the stability around the joints in each phase of motor development, as a result of which the child is enabled to assume a posture. Initially, he will do this symmetrically and if necessary with support, but with increasing postural control he can work towards asymmetrical postures, and support then being gradually decreased. Demand is increasingly made in this way on the effectiveness of the system of postural control. Ultimately, movement dissociation is made possible in asymmetrical initial positions, efforts being made to improve the level of postural control and the variation of movement thus being stimulated. The increasing postural tonus of the DS child means that postural and movement patterns, corrected by intervention, achieve a greater foundation in the long term of being maintained in movement.

As indicated above, the treatment framework consists of exercise therapy. By definition, this requires the active participation of the child. Since what is concerned here is a physiotherapy treatment of a very specific group of clients, it is important to relate this therapy to the children's experience. Children should be challenged by the movement situations provided. They should recognise and experience something in them. Movement situations must offer safety. Exercise therapy should therefore be well-balanced, but should also contain enough challenge so that the children are prepared to explore the boundaries of their motor potential and add new elements. Movement situations should be manifest and recognisable, they should be derived from the demands of daily life. A movement demand should result in a motor response, as a matter of course.

4 Parental participation

In this physiotherapeutic framework, the instruction and participation of parents are seen as essential elements of the treatment. The quality and effectiveness of motor activities can only be influenced if parents integrate the application of corrections in their interactions with their children. The treatment objectives of physiotherapy should therefore be integrated into the activities of daily life. After all, motor development takes time, and the learning and mastering of motor skills requires practice and repetition.
However, a paediatric physiotherapist should consider carefully the position she[2] is going to take in a family with a young DS child. The family, into which a disabled child has been born, may be feeling uncertain because ordinary and obvious patterns of interaction do not seem to work. A treatment programme offered from outside may be seen as a solution, but there is a possibility that the therapist with her therapy programme may determine the daily routine of the family. However, the family has the primary responsibility regarding upbringing and family life, and should also maintain that position in this situation. The task of the paediatric physiotherapist is to support the overall objectives of the parents with regard to specific motor (subsidiary) objectives. Parents should determine in what manner this assistance should take shape; physiotherapy is a product of the parents' objectives.
It is probable that a higher degree of parental participation might lead to better treatment results. It is, of course, the therapist's task to stimulate this, but also to plan a balanced programme together with the parents. In this respect, it is a good idea to broaden the parents' outlook by informing them about the motor problems of their child, on the objectives and the manner of procedure of the intervention together with the importance of their participation. Furthermore, it is important to pay due attention to the transfer of skills. In the context of this treatment, the physiotherapist will demonstrate assistance in the desired motor activity during the treatment and the parents are then given the opportunity to practise doing this under supervision during the session. They will take home with them a brief description on paper, and this will be referred to during the following treatment sessions. Parents are asked to demonstrate their skills and the physiotherapist gives feedback. It is important to restrict the amount of information given per session. There are forty standard assignments

[1] 'She'and 'her' are used to refer to both male and female physiotherapist

connected with the therapeutic framework, supporting the written assignment given by the physiotherapist to the parents.
Although the parents' support of a treatment always demands time and focused attention, the participation should be as minimally taxing as possible and should encroach as little as possible on family life. The more taxing the parents consider the participation to be, the more likely that the treatment frequency will be reduced. Every family has its own optimal situation in this respect. A practical, but at the same time functionally focussed, modus operandi is to strive to integrate the skills within the parents' daily interactions with the child. Integration can be achieved, for example, by imitating the play and care situations during the treatment and by periodically giving the treatment at the child's home. Parents can be taught in which way they can stimulate the child in a focused motor skill during everyday situations, without it costing extra time and without it interfering with their care routine. Suggestions from parents on this point are appreciated.

5 Physiotherapeutic treatment framework

5.1 Phase 1: Motor behaviour in the prone position

General motor picture
- There are problems in the development of posture and movement against the force of gravity.
- This leads to a mainly flat prone position with a preference for a great deal of symmetrical support. This has a negative influence on the development of an adequate symmetrical extension of the head, trunk and limbs.
- The proclivity for symmetrical support and the lack of extension development interferes with the occurrence of dissociated movement in the prone position. One feature of motor behaviour in this initial posture is its static character, the child appearing passive and hypotonic.

Specific motor problems
- The head lies passively supported by the ground underneath. The child has problems in raising the head and therefore also in turning it.
- Positioning of the head in a raised posture is problematic due to a lack of stability.
- If a raised head posture can be assumed, this is initially only possible symmetrically.
- Functional stabilisation of the head position (looking round) is developed with difficulty, as is adequate reaction to posture changes with posture reactions.
- The arms lie passive and bent, next to the body and supported by the ground.
- The development of raising, stretching and reaching out to the front with both arms takes place with difficulty due to a lack of stability in the shoulder girdle.
- Problems arise in supporting on the elbows and on the hands, due to a lack of stability in the shoulder girdle and an inadequate development of trunk extension.
- When the child is able to support himself on his elbows or hands,

this takes place symmetrically. There are problems in transferring weight laterally to one arm and then reaching out with the contralateral arm. This is not possible until sufficient stability has developed in the shoulder on which the child is supporting himself, and until the ability to extend and rotate the trunk has increased.
- Manual motor ability and play are inadequately developed.
- The ability to stretch the trunk and the hips is inadequately developed. Problems arise in raising the thorax and the pelvis from the ground.
- The child has difficulty in stabilising the trunk in an extended position, for example when raising the head, arms and legs.
- The lack of trunk stability leads to an inadequate development of trunk rotations and of balance in the prone position. In addition, this has repercussions on the development of arm motor activities in the prone position.

Compensatory motor activities
- Making use of support from the ground compensates for the lack of stability in head, trunk, shoulder girdle and hips.
- The problem in stabilising the position of the head is offset by drawing the head into the neck for support.
- The lack of stability around the shoulder girdle is compensated for by using the arms for symmetrical support and a symmetrical trunk position.

Consequences for motor development
- The defective development of postural control, and therefore of movement dissociation of the head, influences the development of these functions in more vertical positions.
- The inadequate development of postural control around the shoulder girdle has consequences for the development of moving forward over the ground (crawling, creeping). In addition, it influences the development of adopting the sitting position, as well as manual motor activity in the supine position, during sitting and standing.
- The lack of postural control of the head and the problems in reaching out both influence the development of spatial orientation, play and the development of playing, together with the development of manual function.
- The inefficient extension development of the trunk and the hips influences stretching and stability in more vertical positions, for example in sitting and in the course of walking and standing.

- The inadequate development of trunk rotation and of balance in the prone position influences the development of dissociation possibilities of the trunk in more vertical positions, for example in sitting and in standing.
- The emergence of compensatory movement strategies thwarts the development of normal and more functional movement patterns.

Treatment objectives
- The development of an efficient level of postural control of the head. It should be possible to stabilise the position of the head. The child will then be able to react adequately to postural changes and be able to look round.
- The development of adequate stretching in the trunk, the hips and the limbs.
- The development of trunk stability to the extent that trunk motor activities can develop and that the head and limbs can be moved efficiently.
- The development of an effective level of stability of the shoulder girdle so that it is possible to reach out with the arms, making manual functions and play development possible.

Exercise therapy
Initial posture: prone position, for example on a mat or a balance board.
- To facilitate raising the head: exercise stability, balance and motility of the head in relation to the trunk.
- To facilitate symmetrical support on the elbows and on the hands, transferring weight, reaching out and grasping, playing.
- A rolled towel under the chest, or a wedge cushion, makes it easier for the child to stabilise the position of the head and to reach out with the arms.
- To facilitate extension in the trunk, the hips and the limbs.
- To facilitate trunk stability and trunk motor activity (lateral trunk flexion, rotation and balance).
- To rotate with the purpose of improving postural control of the head, trunk stability and trunk motor activity (lateral trunk flexion, rotation and balance).

Initial posture: prone position with the chest supported on moveable exercise material (rolled towel, leg, Bobath ball, football). In this way there is an opportunity of varying the initial posture from horizontal to a more vertical one and vice versa, introducing rotations and eliciting

balance responses.
- To facilitate raising the head: exercise stability, balance and motility around the head.
- To vary the degree of support on the arms, transfer weight, stimulate righting reactions, wheelbarrow.
- Elicit reaching out, grasping and play.
- Vary the degree of trunk extension. Facilitate extension in the hips and the limbs.
- Rotating with the aim of postural control of the head and trunk stability, lateral flexion, rotation and balance.
- Balance responses of the trunk, to the front, behind and sideways.
- Gradual lessening of support on the legs.

Assignments for parents
- If necessary, support well when carrying.
- Pick up and carry in the prone position and in the sitting position whereby, dependent on the support given, raising and stabilising the head and stretching the trunk can be encouraged to a varying degree.
- Picking up the child in such a way that rotations are required, as a result of which the child has actively to stabilise the head. It is essential to wait for a motor response on the part of the child.
- Making use of rotation and following of the head during care activities. It is essential to wait for a motor response.
- Regularly select the prone position.
- Elicit the activities referred to under ‘exercise therapy’ during play and care activities.
- Seek advice on the use of a pram, pushchair, baby sling, rocking chair, changing mat and playpen.

5.2 Phase 2: Motor behaviour in the supine position

General Motor picture

- There are problems in the development of posture and movement against the force of gravity.
- There is a generally a flat supine position with a preference for much support. This has a negative influence on the development of raising the head and the limbs from the ground and on the development of flexion motor activities and stability in the trunk.
- The urge for support and the lack of flexion development and of stability block the emergence of dissociated movement in the supine position. One feature of the motor picture in this initial posture is its static character: the child appears passive and hypotonic.

Specific motor problems

- The head lies mainly passive, supported by the ground. The child has problems in raising the head.
- The ability to flex and stabilise the trunk is inadequately developed. This has a negative influence on the development of the ability to raise the head, tilt backwards, and raise the pelvis and the legs.
- The child has problems in reaching out with the arms against gravity, and therefore also in bringing the hands together at the midline and to the mouth. There is a preference for the arms to be supported. Arm motor activity has a passive character. The main factor here is the lack of stability in the shoulder girdle.
- There is a problem in raising the legs, and therefore also in bringing the feet to the hands and to the mouth as a result of a lack of stability in the hips and trunk. The flexion possibilities of the trunk are inadequate to tilt the pelvis backwards and to stabilise the pelvis and trunk positions in order to support raising the legs. As a result, for the most part the legs lie passively and are supported on the ground.

Compensatory motor activity

- Reaching out with the arms is supported by placing the elbows on the chest.
- The arms and legs are initially moved on the horizontal plane and are still supported by the ground.

Consequences for motor development

- The inadequate development of flexion motor activity of the head, the trunk and the hips influences the development of the function of the stomach muscles, and consequently the ability to stabilise the trunk in other postures, for example in the prone position, in sitting or in standing.
- The problems in the development of raising and reaching out with the arms and the legs influence the development of manual motor activities, the development of playing with hand/hand, hand/mouth and hand/foot and consequently the development of the body schema.
- There is inadequate development of trunk rotation and of trunk lateral flexion as a result of the poor development of reaching out with the arms. This continues in more vertical postures.
- The relative motor passivity of the legs has consequences for the leg function in more vertical positions.
- The occurrence of compensatory movement strategies blocks the development of normal and more functional movement patterns.

Treatment objectives

- The development of the ability to raise the head.
- The development of adequate flexion in the trunk.
- The development of trunk stability so that trunk motor activity can develop and that the head and limbs can move efficiently.
- The development of adequate stability of the shoulders so that reaching out with the arms and the development of manual motor activity and playing is then possible.
- The development of adequate stability of the hips so that raising the legs and that games with hands/feet can be realised.

Exercise therapy

Initial posture: supine position, for example on the lap (the child's head is supported on the knees of the therapist), supine position on a mat, balance board and suchlike.

