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A Model for Combined Assessment of Motor Performance and Behaviour in 3-year-old Children

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ABSTRACT

This paper presents a new model for combined assessment of motor performance and behaviour (CAMPB) in 3-year-old children. It is intended for simultaneous use with a scale for assessment of motor-perceptual development. The child's performance is observed and compared with detailed descriptions of performance in gross and fine motor functions, and descriptions of co-ordination, attention and social behaviour, included in a protocol. An overall evaluation is also made. These assessments have been performed in a longitudinal follow-up study of children who needed intensive care neonatally and a control group of 72 neonatally healthy children. In this report the results from CAMPB assessments in the control group are presented. CAMPB together with the motor-perceptual scale was feasible in these 3-year-old children and CAMPB was sensitive enough to detect differences between children. The motor performance in most children conformed with the descriptions of gross and fine motor function in the protocol, and clear deviations were few. Seven per cent of the children had considerable problems in motor function and/or perception, in combination with a lack of attention, according to the overall evaluation.

INTRODUCTION

In contrast to major impairments such as cerebral palsy and mental retardation, which mostly are identified within the first four years of life, subtle impairments are not necessarily discovered in early childhood but only become evident with time (22, 42). Less obvious deviations in motor performance such as developmental co-ordination disorder or clumsiness (2, 30, 44, 51), with or without perceptual delays and behaviour problems, are usually not recognized until the age of 5-6 years (48). Even though a dysfunction in motor control in a child may be regarded as subtle, it can be a considerable hindrance to the achievement of age-appropriate skills. Furthermore, poor motor performance is frequently found in children with

learning difficulties (6, 15, 35, 49), and may also be associated with emotional problems such as anxiety and lack of confidence (35, 48). Early identification of deviations in motor performance and combined deficits in other areas will provide a possibility for appropriate referrals to further examinations and treatments well before the child starts school. It is important for a child with such deviations that the parents and the staff of day-care centres or nursery schools, for example, gain knowledge of the child's deficits and strengths so as to be able to understand his difficulties and provide support (27).

The identification of dysfunction in motor performance in children of toddler age is difficult for many reasons. With the continuous maturation of the nervous system, the severity and type of impairment during childhood can change (4, 22, 25) and the interpretation of early findings may be unreliable. There is a tendency to regard deviations in motor performance such as clumsiness at this early age as an expression of normal variations (27, 48). It is easier to recognize clumsiness when the children meet standardized demands together with other children at nursery school or at school (48, 51). Moreover, since complex motor performance can only be achieved at a certain stage of maturation of the nervous system, it is also easier to detect minor neurological dysfunction when the child has reached school age (22, 55). However, there is still a repertoire of complex motor functions that can also be observed in the very young child.

The identification of deviations in motor performance may be made difficult by the use of insufficient or inappropriate methods of assessment. In a clinical neuropaediatric examination the state and maturity of the nervous system are assessed through specific tests (1, 54) which provide limited information on motor function and behaviour in young children. Moreover, some children of young ages may be uncooperative, and this may affect the precision of the examination (1). Assessment of motor function in young children can also be made by standardized developmental scales (21, 29, 32, 37). These developmental tests are norm-referenced to enable significant developmental delays to be identified and the motor function to be assessed quantitatively according to achieved milestones, mostly on a pass and fail basis. Tests especially designed to assess the motor function provide more detailed information about motor functions achieved (17), but give no information about types of deviations when a child is not able to perform as expected. More information about motor impairments can be obtained by an assessment focused on the quality aspect of motor performance than by one that is merely based on the achievement of motor functions (8, 20, 27, 43). Furthermore, it is important to observe components of motor function during goal-directed activity and in interaction with the environment (31, 40). In addition, motor function should not be regarded as an independent

factor but should be considered in conjunction with the development of other areas (25, 32, 38, 40), such as perception and attentional behaviour.

Deviations in motor performance as well as in perception and behaviour may be found both in children born at term and in those born preterm (5). During the first year of life the quality of motor performance in infants born very preterm differs from that of infants born at term, while the level of motor development is the same (43). To be able to interpret early findings of motor deviations, more detailed knowledge of the motor function during the first years of life in children born at different gestational ages is required.

In an ongoing follow-up study of preterm and term infants who needed neonatal intensive care (43, 52), the motor performance, the development of perception and the behaviour in these children are being investigated at different ages (from birth to 10 years of age). Earlier examinations have been performed at corrected ages (i.e. age from estimated due date of delivery) of 0, 2, 4, 6, 10 (43) and 18 months. For the investigation at the age of 3 years a new model for combined assessment of motor performance and behaviour (CAMPB) has been designed, with the intention that it can be used simultaneously with a scale for evaluating motor-perceptual development with the following aims:

- to allow a detailed description of motor performance in age-appropriate motor functions,
- to determine what types of deviations may be regarded as variations of normal motor performance and what types indicate abnormality,
- to assess the predictive value of the total number of deviations,
- to allow a description of the co-ordination ability,
- to allow a description of the attentional behaviour under different conditions,
- to allow a description of the social behaviour of the child during the assessment,
- to identify children with deviations in motor performance with or without deviations in perception and attention.

Moreover, it was considered important when designing this model that the assessment session should be enjoyable to a 3-year-old child.

The aims of the present study were:

- to describe the different assessments included in the new model (CAMPB),
- to elucidate the feasibility of the assessment model for use in children at the age of 3 years,
- to assess the behaviour in a group of 72 children, neonatally healthy and born at term, according to the different assessments within the CAMPB.