- Varying the initial posture from horizontal to more vertical and vice versa.
- The passive stabilisation of the shoulder girdle as an effect of which it becomes possible for the child to reach out resulting in the development of hand/hand and hand/mouth games, eye/hand coordination and the body schema.
- The tilting backward of the pelvis and raising the legs in combination

with passively stabilising the hips with the result that playing with the feet and trunk flexion are possible.
- Accentuating the feet with a toy, stimulating the sole of the foot and suchlike so as, among other things, to develop the body schema and trunk flexion.
- Facilitating head and trunk flexion, support of the shoulders. Build up from a vertical, supported sitting position to a more horizontal initial posture.
- Introduce trunk rotation as a result of which lateral flexion and rotation of the head are stimulated.
- With the therapist sitting and the child lying on the therapist’s legs, rotations of the child’s head are facilitated when the therapist moves her legs alternately, causing the child to move.
- Axial tapping under the feet and against the hands to facilitate hip and shoulder stabilisation.

Other possible initial postures.
- Facilitate stability around the shoulder girdle in the prone position when the child is supporting himself on the arms.
- Facilitate stability of the hips by extension stimulation in the prone position and by assuming weight in the crawling posture, kneeling and standing.

Assignments for parents
- If necessary, support well when carrying.
- Pick up the child in such a way that active rotation and flexion of the head and of the trunk are required.
- Provide a supported, flexed supine position. The head, the trunk and the pelvis are supported in a slightly bent position, as a result of which the raising of the head, the arms and the legs is stimulated.
- Seek advice on the use of a pram, pushchair, car seat and rocking chair.
- Integrate the activities mentioned under ‘exercise therapy’ into game and routine care activities.

5.3 Phase 3: Motor behaviour during rolling over

General motor picture

- Initially, there is very little rolling over. The child looks passive and hypotonic.
- In the course of rolling over, there are problems in raising the head, the trunk and the limbs from the ground.
- There is a lack of developing trunk motor activity. Rolling over takes place mainly symmetrically, the development of trunk rotation and dissociation is delayed and inefficient.
- There is an inadequate development of dissociation between the head, the trunk and the limbs.

Specific motor problems

Rolling over from prone to supine.

- Initially, there are problems in flexing and rotating the head from a symmetrically assumed head position as the onset to rolling over.
- Initially, there is a preference for a symmetrical arm function during the onset of rolling over, with inadequate development of the asymmetrical arm function. In addition, the child prefers to let the arms be supported by the ground and the trunk.
- Initially, the action of the legs is minimal. There is a preference for developing leg motor activities symmetrically, asymmetry not taking place for a considerable time. At first the legs are not raised and there is a preference for support being given by the ground or by the underlying leg.
- Trunk motor activity is initially insufficient to enable adequate rolling. There is inadequate development of trunk flexion in the prone position in the course of the onset to rolling over and more particularly in trunk rotation.

Rolling over from supine to prone.

- There are problems in the development of raising the head in the course of the onset to rolling. Rotation and flexion take place with the support of the ground.
- Raising the arms and reaching out is inadequate during the start of rolling over. Once reaching out has become possible, the arms initially remain supported by the trunk. For a considerable time symmetrical arm function is preferred.
- After rolling over to prone, the child is not able to pull the arms from

under the body because of a lack of trunk extension.
- The leg action is initially minimal. When the legs do make an effective contribution to rolling over, there is a preference in the first instance for this to take place symmetrically. First, there are problems in raising the legs, the leg motor activities taking place with the support of the ground and the leg lying underneath.
- The trunk motor ability is initially not sufficient to facilitate rolling over effectively. Trunk flexion in the prone position and trunk extension in the supine position are both inadequate. Trunk rotation is inadequately developed.

Compensatory motor activities
- Excessive stretching of the head and the trunk are used in order to instigate the rolling movement, both from supine to prone and from prone to supine.
- The limbs and head, supported by the ground, are moved as a compensation for the problems that exist in raising the body against the force of gravity.
- Dependent on the individual specific degree of hypotonia and of individual specific distribution of postural tonus over the body, motor inability is compensated for by emphasising the subsidiary functions of rolling which underlie a relatively better postural tonus and stability.

Consequences for motor development
- The inadequate development of trunk motor activity, such as rotation, flexion and extension, influences the development of trunk motor activity in more vertical initial postures. The operative effect leads to problems in balance, for example, in sitting and standing, and in walking.
- The relative passivity of the legs has repercussions on the development of leg motor activities in the successive stages of motor development.

Objective of the therapy
- A general objective can be said to be the development of a level of such postural control that the head, the trunk and the limbs can participate in a functional and dissociated way in rolling over.
- The development of stability, to the extent that the head and limbs can be raised in the course of rolling over, resulting in asymmetrical rolling over being possible.

- The development of effective and dissociated trunk motor activities.
- Emphasising and developing leg motor activities.

Exercise therapy

- Enabling dissociated rolling over. Depending on the subsidiary function that is to be emphasised, the point of application should be varied between the head, the arms, the trunk, the pelvis or the legs, or the therapist can work with resistance against subsidiary functions of rolling over. It is important to anticipate the child's motor reaction.
- Rolling over can be facilitated by exercise aids, such as a Bobath ball, a balance board or a balance roll.
- If necessary, the therapist can work with pre-setting. Before rolling over, for example, the head can be placed in a raised position in order to activate the stomach muscles.

Assignments for parents

- Rotating can be integrated into the everyday care of the child, in the course of lifting up and during play.
- Trunk motor activity and postural control of the head, the trunk and the limbs can also be stimulated in prone and in supine positions. See under motor behaviour in prone and supine positions.

5.4 Phase 4: Motor behaviour in the sitting position

General motor picture

- Problems occur in maintaining the sitting position.
- The child sits with a bent back and supports the posture by leaning with the arms on the legs or on the ground.
- The child's legs create a broad sitting base.
- Initially, the sitting posture has a static nature. The child is not capable of engaging in play or of altering postures.

Specific motor problems

- The ability to stabilise the position of the head develops inadequately. The child has difficulty in maintaining the head posture, as a result of which rotating, for example with the goal of looking round, is not possible to an adequate degree.
- A poorly developing trunk extension can be noted in the sitting position. The pelvis is initially tilted backward and the child sits on the sacral vertebrae. The back is bent and there is no evidence of a lumbar lordosis.
- The child supports the sitting posture by leaning on the extended arms, with the hands placed on the legs or on the ground. If it is necessary, one hand can be freed to reach out or grasp something, but the other arm is needed to maintain the sitting posture. The result is that the child does not have two hands available for play and the lack of trunk extension has a negative influence on the development of play and of manual motor activities.
- There is poor development of the ability to stabilise the shoulder girdle and to raise the arms against the force of gravity. This has negative consequences for the development of manual motor activity, of crossing the midline and of play.
- The lack of trunk extension and the problems of reaching out with the arms result in consequences for the development of trunk motor activity. Rotating and lateral flexing of the trunk are inadequately developed, thus making the trunk motor activity insufficiently competent. This results ultimately in an inadequate ability to control posture in sitting and the balance reactions are non-operational. The sequence in which balance and righting reactions develop diverges from the norm. Righting reactions will develop relatively earlier as a substitute for the inadequate balance reactions.

- As a result of this, the child will benefit from broadening the sitting base and prefer to sit with his legs spread out symmetrically with the legs crossed or wide apart. The legs lie flat, supported on the ground and the child has difficulty in raising them. Asymmetrical leg positions are rarely observed.
- The above aspects lead to a static sitting posture. In a conditional sense the functional level of the trunk motor activity to transfer weight and to assume the side-sitting position will be insufficient for a considerable time.

Compensatory motor activities

- In order to compensate for the lack of postural control of the head it is regularly placed in the neck to support the position.
- In order to compensate for the lack of postural control of the trunk, the sitting posture is supported by the arms, the legs being spread out and the child making little movement. The child may also compensate by holding the back rigidly extended.

Consequences for motor development

- A significant effect of the poorly developing trunk motor activity in the sitting position is the lack of motility that ensues as a result. From the sitting position a child must be able to go via side-sitting, for example, to the crawling posture or the prone position and vice versa. The asymmetrical forms of posture and movement required are not included in the movement arsenal that the DS child has at his disposal, since good trunk motor activity is required. As a result, the child does not vary the sitting position or makes himself symmetrical and thus masters compensatory movement patterns.
- The sitting posture is an important initial posture for the development of manual skills. The problems indicated in the development of manual motor activities and of playing, which also occur in previous stages of the motor development, emerge clearly in sitting, thus influencing manual function in further stages of motor development.
- The inadequate development of the trunk extension and of postural control are not isolated, but have been indicated previously and will continue to have an effect during the further assumption of the vertical.
- The emergence of compensatory movement inhibits the development of normal and more functional patterns of movement.

Treatment objectives
- The development of a functional level of postural control of the head (extension, rotation, lateral flexing and balance).
- The development of a functional level of postural control of the trunk (extension, rotation, lateral flexion and balance).
- The development of an adequate level of stability of the shoulder girdle resulting in the development of manual motor activity becoming possible.

Exercise therapy
- Stimulation of head motor activity in the prone and supine positions.
- Stimulation of head motor activity in sitting on a stable or moving surface, if necessary with a supported trunk. Facilitation of balance, rotation, lateral flexion and an active stretching of the head.
- Trunk motor development (rotation, lateral flexion, extension, balance, righting) in the prone position, supine position and in rolling over.
- Sitting on a stable surface (horizontal, negative wedge, broad/narrow base). Facilitation of balance and righting responses, facilitation (via shoulders, pelvis or legs) of trunk rotation, trunk lateral flexion and extension (pelvis forward).
- Sitting on a moving surface, legs supported (ball, towel roll, chair, block, (therapist's/parent's) leg, swing etc.). Facilitation of trunk motor activity (rotation, lateral flexion, extension, balance, righting).
- Sitting behind a low table: supporting the trunk and facilitation of extension.
- Facilitation of extension, lateral flexion and rotation of the trunk by reaching out.
- Stimulation of the shoulder girdle stability by propping and reaching out in the prone position.
- Reaching out with a supported trunk in the sitting position.
- Sitting in front of a low table: supported reaching out and grasping/play.
- Propping himself up and reaching out in the sitting position. Combine this with trunk rotation.
- Facilitation of reaching out, grasping and play in various initial postures.

Assignment for parents
- Constant awareness of the position adopted by the child and support when he is carried.
- Seek advice on the use of the pushchair, rocking chair, car seat,

child seat and bicycle child seat.
- Make use of the sitting posture on the ground or on a stool, for example when dressing, washing and feeding.
- Elicit the activities named under ‘exercise therapy’ in the course of play and routine care.
- Refer also to motor activities in the prone and supine positions and during rolling over.

5.5 Phase 5: Motor behaviour during moving forward over the ground

General motor picture

- There are problems in the development of posture and movement against the force of gravity. The child has difficulty in supporting himself on his arms and legs and in efficient stretching of the trunk; he seeks as much support as possible.
- In order to compensate for the lack of stability, symmetrical posture and movement patterns are developed ('seal-like movements, 'bottom shuffling', 'hare leap'). The child has problems in transferring weight laterally and moving forward is developed with difficulty.

Specific motor problems

- There are problems in stabilising the shoulders and the hips.
- The ability to raise limbs against the force of gravity is inadequate.
- Frequently, the legs do not push forward enough.
- The trunk motor activity is insufficiently developed. There is a lack of trunk extension, of trunk rotation and lateral flexion, of trunk stability and of balance.

Compensatory motor activities

- The child will feel the need to move. When he starts to move he will compensate for the lack of extension, of stability and of pushing power. The manner of moving forward that the child uses will depend on individual disturbances in postural control and on the child's stage of development.
- When the main disturbances in postural control stem from a lack of stability around the shoulder girdle combined with a poor extension development in the trunk, this leads to a preference for symmetrical support on the elbows or on the hands. Transferring weight laterally in order to move the contralateral arm initially causes problems resulting in the development of symmetrical movement strategies. In the prone position, the child starts to 'move like a seal' or makes use of the 'hare leap' in the hands-and-knees position.
- The lack of stability in the shoulder girdle and of extension in the trunk can be such that moving in the prone position or in the hands-and-knees position is not possible. Moving forward in such a case only develops with difficulty. The child moves by rolling over, by symmetrically pushing off with the legs in the supine position or by

moving forward in the sitting position.
- Moving forward in the sitting position or 'bottom shuffling' will initially take place symmetrically. The child takes care not to lose balance, but pushes or pulls forward symmetrically with the legs, supporting this by pushing off symmetrically with the arms, bending and stretching the trunk.
- When moving forward in the prone position it may be that the legs are not pushing adequately. In that case, the child pulls himself forward with his elbows, once again initially in a symmetrical manner.
- In the crawling posture it is possible that the hips cannot be sufficiently stabilised, as a result of which the legs slide sideways.
- When the shoulders show a relative lack of stability in the crawling posture, the child moves the body weight backwards over the legs. The hips are then insufficiently extended during crawling.
- When it is not possible to transfer weight and support to one arm or leg, the child can still crawl alternatively by not raising the contra-lateral limbs but moves them by dragging them over the ground.
- Through the symmetrical postural and movement patterns, the subsequent rotation, lateral flexion and extension, stability and balance of the trunk all develop inadequately in the course of moving forward over the ground.

Consequences for motor development
- The inadequate development of the stability of the shoulders will have an effect on assuming the sitting position, for example, when the trunk has to be brought into a vertical position by the arms. There are also consequences for the further development of manual motor activity.
- The insufficient development of the stability of the hips will result in consequences for the ability to stabilise the hips, for example, in the course of standing, standing up and walking.
- The mediocre further development of trunk motor activity can be observed, for example, during posture changes around the sitting position and in the course of walking. In addition the trunk motor activity, for example in sitting, will not improve further due to this situation.
- A number of children do not crawl in the first instance, but move by 'bottom shuffling'. The fact that the child can move around is very important for his development. From the motor point of view asymmetry (trunk, arms and legs) in 'bottom shuffling' should be the objective. Children go through increasing postural control, still crawling after they have learnt to walk.

- The emergence of compensatory movement patterns interferes with the development of a more goal-oriented movement.

Treatment objectives
- The development of functional stability of the shoulders and of the hips.
- The development of adequate trunk motor activities.
- The development of movement possibilities for the child. The development of asymmetrical movement patterns to move about ('creeping', crawling, asymmetrical 'bottom shuffling').

Exercise therapy
- The basic conditions for moving forward over the ground evolve more particularly in previous developmental phases. Trunk motor activity and stability of the shoulder girdle and the hips should be made possible in the prone position, in the supine position and in the course of rolling over and sitting. The emphasis in these developmental phases is on the development of asymmetrical and dissociated postural and movement patterns. That means that the level at which the child can stabilise the trunk, the shoulders and hips should make functional motor activity possible. When propping up on the elbows in the prone position, for example, the emphasis should be on transferring the weight laterally and on freeing the contralateral arm. Subsequently, reaching out is facilitated above the horizontal plane, in order to exercise bilateral extension, rotation, lateral flexion and stabilisation of the trunk (see further under 'prone position', 'rolling over' and 'standing').
- The improvement of the ability to stabilise the shoulder girdle, the trunk and the hips in the hands-and-knees position. Work is then done on the ability to achieve dissociation in this initial posture. If necessary this can be practised with extra support of the trunk, for example in the prone position on a rola.
- Making it easier to move over the ground, possibly symmetrically at first, but emphasising asymmetrical and dissociated postural and movement patterns.
- Moving over the ground on an incline or up steps stimulates the development of asymmetrical movement patterns.

Assignments for parents
- Stimulating movement over the ground.
- See further under 'prone position', 'rolling over' and 'standing'.

5.6. Phase 6: Motor behaviour during changes in posture around the sitting position

General motor picture

- A typical feature is the lack of motility; the child shows little change of posture.
- Should the child have mastered changes in posture these are executed symmetrically. An inadequate level of trunk motor activity can also be observed. Trunk rotation, lateral trunk flexion and balance only develop to a limited extent. It is more particularly in this developmental phase that trunk motor activity seems to be dysfunctional.
- As a result, there is a need for frequent and mostly symmetrical support.

Specific motor problems

- There is a lack of stability of the shoulder girdle, as a result of which problems arise, for example, in pushing up from the prone position with rotation to a sitting position.
- Problems arise in stabilising the position of the head in the course of assuming the sitting posture.
- There is a lack of stability in the hips as a result of which the legs slide away, for example when the crawling posture is used to come to the sitting position from the prone position.
- The trunk motor activity does not develop adequately. There is a lack of rotation, lateral trunk flexion, balance, stability and stretching of the trunk in the course of changes of posture.

Compensatory motor activity

- In the course of progressing the sitting posture from the prone position and from sitting to the prone position, the lack of trunk motor activity is compensated for by symmetrical movement patterns in combination with extreme hip abduction. Side-sitting is not observed in this respect, any more than trunk rotation, lateral trunk flexion and balance.
- As a result of limited trunk motor activity, the child progresses from the prone position to the hands-and-knees posture by pulling the knees under the trunk. Subsequently, the child can sit by pushing the trunk upwards with the arms and tilting the body weight backward over the bent knees. The child finally manages to sit with

his buttocks between his feet. Similarly the prone position can be assumed once more from the crawling posture. In these forms of movement, side-sitting is observed and adequate trunk motor activity is not necessary.

Consequences for motor development

- It is particularly during this stage of development that a great demand is normally made on the quality of trunk rotation. The main factor here, however, is that the trunk motor activity that has developed so far appears to be dysfunctional. By using compensatory movement strategies the level of trunk motor possibilities will not improve either. This has repercussions with regard to other stages of development. Consider, for example, the development of balance and of trunk rotation in the course of walking and of balance when sitting.
- There is inadequate and delayed development of movement variation and therefore of motility.
- There is inadequate progress in the development of stability of the head, the shoulders and the hips.
- The emergence of compensatory movement patterns hampers the development of more goal-oriented movement.

Treatment objectives

- The development of a functional level of trunk motor activity (balance, rotation, lateral trunk flexion, extension).
- The further development of a functional level of stability of the head, the shoulders and the hips.
- The development of movement variation around the sitting posture with integration of side-sitting, so that the trunk motor ability can develop to a functional level.

Exercise therapy

- The basis for adequate trunk motor ability and for stability of the head, the shoulders and the hips will have to be established during the first phases of motor development. (See the physiotherapy possibilities described under motor activity in the prone and supine positions, during rolling over, sitting, moving forward over the ground and in standing.)
- As soon as the child can sit unsupported, the basis for ‘coming to a sitting posture with rotation’ can be established from the prone position, without the necessary stability being present in the

shoulder girdle, by supporting the child under the chest during the movement. The child, sitting between the legs of the therapist, is enabled to go via side-sitting to the prone position over the legs of the therapist. At the same time, support on the arms, extension of the trunk and dissociation can also be facilitated. Going back to side-sitting and sitting (with trunk rotation) is enabled via the pelvis and the legs. If necessary, the inability to push off adequately with the arms can be assisted by the therapist raising her leg slightly.
- In order to support the trunk, use may be made of a rolled towel or a ball.

Assignments for Parents
- It is essential that parents learn to master the movement 'coming to a sitting position with rotation' and integrate it within everyday interaction and play situations with their child.
- The possibilities of improving conditional stability are described in motor activities in supine and prone positions, rolling over, sitting, moving forward over the ground and standing.

5.7. Phase 7: Motor behaviour during standing

General motor picture

- There are problems in maintaining the standing posture. The child will therefore seek support when standing, but will avoid movement when standing. The child's standing posture looks static and movement dissociation is not sufficiently possible.

Specific motor problems

- Initially, the child does not want to bear any weight on the legs and for a long time displays the so-called 'sitting on air' posture.
- To date, the trunk motor activity has not adequately developed. The ability to stabilise, the extension and the postural reactions of the trunk are therefore not sufficiently operative to react to the transfer of weight and changes in posture.
- There is a lack of postural control in the lower extremities. The hips and the knees cannot be adequately stabilised in an extended position. The child often has a dropped longitudinal arch and transverse arch and the ankles often point inwards.
- The standing position is static in character. The leg function is symmetrical and the ability to transfer weight laterally comes late in development. Trunk rotation when standing is only possible to a limited extent.

Compensatory motor activities

- In general, the problems in controlling the standing posture are compensated for by taking support, by putting weight symmetrically on both legs and by avoiding motility; the standing position is static.
- The child prefers to use the hands and the trunk to support the standing position.
- The lack of stabilising ability of the hips and the knees is compensated for by passive, symmetrical stabilisation in a maximum extension.

Consequences for motor development

- The inadequate development of the trunk motor activity continues, resulting in a negative influence on trunk motor activity in the course of standing up and of walking. This is at the expense of the efficiency of these postural and movement patterns.
- There is a lack of stability in the lower extremities. The child

compensates through symmetry and support and does not therefore develop this stabilising ability. Transferring weight and standing on one leg, skills that are of essential importance for standing up and walking, are not developed.
- When the arms and hands are used to support the posture in the course of standing this has a negative effect on the development of manual motor activity in standing. In addition, this means that no appeal can be made to the stabilising ability of the trunk in the course of reaching out and grasping. This too has a negative effect on the development of trunk motor ability.

Treatment objectives
- The development of adequate stretching in the trunk, the hips and the knees.
- The development of trunk motor ability in the standing posture.
- The development of the ability to transfer weight laterally in the standing posture.

Exercise therapy
- The basis for an adequate extension and stabilisation of the trunk and the hips and of sufficient trunk motor ability is established, more particularly during motor development in the prone position and concerning the sitting posture.
- The gradual increase in the degree of weight- bearing in the legs and reduction of the amount of support needed.
- In the course of lying prone over a ball, weight can be borne progressively on the legs. The trunk is supported by the ball as the initial horizontal position is gradually made more vertical, with the result that the legs bear more weight. In the course of supported standing in this way the child can be encouraged to work towards transferring the weight to one leg.
- In the course of sitting on a ball or on one leg, weight can be transferred to the legs. The amount of weight can be varied and the ultimate aim can be to transfer weight and to have asymmetrical weight-bearing in the legs.
- With the child standing in front of a block, whether or not he is supported at the trunk, the hips and the knees, he can be encouraged to work towards active standing by a gradual reduction of the support. Standing can be supported with two hands, but also by one hand. Subsequently, in the standing position, trunk rotation and manual functions can be promoted.

- Standing on a moving surface, for example on the therapist's legs, a trampoline, a balance board, a waterbed, a swing etc.
- Narrowing the base, standing in the stepping posture, if necessary with one foot on a bench.
- Transfer the weight to one leg, then raise and move the other leg in the standing position.
- Stand on one leg.
- Kneeling, to enable transfer of weight and balance.

Assignments for parents

- Integrate the possibilities listed under 'exercise therapy' in the course of play and care, for example by having the child stand while playing at the coffee table or when changing his nappy, washing and dressing him.
- Seek advice on play situations in which a demand is made on the legs to stretch against resistance, for example playing with a push truck or a rocking-horse, with a baby-bouncer or a tricycle and when climbing and scrambling over obstacles.
- Seek advice on footwear.

5.8. Phase 8: Motor behaviour during standing up

General motor picture

- There are problems in assuming the standing posture, as standing is only developed with difficulty. What happens is that children pull themselves up symmetrically with their arms to the standing position, using much support in so doing. Consequently, the role of the legs in standing is relatively minor.

Specific motor problems

- Standing up is a motor skill in which weight must be transferred forwards and sideways and therefore for which asymmetrical motor ability is necessary. However, the quality of the trunk motor activity is insufficiently functional for the child to be able to react adequately to the transfer of weight and the changes in posture.
- The level of postural control in the lower extremities is insufficient to allow the legs to make an effective contribution to standing up. The ability to move upwards and to bear the body weight is restricted since there is not enough stability to be able to distribute weight asymmetrically.
- There are problems in providing adequate stretching of the trunk, the hips and the knees.

Compensatory motor activity

- The lack of postural control in the legs leads to the child pulling himself up to the standing position with the arms. The part played by the legs is relatively minor, with the child compensating by distributing weight symmetrically on the legs and stabilising the knees in maximum extension. As a result, the development of dissociated leg motor activities is not very efficient and transferring weight, stepping out with one leg and standing up via the half-kneeling position, only develops with difficulty.
- Inadequate trunk motor activity leads to the child seeking much support for the trunk, the arms and the legs in compensation. He demonstrates a preference for symmetrical movement patterns in order not to lose balance. This preference for symmetrical motor activities again has a subsequent negative influence on the development of dissociated leg motor activity.

Consequences for motor development

- The inadequate development of bearing weight, transferring weight and of movement dissociation of the legs, affects the development of the movement possibilities in standing and in walking.
- In this motor phase too, there is inadequate development of the trunk motor activity. This will have repercussions on the trunk motor activities during walking, but equally on the qualitative trunk motor activity development of posture and movement in earlier motor phases, such as sitting and standing.
- The emergence of compensatory movement patterns interferes with the development of more goal-oriented movement.

Treatment objectives

- The development of postural control in the lower extremities so that the child can achieve the standing position without support via the half-kneeling posture.
- The development of an operational trunk motor activity so that the child can achieve the standing position without support via the half-kneeling posture.

Exercise therapy

- The conditional development of adequate trunk and leg motor activity should take place in the prone and in the supine position, in sitting and in standing and during rolling over, moving forward over the ground and motility around the sitting posture.
- What is important here is the development of movement variation in standing, such as transferring weight to one leg, raising the other leg, walking along and reaching out in combination with trunk rotation.
- The development of operational stability and balance in kneeling and in half-kneeling.
- The development of effective leg-strength in standing and in walking.
- Enabling standing up symmetrically from a sitting position on a stool or on the therapist's leg, while the degree of support to the trunk and the arms is varied.
- Enabling standing up via kneeling and a half-kneeling posture while the degree of support to the trunk and the arms is varied.

Assignment for parents

- The possibilities for potential parental participation are described in motor activities in the prone and in the supine position, in rolling

over, moving forward over the ground, sitting, motility in the sitting position and standing. Furthermore, the points mentioned under ‘exercise therapy’ can be taken over by the parents.
- It is important to stimulate leg function. Possibilities for the parents to do this occur for example in the field of stimulating climbing and clambering, and of going up and down stairs.

5.9. Phase 9: Motor behaviour during walking

General motor picture

- The problems of balance and the lack of movement dissociation of the head, the trunk and the limbs are characteristic of walking. In general, the child walks with a wide-legged gait, with extended knees and without trunk rotation.

Specific motor problems

- In the stages of motor development discussed to date there is the recurrent problem of inadequate trunk and leg motor activities. The same applies equally to walking. Just as in standing up, walking is an asymmetrical motor skill in which weight has to be transferred to one leg in order to raise and move the other leg. This makes great demands on the quality of trunk motor activities and on the level of postural control, particularly of the lower extremities. An operational development of the level of postural control is essential for walking, with the result that inherent shortcomings in the form of compensatory mechanisms emerge during walking. The child has problems in the dynamic stabilisation of the hips and knees. The quality of trunk motor activity is inadequate to make the dissociation of movement possible.

Compensatory motor activities

- Inadequate trunk motor activity is compensated for by excessive extension of the trunk, together with the avoidance of trunk rotation and of lateral trunk flexion. The balance problems are apparent in the way the child holds the arms beside the body like wings.
- Due to the lack of balance and stability, the child prefers to maintain the body weight within the support surface. His gait is wide-legged and his steps are small. The transfer of weight and supporting himself laterally are restricted by the wide-legged gait and by the reduced standing and swinging phase.
- Stabilising the knee in a maximum extension compensates the lack of stability in the lower extremities. Problems around the hip can be seen in the Duchenne gait and problems around the ankle joint can be seen in the eversion when weight-bearing.

Consequences for motor development

- Walking, both supported and unsupported, occurs relatively late in

the DS child's development.
- There is reduced effectiveness in walking in everyday situations and in play.
- Broadly speaking the tendency continues in this phase of an unsatisfactory trunk motor activity, balance and general stability. The consequences affect the development of other forms of walking, such as running, climbing stairs, jumping, hopping, but also 'standing up', for example. Furthermore, it will influence the development of movement forms such as cycling, roller-skating, riding a scooter and suchlike.
- The emergence of compensatory movement patterns interferes with the development of more functional movement.

Objective of the treatment
- The development of an adequate level of postural control in the trunk and in the lower extremities during walking, with the result that dissociated walking is possible in a functional sense.

Exercise therapy
- The conditional development of adequate trunk and leg motor activity, such as stretching, stability and balance should have taken place in previous developmental phases. What is important is the development of movement dissociation in the standing position.

In relation to walking there are numerous possibilities for capitalising on the individual developmental level of a child.
- Supported walking sideways, taking corners.
- Crossing over – varying the distance to be crossed over.
- Supported walking behind a push toy.
- Walking supported by one or two hands.
- Stepping on and off, with or without support.
- Walking over two benches put together, with or without support.
- Walking over a bench, with or without support.
- Stepping over an obstacle, with or without support. Vary the height.
- The same, but then on a bench.
- Influence the length of step, for example by stepping from ring to ring or from bench to bench.
- Walking on a balance board, with or without support.
- Walking up a slope, climbing up a ladder. Vary the angle of the slope.
- Walking up stairs with and without support.

- Jumping on a trampoline.
- Walking over a balance board or seesaw.
- Walking wearing one or two roller skates.
- Jumping on a kangaroo ball.
- Using a scooter.

Assignments for parents
- See the points of assignments given for earlier phases of the motor development and exercise therapy possibilities named above.
- Stimulate walking in all its facets in the course of play and care.
- Provide the relevant play material (rocking-horse, push toy and suchlike).

6 How parents can help

6.1 Activities in the prone (lying on the stomach) position

6.1.1 Raising the head in the prone position

Information
In general, children with Down’s syndrome (hereafter referred to as DS children) find it rather difficult to raise and balance the head when in the prone position.
Raising the head marks the start of the development of extending the back and legs. It is important to be able to do this for the later phase of standing.

Stimulation at home
You can help your child to raise his head by giving some support to the chest in the prone position. For example, you could put a rolled-up towel or baby blanket roll under his chest. Then make sure that there is something interesting to see at eye level, for example, your own face or a nice toy.
If your child finds it very difficult to raise his head you could assist by giving some support with your hand under the chin.
If you do not want to lie on the ground yourself, you could put the child in the prone position on a table.
NB: always try to give as little support as possible. Your child must do as much as he is able himself.

6.1.2 Raising the head in the prone position

Information
In general, children with DS find it rather difficult to develop balance of the head when prone.
Being able to keep his head balanced means, among other things, that your child will be able to look around. Being able to look around is not only attractive for your child if he is lying on his stomach, but also when he is being carried or later on when he can sit and walk.

Stimulation at home
If your child can maintain a raised head it is time to pay more attention to the development of balance. For example you can stimulate your child to look around if he is lying on his stomach. You do that by focussing attention on a toy and then moving it. Your child will then start looking around, which will in turn require a sense of balance. Stimulating the balance of the head can also be achieved in other ways. For example, you could place your child on his stomach on a beach ball, or sit on the ground yourself and support his chest with your legs. At that moment you are in a position to move the base, as a result of which your child has to do his best to keep the head raised.

6.1.3 Propping up on the elbows in the prone position

Information
DS children often have difficulty in propping themselves up on their elbows when in the prone position.
Propped up on his elbows, your child is in a good position to play. In addition, extension of the back and legs develop in this position. This is important, for example, in order to be able to stand later.

Stimulation at home
If your child cannot yet bear any weight on his elbows, you can give him a little help by supporting his chest with a rolled-up towel. Then place the elbows on the ground in such a way that the upper arm is more or less at right-angles to the trunk. If you lie on the ground on your stomach, you can initially support the position of the arms. Provide something nice to look at or to suck on. Offer little toys somewhat higher so that your child must raise himself to look at them. Naturally, the intention is ultimately to give as little support as possible.

6.1.4 Propping up on the elbows in the prone position

Information
In order to be able to play or to get hold of something when using elbow support, your child must be able to use one hand. That means that he can only lean on one elbow (the opposite one). Your child will need to develop stability and balance in order to be able to do this. Once symmetrical support on two elbows has been accomplished, it is

time to move the weight sideways on to one elbow. This will improve your child's stability and balance. Finally it will make it possible to reach out with one arm and thus to grasp things and play with them.

Stimulation at home
You can achieve this by stimulating your child to look around or to get hold of something. In the beginning, there is no reason for not giving extra support to the chest (for example with a rolled-up towel) or to supporting the elbow (with your hand). The main thing is that your child should learn to do as much as possible himself.
Building tower blocks, pushing a toy car or, for example, playing with a geometrical shapes puzzle box in the prone position, are all other ways of stimulating this development.

6.1.5 Propping up on the elbows in the prone position

Information
The higher the child gets hold of something while lying on his stomach and propping himself up on his elbows, the more stability is required from the shoulder which is supporting him. In addition, increasing demand is made on the extension of the back, and on stabilising and rotating the trunk. In this way, the child develops trunk motor ability, which will be important at the next stage, for example, for balance in sitting and in walking.

Stimulation at home
Once your child can get hold of a toy with one hand while propping himself on the other elbow, you should try to offer the toy from a higher position and in various places. You will see that the back is extended to an increasing degree, but also that there is rotation in the trunk.
You can also achieve this effect by getting the child to build a tower in the prone position or by encouraging him to get hold of little toys from the sofa or coffee table.

6.1.6 Propping up on the hands in the prone position

Information
DS children often find it difficult to support themselves in the prone position on their hands with extended elbows. In order to be able to do

this, adequate stability of shoulder and elbow is necessary. The child also has to be able to extend his back sufficiently.
By supporting himself on his hands in the prone position, your child is developing extension of the back and the hips. This will be important when your child learns to sit and to stand. Being able to support himself on extended arms will also be important when your child wants to crawl, when he starts to sit or when he learns to stand up.

Stimulation at home
If your child cannot yet entirely manage to support himself on extended arms, you can assist in various ways. For example, you can make it easier by supporting the chest in the prone position with a thick roll. The farther you place this support in the direction of the stomach and hips, the more difficult you make it for the child.
If you lie on the ground on your stomach in front of your child you can help to keep his elbows straight with your hands. If you lie on your back, you can place the child on your stomach while you support his elbows. Always make sure that there is something nice to look at or to get hold of. Use your own face. A nose, the eyes and hair are all wonderful things to play with. Join him in lying in the prone position and look in a mirror together.

6.1.7 Propping up on the hands in the prone position

Information
By supporting himself on his hands in the prone position, your child is developing extension of the back and the hips. This is important when the child is learning to stand. Being able to support himself with extended arms is important if your child wants to crawl, if he is going to sit up or if he is learning to stand up. Once your child can support himself on two hands in the prone position it is important that he learn to transfer his weight sideways in the hand support posture.
If your child can support himself on two hands in the prone position, it is important that he learn how to transfer weight to the one side while supporting himself on the hands. If he is able to support himself on one extended arm, it is possible to use the other hand to get hold of something, or move an arm. Supporting himself on the hands can thus become an explicitly active posture for your child. In this manner he can see a lot, can fetch toys and can even begin to move towards the toy (creep, crawl).

Stimulation at home

If you sit on the ground with your legs stretched out, you can put your child on his stomach diagonally across your thighs. You are then able to alternate the amount of hand support and to vary it by moving your legs upwards a bit, or by giving more support under the stomach and hips.

Placing your child on his stomach on a beach ball, you can carefully let him roll over to the ground. If your child is up to it, he will save himself by putting his hands on the floor. By moving the ball sideways you can ensure that the support is asymmetrical. You are then in a position to allow your child a measured amount of support on his hands. During this, you should hold your child firmly by the trunk or the hips. Do not allow him to have his head hanging down for too long; make sure there is a lot of variation in posture.

A nice little toy will help to stimulate your child to transfer his weight sideways and to get hold of it.

6.2 Activities in the supine (lying on the back) position

6.2.1 Raising the legs in the supine position

Information
DS children have relatively more difficulty in raising their legs from the ground in the supine position and moving their feet towards their hands. There is not enough stability in the hips and the trunk in order to be able to do so.
By raising his legs, the child can get hold of his feet and play with them. In this way he discovers his legs and his feet. This is very important for later stages of development, for example standing. It is also the case that raising the legs stimulates the activity of the stomach muscles. This benefits the stability of the trunk.

Stimulation at home
If you sit on a comfortable chair with your feet on a footstool you can put your child in a supine position on your thighs. Your child's head is placed on your knees so that you can easily see each other. By placing your child with his hips more or less above your own hips you ensure that he has a slightly arched back and the pelvis is then tilted backwards. It follows naturally that the hips are also bent and the legs are in a raised position. You can also achieve this effect by placing your child diagonally across a changing mat. You can then draw his attention to his legs and feet by directing his hands to them or by bringing the feet to the mouth. You can increase this attention by tickling under the feet or blowing against them. Another thing that works well is tying a little toy to the foot. For example, you could sew a bell to a sock (securely!) and then put on the sock.

6.2.2 Raising the legs in the supine position

Information
DS children have relatively more problems in bending the trunk adequately when getting hold of and playing with their feet in the supine position. The stability in the trunk is inadequate.
By raising his legs, the child can get hold of his feet and play with them. In this way he discovers his legs and feet. This is important for

later stages of development, for example standing. Raising the legs stimulates the activity of the stomach muscles. This is of benefit for bending the trunk and for its stability.

Stimulation at home

It is important that when he is playing with his feet the child should be in a supine position with a rounded back (pelvis tilted backwards). The more your child learns to master raising his legs, the more he will bend his trunk. Support in this posture is then no longer necessary, since your child will be able to lift his legs and get hold of his feet while lying on a flat surface (bed or playpen). You can focus his attention on his legs and feet by tickling under the feet or blowing against them. If you like, you can attach a rattle to his foot. What works well is to attach a toy to a sock. For example, you could sew a little bell to a sock (securely!) and then put on the sock.

6.2.3 Reaching out with the hands in the supine position

Information

Initially, a DS child may have difficulty in stretching out with his arms and getting hold of things. The stability of the shoulder joint is not yet adequate.
It is important for the child to learn to stretch out in connection with his playing possibilities and also for the development of playing and hand functions.

Stimulation at home

If you sit on an easy chair with your feet on a little stool, you can put your child in the supine position on your upper legs. Your child is then lying with his head on your knees so that you can see each other without difficulty. By holding the shoulders firmly and moving them forward a little you are in a position to support the extension of the arms. Your child will really enjoy stretching out towards your face, for example, and getting hold of your hair. Just give him enough support to enable him to reach out. The less support you give, the more the child does for himself.
Once your child has made some progress, it will not be necessary to support his shoulders with your hands. Always make sure that your child is lying comfortably with some support for his head and shoulders. A baby gym in the pram, cot or playpen, for example, can be very stimulating at this stage.

6.2.4 Reaching out the hands in the supine position

Information
Initially, the DS child in the supine position will prefer to reach upwards with his hands. More shoulder stability is required to grasp something sideways or to follow something with the hands that is moved from left to right or vice versa.
It is important for your child's play and for the further development of playing and hand function, that he learn to vary the direction in which he is reaching out and grasping things. Extending sideways stimulates rotation of the trunk together with the stomach muscles. This is of benefit for the stability of the trunk.

Stimulation at home
Make sure that your child is lying comfortably on his back with some support for his head and shoulders. This may be on your lap, or on the sofa or on the ground. If your child is interested in a particular toy or perhaps wants to reach for your face, try to stimulate him in such a way that there is variation in the position of the arm with which he is stretching out. By reaching out in the direction of the feet, for example, the stomach muscles are activated; extending sideways is of benefit for the trunk rotation.

6.2.5 Raising the head in the supine position

Information
DS children find it difficult to raise and to stabilise the head in the supine position. This means that picking up the child from the changing mat or from the bed should be done carefully. Otherwise the head is not adequately stabilised and hangs backwards.
It is very important for your child to develop this control of his head. Moreover raising the head also stimulates the stomach muscles. This is of benefit for the stability of the trunk.

Stimulation at home
Your child will be picked up several times a day from the supine position. Whatever happens, make sure that his head is not hanging backwards. Provide adequate support when necessary. Give your child enough time to acquire adequate control so as to react with stability.

If you sit on a comfortable chair with your feet on a little stool, you can put your child in the supine position on your upper legs. Your child then lies with his head in the direction of your knees so that you can see each other easily. By holding his shoulders firmly with two hands you are in a position to bend his trunk a little. Then you can stimulate your child to raise his head slightly and to look at you. You can support the head from behind with your index and middle fingers.
By putting your feet higher, your child ends up sitting in a more upright position. In this starting posture it is somewhat easier to stabilise the head. You can also move your child from that (half-)sitting position back to the supine position.
Raising and stabilising the head can be very difficult to start with. Watch carefully to see whether your child also actually reacts in moving his head. Wait for that motor reaction.

6.2.6 Raising the head in the supine position

Information
DS children continue to find it difficult to raise and stabilise the head while moving for a relatively long period.
The development of control over the position of the head during movement is important for all sorts of developmental phases. Examples of this are rolling over or sitting independently.

Stimulation at home
If you sit on a comfortable chair with your feet on a little stool, you can place your child in a supine position on your upper legs. Your child lies with his head in the direction of your knees so that you can see each other easily.
By moving one shoulder forwards and holding the other down, you initiate a rotating movement in the trunk. At that moment you can stimulate your child to rotate his head as well. You can make it a little easier for your child by raising one leg somewhat (on the same side as the raised shoulder). If you also raise the shoulders you stimulate your child to raise his head while rotating. If you raise your feet your child will be in a more upright sitting position. In this starting position you make it slightly easier for your child to stabilise his head.
When picking up your child from his cot or from the playpen you also have the opportunity to stimulate him to raise and stabilise his head while moving. For example, you could introduce the rotating move-

ment of the trunk as you are lifting him up.
Watch carefully to see whether your child actually reacts by moving his head. Wait for that motor reaction.

6.3 Activities in rolling over

6.3.1 Rolling over

Information

DS children find it relatively difficult to roll over from a prone to a supine position and back again. It is also the case that they show little trunk rotation in rolling over. In other words, in rolling over, the shoulder and pelvic girdle do not rotate one after the other, but at the same time.

The development of trunk rotation is extremely important. Trunk rotation is essential for the development of further motor skills (e.g. sitting) and of balance reactions, for example in sitting or in standing.

Stimulation at home

Trunk rotation can be elicited in the course of dressing and undressing and during nappy changing. When changing your child's nappy, you usually raise his bottom from the changing mat by lifting both legs at the same time. However, if you bend one leg into the hip and move it forwards over the other leg you rotate your child sideways and the bottom is also released. You are thus in a position to wash the bottom and put on a clean nappy. Then you rotate your child back to lying on his back with his bottom on the nappy, by straightening the leg lying on top.

In all this, it is important to wait for the motor reaction of your child. If you rotate him to lying on his side and then back again he does not have an active part to play. When you initiate the movement by bending one leg into the hip you must wait for a motor reaction from your child. If he actively supports the rotation you are stimulating the development of trunk rotation. Rotation is observable, for example, at the time that your child actively turns his head with the movement, or when the arm and shoulder girdle are actively moved at the same time.

Before lifting up your child in the supine position from the changing mat or out of his cot, you can first rotate him to lie on his side. By firmly holding the trunk under the shoulders with two hands you can initiate a rolling movement into a lying-on-the side position. Watch carefully to see whether your child is reacting, by moving his head for example, or by following the movement with pelvis and legs. By bending the trunk concurrently, you are also stimulating your child actively to raise his head at the same time.

6.3.2 Rolling over

Information

DS children find it relatively difficult to roll over from a prone to a supine position and then back again. It is also the case that they show little trunk rotation in rolling over. In other words, in rolling over, the shoulder and pelvic girdle do not rotate one after the other, but at the same time.

The development of trunk rotation is very important. Trunk rotation is essential for the development of further motor skills (e.g. sitting) and for balance reactions, for example when sitting or standing.

Stimulation at home

If you sit on a comfortable chair with your feet on a little stool, you can put your child in the supine position on your upper legs. Your child lies with his head in the direction of your knees so that you can see each other clearly.

If you now bend one of your child’s legs at the hip and the knee and move it forward over the other leg, you will stimulate him to roll on his side. You can emphasise this by slightly raising your own leg on the same side as the child’s leg that you are moving. Then it will be as if your child is rolling down a slope. You can then make it more difficult for him by keeping your legs at the same level. It is important to wait for the motor reaction of your child. If you just turn your child to lying on his side and then back again, he has no active part to play. If you initiate the movement by bending one hip you should wait for your child’s motor reaction. If he is actively supporting the rotation, you are stimulating the development of trunk rotation. Rotation can be observed, for example, at the time that your child actively turns his head or when arm and shoulder girdle are actively moved together with the movement.

In this way, you are in a position to stimulate rolling over in such a way that you are making the optimal use of your child’s possibilities. The trick is to have your child roll over with as little help as possible. Once you notice that your child is finding it easier to roll over by himself you should gradually reduce your help.

6.3.3 Rolling over

Information

DS children find it relatively difficult to roll over from a prone to a supine position and then back again. It is also the case that they show little trunk rotation in rolling over. That means that when they are rolling over, the shoulder girdle and the pelvic girdle do not turn one after the other, but at the same time.

The development of trunk rotation is very important. Trunk rotation is essential for the development of further motor skills (e.g. sitting) and for balance reactions, for example when sitting or standing.

Stimulation at home

Rolling over can also be stimulated when your child is lying on the floor (carpet or exercise mat). You are in a position to stimulate him to roll over from a supine to a prone position by bending one of his legs at the hip and knee and moving it forwards over the other leg. You can also stimulate your child to roll over from a prone to a supine position by bending one of his legs at the hip and knee and then moving that leg backwards over the other leg. It is a good idea to combine this with offering a toy. If you put something attractive in the path in which he is going to roll, perhaps he will want to get hold of it. The rolling movement is encouraged as he reaches out with the arm towards the toy.

It is not only via the legs that you can elicit the rolling over movement in your child. You can also stimulate rolling over via the pelvis or via an arm. Your child will then have the opportunity to react with leg movements. Discuss this with your physiotherapist.

It is important to wait for your child's motor reaction. If you roll the child over, he has not played an active part. If you initiate the movement, you must wait for a motor reaction from your child. If your child is actively supporting the rotation, you are stimulating the development of trunk rotation. Rotation can be observed, for example, at the time that your child actively turns his head or when arm and shoulder girdle are moved actively with the rest of the body.

By varying the exercises, you are in a better position to stimulate rolling over in such a way that you are making optimal use of your child's potential. The art is to have your child roll over with as little help as possible. Once you notice that your child is getting more opportunities of rolling over by himself, you should gradually reduce your help.

6.3.4 Rolling over

Information

DS children find it relatively difficult to roll over from a prone to a supine position and then back again. It is also the case that they show little trunk rotation in rolling over. That means that in rolling over, the shoulder girdle and the pelvic girdle do not turn one after the other, but at the same time.

The development of trunk rotation is very important. Trunk rotation is essential for the development of further motor skills (e.g. sitting) and for balance reactions, for example when sitting or standing.

Stimulation at home

Once your child finds it a little easier to roll over, you will see that it is not always necessary to touch your child in order to stimulate rolling over. An excellent way of eliciting rolling over is to focus his attention on a toy and then to place it in his line of vision in the desired direction of rolling.

It is important that he learn to roll over with trunk rotation. If your child is not yet doing that, but can roll over independently, you can stimulate trunk rotation by holding back the pelvis or an arm for a moment as he is rolling. By varying this you are in a position to influence the mode of rolling. Discuss this with your physiotherapist.

6.4 Activities in sitting

6.4.1 Sitting

Information
DS children have difficulty in extending the back when sitting and in maintaining balance. They often sit with a bent back and support the sitting posture with the hands either on the floor or on their legs.
The development of balance is important because sitting is primarily a posture from which to engage in play. However, if your child constantly needs his hands to support his posture, he is not going to be able to develop fine motor skills or playing.

Stimulation at home
It is essential that children are not placed in the sitting position too early. It is preferable first thoroughly to develop the extension of the back in the prone position and stomach muscle activity in the supine position.
You can put your child on the floor in front of a little low table (or low stool). By placing toys on the table, encouraging him to reach for them, and by having him play with his hands on the table you are encouraging the sitting position. Then by having him reach for the toys at a higher level you are stimulating extension of the back. For example, you can have your child build a tower (or knock it down). The higher he gets, the further he will have to extend his back.
You can also influence your child's sitting posture by placing a little cushion under his buttocks. The effect will be that the pelvis is tilted a little forwards as a result of which the back is further extended. You can use the low table, little cushion and stretching upwards separately, but they can also be combined. Consult your physiotherapist as to what is the best solution for your child.

6.4.2 Sitting

Information
DS children have difficulty in extending the back when sitting and in maintaining balance. They often sit with a bent back and support the sitting posture with the hands either on the floor or on their legs.
The development of balance is important because sitting is primarily a

posture from which to engage in play. However, if your child constantly needs his hands to support his posture, he is not going to be able to develop fine motor skills or playing.

Stimulation at home
You can exercise your child's balance abilities by having him sit on a moving base. Sit on the ground, for instance, and have your child sit on your upper leg. By gently moving your leg you are challenging your child's potential to maintain his balance. It is important that this be done by degrees. The intention is to elicit balance reactions in your child. He should not fall off your leg. You can also have your child sit on a beach ball. If he is supporting himself with his feet on the ground the pelvis will tilt forward somewhat, as a result of which extension of the back is stimulated. By moving the ball gently you are stimulating balance reactions. If your child finds it frightening, you can give some support to the pelvis, for example. The trunk is then free to cope with balance reactions. You could also let some air out of the ball. Your child will then sink somewhat into the ball. The pelvis will then be encased, as it were, giving him more support.

6.4.3 Sitting

Information
DS children have difficulty in extending the back when sitting and in maintaining their balance. They often sit with a bent back and support the sitting posture with the hands either on the floor or on their legs. The development of balance is important since sitting is primarily a posture from which to engage in play. However, if your child constantly needs his hands to support his posture, he is not going to be able to develop fine motor skills or playing.

Stimulation at home
You can have your child sit on a beach ball in such a way that his feet cannot reach the ground. You will have to support the pelvis. By moving the ball, you elicit balance reactions. If you allow the ball to roll forwards, your child will react by extending his back. If you allow it to roll to the side, you will then stimulate sideways balance reactions. Once your child has a good feeling for balance, it is enough just to hold the ball. The game is then to stay sitting on the moving ball. Once your child is sitting on a moving base, you can then encourage

him to get hold of a toy. By having him grasping and stretching out sideways you are stimulating balance reactions.
Balance in the sitting posture can be stimulated in all sorts of play situations. Sitting on a rocking-horse or on a swing require balance reactions. Put your child on a skateboard and allow him to ride round the room very carefully. DS children often find this sort of play situation frightening. Always provide adequate safety and make sure that your child does not fall. Once again, do not give too much support. Too much support makes balance reactions unnecessary.

6.4.4 Sitting

Information
DS children have difficulty in extending the back when sitting and in maintaining balance. They often sit with a bent back and support the sitting posture with the hands either on the floor or on their legs.
The development of balance is important because sitting is primarily a posture from which to engage in play. However, if your child constantly needs his hands to support his posture, he is not going to be able to develop fine motor skills or playing.

Stimulation at home
Once your child is capable of sitting unsupported, it's a good idea to use the sitting posture regularly. You can then manipulate sitting in such a way that your child needs to use balance reactions in order to stay sitting.
In the course of the daily routine, there are all sorts of opportunities for this. For example, take dressing and undressing in the sitting posture. When you are putting on a sock or a shoe you are in a position to stimulate balance reactions. It is also possible in the course of brushing teeth or washing. Once your child is in the sitting position while you wash and dress him, he will have to react with balance responses.
It may even be possible to make deliberate use of the sitting position while he is eating. It makes a big difference whether your child sits on a stool to eat or whether he is completely supported in a highchair. In this connection, it is very important to be conscious of the extent of support you are providing in the sitting position. You want to let your child do as much as possible by himself, but it must remain a safe and practical situation. Discuss this with your physiotherapist.

If your child is sitting on the ground to play, many possibilities are available. You can put down toys in such a way that your child has to use balance reactions to get hold of things to play with. Thus, you can place the toys alongside or behind your child. You can stimulate his balance reactions, for example, by having him ride in a toy car or by rolling over a ball.

6.5 Activities in moving forward over the ground

6.5.1 Moving forward over the ground ('creeping', crawling[1])

Information
DS children have relatively more difficulty than other children in moving over the ground (creeping, crawling, bottom shuffling). The major reason for this is that it is rather difficult for the child to extend his back and to support himself on hands and knees. Pushing off with the legs often develops more slowly also. Being able to move over the ground is extremely important for a child 's general development. Once a child can crawl, for example, he can take the initiative, go to certain toys, explore the room etc. He then becomes much more active and can play more intensively.

Stimulation at home
A child who begins to relocate himself, whether that is on his stomach, on his back or on his bottom, should be stimulated in doing so. Offer your child a nice toy just out of reach and make it more interesting by rattling it or making it squeak and stimulate your child to come towards it. Ensure that if he does go towards the toy it has the desired result; after that he can play with it. It is often the case that the prerequisites for crawling, for example, have not yet been met from a motor perspective, but the child actually really wants to go somewhere. Consider supporting the arms and legs, extending the back and pushing off with the legs. These conditions can be stimulated in the course of play when the child is prone. Consult your physiotherapist on this point. If the child cannot bear his body weight sufficiently in order to crawl, it might be pleasant to place him in the prone position on a skateboard, for example. By pushing with his arms and legs on the ground or against your hands the child can make the skateboard move.

6.5.2 Moving forward over the ground (creeping, crawling)

Information
DS children have relatively more difficulty than other children in moving over the ground (creeping, crawling, bottom shuffling). The

[1] 'Creeping' is defined as moving forward over the ground with the stomach on the ground, pulling with the arms and pushing with the legs. 'Crawling' is defined as moving forward over the ground on hands and knees with the stomach up from the ground

major reason for this is that it is rather hard for the child to extend his back and to support himself on hands and knees. Pushing off with the legs often develops more slowly. Being able to move over the ground is extremely important for the general development of the child. Once a child can crawl, for example, he can take the initiative, go to certain toys, explore the room etc. He then becomes much more active and can play more intensively.

Stimulation at home
It is important that your child learn to push off with arms and legs in turn. That also applies to using the legs alternately. DS children are inclined to push off with two arms together or two legs together. You can promote pushing off with alternating arms and legs by getting the child to clamber over cushions. If you lie on the ground you can use yourself as an obstacle. You are then in a good position quietly to give a push in the right direction at the appropriate time. NB: let your child do as much as possible himself.
You can also use the stairs or the sofa for this. For example, put a toy on the third stair from the bottom. Do not neglect safety measures!

6.5.3 Moving forward over the ground ('bottom shuffling')

Information
DS children have relatively more difficulty than other children in moving over the ground (creeping, crawling, bottom shuffling). The major reason for this is that it is relatively difficult for the child to extend his back and to support himself on hands and knees. In addition pushing off with the legs is often somewhat slower. Being able to move over the ground is extremely important for a child's general development. Once a child can 'bottom shuffle', for example, he can take the initiative, go to certain toys, explore the room etc. He then becomes much more active and can play more intensively.

Stimulation at home
If your child moves around in a sitting position instead of crawling, you should not be surprised. Approximately 30% of DS children move around in this way. There are also bottom shufflers in the population of healthy children. It is very important for your child's development that he can now go somewhere himself.
It is often the case that the prerequisites for crawling, from a motor

perspective, have not yet been met, but that the child actually wants to go somewhere. These conditions include supporting the body on arms and legs, extending the back and pushing off with the legs. They can be stimulated during play in the prone position or in sitting. Consult your physiotherapist about this.

It is possible to modify the technique of ‘bottom shuffling’. Children will prefer to do this symmetrically, i.e. with the legs spread out and the arms between the legs or outside the legs on the two sides. Try to have your child ‘bottom shuffle’ in the sideways sitting position by placing both legs on the same side. That means that both feet are pointing to the side in one direction, the back is bent sideways and the arms are supporting the posture on the other side. Ask your physiotherapist to demonstrate this. The advantage of this position is that your child can practice balance while ‘bottom shuffling’.

6.6 Activities in changes in posture around the sitting position

6.6.1 From the prone position to sitting

Information

DS children have relatively more difficulty in sitting up independently from the prone position. When they master 'sitting up' you usually see that the side-sitting posture is not used. Normally, side-sitting is a part of 'sitting up'. However, to do this, the child needs good trunk motor ability (stability and balance).

For a child, the sitting position is an important playing position. To be able to sit up by himself also means a lot for a child in functional terms. 'Sitting up' requires good trunk motor ability (stability and balance). Acquiring this motor skill in the correct manner is then also of major importance for the development of trunk motor abilities. In addition, this movement pattern is also used to come to the crawling posture or from the crawling posture to sitting up.

Stimulation at home

It is often the case that the prerequisites for 'sitting up' have not yet been fulfilled from a motor perspective, but that the child is already sitting up in his own way. These prerequisites include supporting the arms, extending and stabilising the back and balance. They can be stimulated during play in the prone and supine postures or during rolling over and sitting. Consult your physiotherapist about this.

As soon as your child can sit without support and demonstrate balance in this, you can begin to introduce sideways sitting in the movement from sitting to the prone position. To do this, sit on the ground with your legs wide apart and put your child on the ground between your legs. Put a toy down next to your child but on the other side of your leg. Encourage your child to go from side-sitting to the prone position over that leg so that the toy can be reached. You will have to guide your child's movements in pelvis, legs and trunk. Ask your physiotherapist for instructions. From the prone position on your upper leg you can stimulate your child to go from side- sitting to sitting. If necessary, you can give extra support to your child's trunk by raising your upper leg a little. In this too, you will have to guide your child's movements in pelvis, legs and trunk. Ask your physiotherapist for instructions. As soon as your child is sitting again you should focus his attention on a

toy lying on the other side next to your leg. In this way you will stimulate 'sitting' via the other side.
Once you have mastered stimulating this movement, you can make a really dynamic game out of it. Your aim should be to give as little support as possible eventually.

6.6.2 From the prone position to sitting

Information
DS children have relatively more difficulty in sitting up independently from the prone position. When they master 'sitting up' you usually note that the side-sitting posture is not used. Normally, side-sitting is a part of 'sitting up'. However, in order to achieve this the child needs good trunk motor ability (stability and balance).
The sitting posture is an important play position for a child. To be able to sit up by himself also means a lot for a child in functional terms. 'Sitting up' requires good trunk motor ability (stability and balance). Acquiring this motor skill in the correct manner is also of major importance for the development of trunk motor abilities. In addition, this movement pattern is also used to assume the crawling posture or to move from the crawling posture to sitting up.

Stimulation at home
It is often the case that the prerequisites for 'sitting up' have not been completely fulfilled from a motor perspective, but that the child is already sitting up in his own way. These conditions prerequisites include supporting on the arms, extending and stabilising the back, and balance. They can be stimulated in the course of play in the prone and the supine position or during rolling over and sitting. Consult your physiotherapist about this.
If your child no longer needs to have his trunk supported by your upper leg (see from prone position to sitting (1)), you can also stimulate him to 'sit up' from a flat prone position on the floor. Dangle a toy in front of your child but move it over the ground just out of reach of his hands to the side and to the back. In doing this you instigate the movement by guiding it via pelvis, legs and trunk. Make sure that 'side-sitting' is used. Ask your physiotherapist for instructions.
The movement from sitting via side-sitting to the prone position is somewhat easier. Offer your child a toy as he is sitting, but move it just out of his reach over the ground to the side and to the back. If your child

follows the toy, he ends up in the prone position. Guide the movement via pelvis, legs and trunk. Make sure that side-sitting is used.
Once you have mastered the stimulation of this movement, you can make a really dynamic game out of it with your child. Your eventual aim should be to give as little support as possible.

6.6.3 From the prone position to sitting

Information
DS children have relatively more difficulty than other children in independently moving from the prone position to sitting. Some of the children use the crawling posture as an intermediate position to sitting. You often see that the side-sitting position is not used. Side-sitting is usually part of 'sitting up'. However, this requires good trunk motor ability (stability and balance).
The sitting posture is an important play position for a child. Being able to sit up on one's own also means a lot to a child in functional terms. 'Sitting up' requires good trunk motor skills (stability and balance). Learning these motor skills in the correct manner is also very important for the development of trunk motor abilities. In addition, these movement patterns are also used to assume the crawling position.

Stimulation at home
It is often the case that the prerequisites for 'sitting up' have not been fulfilled from a motor perspective, but that the child is already sitting up in his own way. These conditions include supporting on the arms, extending and stabilising the back and balance. They can be stimulated in the course of play in the prone and the supine position or during rolling over and sitting. Consult your physiotherapist about this.
If your child is in the crawling position you can stimulate him to sit up via side-sitting. You can indicate this quite easily via the pelvis by pushing the buttocks alongside the heels to the ground. If you let your child do it himself you will often see that he sits on his heels.
In any case, you are now in a position to stimulate your child to move from sitting via side-sitting to the crawling position. Again, you should combine this with a game or toy.
Once you have mastered the stimulation of these movements you can make a really dynamic movement game out of it with your child. You should ultimately aim to give as little support as possible.

6.7 Activities related to standing

6.7.1 Standing

Information
DS children have rather more problems than other children in taking the weight on their legs and, consequently, with the development of standing. They are not sufficiently capable of stabilising hips and knees in an extended state and have difficulty in keeping their balance. Initially, they can only stand with a lot of support.
Standing is a prerequisite for learning to walk. The ability to maintain balance in standing eventually influences the efficiency of walking.

Stimulation at home
Being able to stand means that your child should be able to extend the back, hips and knees adequately. A child already learns this extension when developing motor skills in the prone position. In terms of prerequisites, extension of the back and hips can be stimulated in the prone position. Ask your physiotherapist about the possibilities.
In the first instance, your child will only be able to stand with support. It is a good idea to use a 'kangaroo ball' at this point. Lay your child in the prone position over the ball and kneel behind it. Allow the ball to roll gently towards you. You can then have your child's feet supported by your upper legs or on the ground. As your child rolls a bit further backwards he will take more weight on his legs. By holding him at the pelvis you can avoid the bending of hips and knees. The less support you give, the more your child is doing for himself.
You can also have your child standing with his buttocks against the ball. He is then in a sort of half-sitting position and must bear weight on the legs. The advantage is that the hips are supported and that the trunk is relatively unsupported.
Standing on two legs is easier for your child than standing on one leg. For the development of balance in standing and also with a view to walking eventually, he has to learn to transfer weight sideways from one leg to the other. For the time being, it is not necessary to lift up the feet as well. By moving the ball gently sideways you stimulate your child to transfer his weight to the side.
If you place your child upright, leaning against the ball in front of a mirror, you can have a nice game of peek-a-boo together.

6.7.2 Standing

Information

DS children have rather more problems than other children in taking the weight on their legs and, consequently, with the development of standing. They are not sufficiently capable of stabilising hips and knees in an extended state and have difficulty in keeping their balance.

Standing is a prerequisite for learning to walk. The ability to maintain balance in standing influences the efficiency of walking eventually.

Stimulation at home

Being able to stand means, among other things, that your child should be able to extend his back, hips and knees adequately. A child already learns this extension when developing motor skills in the prone position. In terms of prerequisites, the extension of back and hips can be stimulated in the prone position. Ask your physiotherapist about the possibilities.

In the first instance, your child will only be able to stand with support. The amount of support you give, however, may vary. For example, put your child in front of a low table (coffee table). You can avoid the hips and knees bending by supporting the pelvis and upper legs with your hands. Initially, your child will support himself with both his arms and his chest on the table. See whether you can get him to support himself just with his arms or hands on the table. Move the chest away from the table. What you are doing, in fact, is moving the body weight back to above the feet. You can put a toy on the table. The moment your child grasps the toy, he is using only one hand to support himself in standing. It is easier for your child to stand on two legs than on one. For the development of balance in standing and also with a view to walking, he has to learn to bear weight on one leg. If you put the toy to the side of the table, you will stimulate your child to transfer weight sideways to one leg.

6.7.3 Standing

Information

DS children have rather more problems than other children in taking the weight on their legs and, consequently, with the development of standing. They are not sufficiently capable of stabilising hips and

knees in an extended state and have difficulty in keeping their balance.
Standing is a prerequisite for learning to walk. The ability to maintain balance when standing influences the efficiency of walking eventually.

Stimulation at home
Being able to stand means, among other things, that your child should be able to extend the back, hips and knees adequately. A child already learns this extension when developing motor skills in the prone position. In terms of prerequisites, therefore, the extension of the back and hips can be stimulated in the prone position. Ask your physiotherapist about the possibilities.
Maintaining balance when standing requires good trunk motor skills from your child. He is already developing these trunk motor skills at the time you stimulate motor abilities in the prone position, the supine position and in rolling over, sitting and sitting up. Ask your physiotherapist for more information.
Once a child can stand with the support of a little table, you should try to persuade him to move away from the table. You can do this by offering a toy at right angles to the table. If your child wants to grasp the toy, he will move away from the table. However, he will still support himself on the table with one hand. By offering the toy high, or indeed low, you will stimulate your child to maintain his balance. Make a dynamic game of grasping the toy and make sure that your child makes an effort to get hold of it.
See whether your child can stand steadily enough with support for you to be able to change his nappy in the standing position.

7.7.4 Standing

Information
DS children have rather more problems than other children in taking the weight on their legs and, consequently, in the development of standing. They are not sufficiently capable of stabilising the hips and knees in an extended state and have difficulty in keeping their balance.
Standing is a prerequisite for learning to walk. The ability to maintain balance when standing influences the efficiency of walking eventually.

Stimulation at home

Being able to stand means, among other things, that your child should be able adequately to extend the back, hips and knees. A child already learns this extension when developing motor skills in the prone position. In terms of prerequisites, the extension of the back and hips can be stimulated in the prone position. Ask your physiotherapist about the possibilities.

Your child requires good trunk motor skills to maintain balance in standing. He is already developing these trunk motor skills when you are stimulating his motor abilities in the prone and the supine position and in the course of rolling over, sitting and sitting up. Ask your physiotherapist for more information.

Now your child is ready to stand without support. Just try to stimulate it from a supported position at a low table. For example, offer a toy that needs to be grasped with two hands. Or put your child with his back supported against the table and stimulate him with the toy to move his body-weight forward. He will then bring his weight above his feet and brings his trunk away from the table.

When both parents are doing the activities with the child, one can give support to his pelvis from behind. The other can offer a ball game (two-handed), for example, sideways. The person providing the support from behind can give less support when the child is involved in the game, or even letting go.

You can provide your child with toys for which he will have to use his legs purposefully. An example is a rocking-horse or a 'Flintstones' car. Maybe your local toy loan scheme will have something like that.

Have you tried to see if your child is ready to have a nappy changed while standing?

6.7.5 Standing

Information

DS children have rather more problems than other children in taking the weight on their legs and therefore with the development of standing. They are not sufficiently capable of stabilising the hips and knees in an extended state and have difficulty in keeping their balance.

Standing is a prerequisite for learning to walk. The ability to maintain balance in standing influences the efficiency of walking eventually.

Stimulation at home

For your child to maintain his balance while standing, he needs good trunk motor ability. In fact, he is developing these trunk motor skills when you stimulate him in the prone position and the supine position and when rolling over, sitting and sitting up. Ask your physiotherapist for more information.

The thing to do now is for your child to develop balance when standing without support. You can use all sorts of games for this. Your child will be inclined to be cautious. In the first instance, he will not move much for fear of losing his balance. Encourage him to achieve balance when he is standing. Encourage him to reach for toys that are out of reach, play volleyball with a balloon or use a rolled newspaper together with the balloon.

As your child is taking steps to get to a toy, you will realise that he is not using any balance reactions. Make it clear to him that he must keep his feet in one place. Put him on a mat (calling it a boat) for example and tell him that he will get his feet wet if he leaves the mat.

To make it more difficult you can also have your child stand on a low stool or on two large blocks. Vary the activity by letting him put one foot on the stool during the movement games.

Once he can stand firmly on two legs it is attractive to try to stand on one leg.

Have you realised that your child can now be dressed and undressed standing?

6.8 Activities related to standing up

6.8.1 Standing up

Information
In 'standing up' DS children initially have difficulty in extending their legs and in maintaining balance. They often use their arms to pull themselves up to standing.
Standing up requires well-developed balance. Learning to stand up in the correct manner without support from the arms is an important form of training for this sense of balance. Apart from that, it's eminently practical if you can stand up from where you are sitting on the ground without the support of a chair or the wall.

Stimulation at home
From a motor perspective, in order to be able to 'stand up' your child must be able to do quite a lot. In terms of prerequisites, standing up entails good leg motor skills and a good sense of balance. The necessary leg motor ability can be stimulated during crawling, standing and walking, the necessary trunk motor ability during sitting, sitting up, standing and when walking. Consult your physiotherapist about this.
If your child stands up with a little bit of support, from a low table for example, it will not be long before he wants to stand up on his own. Try sitting on your heels on the floor in front of a low table. Take your child on your lap with his face towards the table and put his feet on the ground in such a way that he can stand. Put a toy on the table. Put your child's hands on the table and draw his attention to the toy. If he wants to stand up, give him the necessary support. The lower your child begins, the more difficult it is for him. It makes a big difference whether he starts from the ground or from your lap. If, in addition to that, you raise your upper leg it has the effect of pushing him upwards as it were. In doing this, you can support his trunk if your child finds it difficult to maintain his balance. You can also use a low stool as a starting point.
Should your child have difficulty in extending his legs you can give extra support to his knees with your hands. Children will be inclined to extend the knees quickly and then to pull themselves up by their arms. Try to guide him in this. By holding your child's knees somewhat bent you will stimulate him actively to push against you and so to extend his knees.

6.8.2 Standing up

Information

In ‘standing up’ DS children initially have difficulty in extending their legs and in maintaining balance. Children often use their arms to pull themselves up to standing.

Standing up requires well-developed balance. Learning to stand up in the correct manner without support from the arms is an important form of training for their sense of balance. Apart from that, it is eminently practical if you can stand up from where you are sitting on the ground without the support of a chair or the wall.

Stimulation at home

In order to be able to ‘stand up’, from a motor perspective your child must be able to do quite a lot. In terms of prerequisites, standing up entails good leg motor skills and a good sense of balance. The necessary leg motor ability can be stimulated in standing and in crawling and walking. The necessary trunk ability can be stimulated in sitting, sitting up, in standing and in walking. Consult your physiotherapist about this.

Your child will stand up most easily by pushing off with two legs at the same time. Once he has mastered this you should make ‘standing up’ more asymmetrical. Do this as follows. Place your child in a kneeling or crawling posture in front of a low table and then kneel behind him. Put your hands on your child’s pelvis and push him a little to the side. By doing this you bring your child’s body weight on to one leg. Then bring his other leg forward and place it with his foot on the ground. Your child is now standing in a half-kneeling position. By pushing forward a bit against the pelvis you stimulate your child to transfer his weight to the leg in front of him. If your child then extends this leg he will stand up via the half-kneeling position. Give him the support he needs via the pelvis. Ask your physiotherapist to demonstrate this. NB: always aim for the minimum amount of support.

6.8.3 Standing up

Information

In ‘standing up’, DS children initially have difficulty in extending their legs and in maintaining balance. They often use their arms to pull themselves up to standing.

Standing up requires well-developed balance. Learning to stand up in the correct manner without support from the arms is an important form of training for their sense of balance. Apart from that, it is eminently practical if you can stand up from where you are sitting on the ground without the support of a chair or the wall.

Stimulation at home
From a motor perspective, in order to be able to 'stand up', your child must be able to do quite a lot. In terms of prerequisites, standing up entails good leg motor skills and a good sense of balance. The necessary leg motor ability can be stimulated in standing and in crawling and walking. The necessary trunk ability can be stimulated in sitting, sitting up, in standing and in walking. Consult your physiotherapist about this.
Once your child can stand with the support of a table via the half-kneeling position, try to make the support from the table as minimal as possible. Maybe he will manage to stand up with the support of only one hand on the table. Just give him a toy in the other hand, for example, or move the table away and try to see if he can manage with the support of your hands. Have him supported by a beach ball. Vary the amount of support. Eventually your child should be able to stand up without support.
In order for him to learn how to stand up without support you can do balance games when kneeling and in the half-kneeling position. Now and then when your child is in this position throw a ball to and fro, or let him beat a balloon with a rolled up newspaper.

6.8.4 Standing up

Information
In 'standing up' DS children initially have difficulty in extending their legs and in maintaining balance. They often use their arms to pull themselves up to standing.
Standing up requires well-developed balance. Learning to stand up in the correct manner without support from the arms is an important way of training their sense of balance. Apart from that, it's eminently practical if you can stand up from where you are sitting on the ground without the support of a chair or the wall.

Stimulation at home

From a motor perspective, in order to be able to ‘stand up’, your child must be able to do quite a lot. In terms of prerequisites, standing up entails good leg motor skills and a good sense of balance. The necessary leg motor ability can be stimulated in standing and in crawling and walking. The necessary trunk ability can be stimulated in sitting, sitting up, in standing and in walking. Consult your physiotherapist about this.

In the long run, your child will learn to stand up independently. It may be that in order to do that he will continue to support himself with his hands on the floor. Just see if you can guide him by putting toys in both hands. Alternatively get him to hold on to a rope that you are holding up high. It is very easy to reduce the amount of support that you are giving him via the rope.

You can always give direction and support via the pelvis. This is how you do it. Put your child in a kneeling position and then kneel behind him. Place your hands on his pelvis and push a bit to the side. By doing this, you bring your child’s body weight on to one leg. Then bring the other leg forward and place it with his foot on the ground. Your child is now in the half-kneeling position. By pressing forwards against the pelvis you stimulate your child to transfer weight to the leg in front. If your child then extends this leg he will go via the half-kneeling position to standing. Give the necessary support via the pelvis, but use this support as sparingly as possible. Ask your physiotherapist to demonstrate this procedure.

In order for your child to learn to stand without support, you can do balance games in the kneeling position and in the half-kneeling position. You could throw a ball to and fro in this position, or have your child beat against a balloon with a rolled up newspaper.

Demonstrate now and then to your child how you want him to stand up. Notice whether he spots the differences and then wants to imitate you.

6.9 Activities related to walking

6.9.1 Walking

Information
DS children start to walk later, relative to other children, and have more problems in maintaining their balance while walking. This is often visible because they walk with their legs wide apart, with extended knees and do not show any rotation movement of the trunk (trunk rotation).
You have to be able to master walking to get from A to B. Walking provides freedom and opens up all sorts of possibilities. In addition, it is very important that when walking your child has a good sense of balance. Moreover, it means he can join in freely with all sorts of games with his peers and does not have to be frightened of being trampled under foot. One other significant factor is that the foundation is made for possible participation in sports later.

Stimulation at home
In order to be able to walk, it's important to be able to extend the back and the legs. In addition, your child will have to be able to transfer his weight from one leg to the other; he must have control over his balance. That is another good reason why good trunk ability is necessary. These are the prerequisites for walking with which, in his motor development, your child has been involved for a long time. It is also quite easy to stimulate these conditions in the prone or the supine position, in the course of rolling over and when standing. Discuss this with your physiotherapist.
The first sign of walking a child will show will be walking besides a table, or in the playpen, with the support of hands, arms and chest. Once your child is capable of standing with support and can transfer his weight sideways to one leg, you can try to see whether he will move the other leg. Put an interesting toy on the table just out of reach and if necessary help him to move a foot. In the beginning you will have to be satisfied with very small steps.
When your child moves sideways along a table, you should try to let that happen with as little support as possible. For example, he will support himself by spreading his chest out on the edge of the table. Just try to see whether it is possible to get that chest free of the table edge and whether he will then put more weight on his feet. The same

applies to supporting with arms and hands. The aim should be that when he is walking he only supports himself on the table with his hands. Once that is the case, your child might carry a toy to you in one hand, and then he is only supporting himself with one hand on the table.

6.9.2 Walking

Information

DS children start to walk later, relative to other children, and have more problems in maintaining their balance while walking. This is often visible because they walk with their legs wide apart, with extended knees and do not show any rotation movement of the trunk (trunk rotation).

You have to be able to master walking to get from A to B. Walking provides freedom and opens up all sorts of possibilities. In addition, it is very important that when he is walking your child has a good sense of balance. Moreover, it means he can join in freely with all sorts of games with his peers and does not have to be frightened of being trampled under foot. One other significant factor is that the foundation is made for possible participation in sports later.

Stimulation at home

In order to be able to walk, it is important to be able to extend the back and the legs. In addition, your child will have to be able to transfer his weight from one leg to the other; he must have control over his balance. That is another reason why good trunk ability is necessary. These are the prerequisites for walking with which your child has been involved in his motor development for a long time. It's also quite easy to stimulate these conditions in the prone or the supine position, in the course of rolling over and when standing. Discuss this with your physiotherapist.

Once your child is ready to stand at a table with the support of one hand, you can try to stimulate him to cross over to another table, for example, or to a stool. Keep the distance safe and small to begin with. Your child should actually be able to hold on to one of the two tables all the time. Gradually increase the distance between the two tables. Have you already tried to see whether your child wants to walk hand-in-hand between two people or perhaps even holding one hand?

At this stage, a push- trolley or a bricks cart can be very helpful. Make

sure that there is enough counter balance so that your child does not fall over with the cart and bricks. It may be that your child is already too big for a normal bricks cart. Check at the local toy loan scheme to see if a bigger version is available. Some children really enjoy pushing their own pushchair.
You can provide your child with toys for which he has to use his legs in a very goal-directed fashion. You can think of a rocking-horse for example, or a 'Flintstones' car. Again, perhaps it may be possible that the toy loan scheme has something similar.

6.9.3 Walking

Information
DS children start to walk later, relative to other children, and have more problems in maintaining their balance while walking. This is often visible because they walk with their legs wide apart, with extended knees and do not show any rotation movement of the trunk (trunk rotation).
You have to be able to master walking to get from A to B. Walking provides freedom and opens up all sorts of possibilities. In addition, it's very important that when he is walking your child has a good sense of balance. Moreover, it means he can join in freely with all sorts of games with his peers and does not have to be frightened of being trampled under foot. One other significant factor is that the foundation is made for possible participation in sports later.

Stimulation at home
In order to be able to walk, it's important to be able to extend the back and the legs. In addition, your child will have to be able to transfer his weight from one leg to the other; he must have control over his balance. That is another valid reason why good trunk ability is necessary. These are prerequisites for walking with which your child has been involved for a long time in his motor development. It is also quite easy to stimulate these conditions in the prone or the supine position, in the course of rolling over and when standing. Discuss this with your physiotherapist.
Once your child is able to walk small distances without support, the thing to do is to increase the distance to be covered. Do walking games, for example play 'who's coming to my house'. Try to get your child to turn round while walking, call him back, and ensure that there is a change of direction in his walking.

Have your child carry a toy, for example, while he is walking. Choose something big so that he will need two hands to carry it. Get him to help you lay the table.
You should also get your child to walk in an area full of obstacles. See if he can keep on his feet in a shopping area on a Saturday morning, or in the supermarket.
Does your child want to hold your hand when walking?

6.9.4 Walking

Information
DS children start to walk later, relative to other children, and have more problems in maintaining their balance while walking. This is often visible because they walk with their legs wide apart, with extended knees and do not show any rotation movement of the trunk (trunk rotation).
You have to be able to master walking to get from A to B. Walking provides freedom and opens up all sorts of possibilities. In addition, it’s very important that when he is walking your child has a good sense of balance. Moreover, it means he can join in freely with all sorts of games with his peers and does not have to be frightened of being trampled under foot. One other significant factor is that the foundation is made for possible participation in sports later.

Stimulation at home
Once your child is capable of walking somewhat longer distances, of carrying toys with him and of changing direction without any problem, it is time to use walking in all sorts of situations. For example, concentrate on kerbs, or go for a walk in the woods where you have to step over twigs. Here too, it may be that he needs the support of holding your hand initially, but the aim is ultimately to ‘do it himself’. Go up stairs together. It is often easier to go upstairs than down. Make a deliberate choice to do it with or without the banister. Always go upstairs below your child (safety).
If you play football with your child he will lift one foot every time he kicks the ball and he will thus be standing on one leg. Stimulate your child to run, to run backwards or to hop.
If you are in a playground, choose a balance beam or climbing frames. If you are at the seaside, let your child walk barefoot on the beach. If there are dunes there, use them to walk up and down or to scramble on them.

In the long run, think in terms of roller skates, scooters, the trampoline and jumping on air cushions. Do not forget the tricycle. He will, of course, have a bicycle in the future.

Have you thought of toddler gymnastics? It is possible that there is a toddler gym in your area for DS children. Otherwise you will probably find what you are looking for at a gymnastics association. Find out from your physiotherapist.

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Monografie

The motor development of young children with Down's syndrome is typified by specific problems. The limitations that occur in their motor behaviour are described and interpreted in the theoretical construct 'Disturbances in the system of postural control'.

On the basis of this construct, the measuring instrument 'Basic Motor Skills of Children with Down's syndrome' and the treatment framework 'Physiotherapy for young child with Down's syndrome' have been developed. Both the measuring instrument and the treatment framework are included as appendices.

The study reports on the psychometric research of the motor test and of research into the effectiveness of the physiotherapeutic treatment.