METHOD

Subjects

The study comprised 72 children, 30 girls and 42 boys, born at term without any neonatal problems. The mean gestational age at birth was 40 weeks (range 37-42 weeks), mean birth weight 3557 g (2890-4580 g), mean birth length 51 cm (47-57 cm) and mean head circumference 35 cm (32-38 cm), and the mean Apgar scores at 1 and 5 minutes were 9 (7-10) and 10 (9-10) respectively. The children were all born at the University Children's Hospital, Uppsala, and constituted the control group in a longitudinal study of preterm and fullterm infants who needed neonatal intensive care. The mothers were of Swedish nationality and 96% were married or living together with the father of the child. All parents gave their informed consent and the study was approved by the Ethics Committee of the Medical Faculty of Uppsala University.

Missing data

The assessment was completed in all children at 3 years of age (± one month). In three boys a few items were not assessed because of refusal. Notes on missing data are given together with the results.

Description of the CAMPB model for use at the age of 3 years

The CAMPB model includes a detailed assessment of four gross and four fine motor functions (A), assessments of co-ordination (B), attention (C) and social behaviour (D), and an overall evaluation of the child's performance in motor function, perception and attention (E) (Fig. 1). A developmental scale, Motor-Perceptual Development, 0-7 years, MPU (29), was used simultaneously with the CAMPB model and formed the basis of the whole assessment. The MPU scale allowed the child's co-ordination, attention and social behaviour to be assessed with consideration to the child's level of motor-perceptual development. The MPU scale provides a profile of the child's developmental level in 14 areas. The MPU items were arranged in a standardized order to suit a 3-year-old child. The items were grouped into two sessions to allow observation of the child's attentional behaviour under different conditions. The child's observed behaviour was compared with descriptions of optimal performance in both gross and fine motor functions, and with categories of co-ordination, attention and social behaviour. These descriptions, which were developed for this follow-up study (52) were written down in a protocol (Appendices I-IV). Further descriptions of the MPU scale and results obtained with its

use will be presented in a separate paper. The MPU scale is mentioned in the present report in order to complete the description of the CAMPB model.

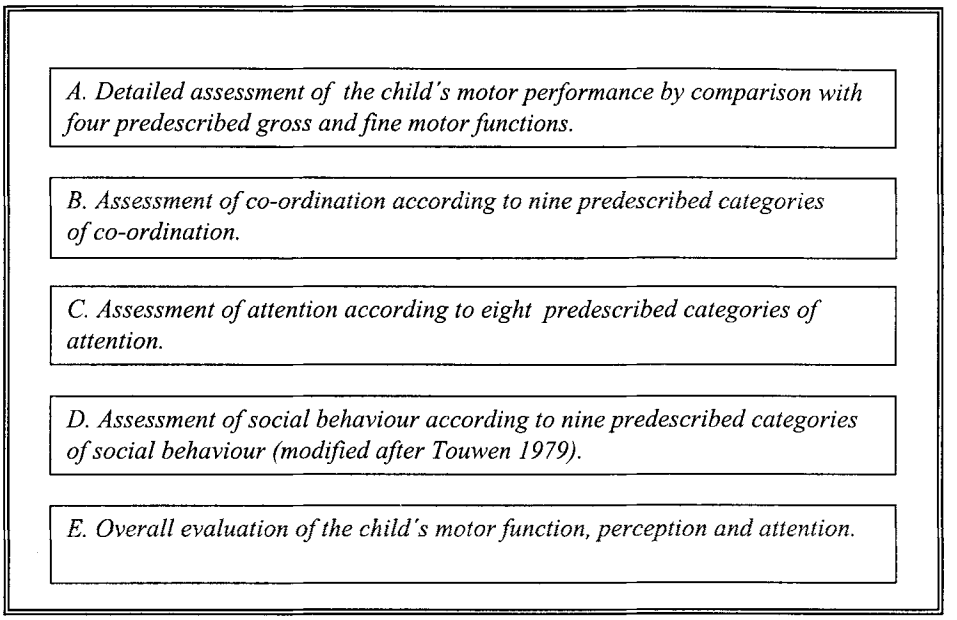

Fig.1. The new model, CAMPB, for Combined Assessment of Motor Performance and Behaviour in 3-year-old children.

Detailed assessment of gross and fine motor performance (A)

Detailed descriptions of movements and postures were made for four gross motor and four fine motor functions as criteria for the assessments, based on literature surveys. These motor functions are regarded as age-appropriate according to the literature (13, 17, 18, 29, 32, 45, 53, 54) and were selected to allow an observation of basic motor functions as well as of functions which place demands on the motor performance. These descriptions are given in detail in Appendix I.

During the assessment the child's movements and the positions of different parts of the body were observed and compared with the descriptions of optimal performance. Any observed deviation from the descriptions was classified regarding its degree. A suspected deviation was recorded in the protocol when the motor performance was almost, but not completely, in accordance with the described performance. A clear deviation was recorded when the motor performance was clearly not in accordance with the described performance. This grading of deviation as suspected or clear allows an assessment of less obvious deviations. The type of deviation and any side difference were also noted. A total of 27 clear and/or suspected

deviations in the gross motor assessment and a total of 10 in the fine motor assessment could be attained. The type of deviation was noted according to a predescribed list in the protocol for each part of the body in the different motor functions (Appendix I). Note that the deviations here are not seen as abnormal performance, but only as deviations in comparison with the descriptions in the protocol.

Additional descriptions included in the protocol concern mouth co-ordination and hand and eye preference.

Assessment of co-ordination (B)

As a complement to the detailed assessment of gross and fine motor performance, the child's ability for co-ordination was observed and compared with given descriptions of co-ordination ability developed during the follow-up study (KP) (Appendix II). The definition of optimal co-ordination (category 1) was included in the protocol together with descriptions of different suboptimal performance in co-ordination (categories 2-8).

The assessment room was arranged with special equipment to capture the child's interest and to create a demanding environment regarding the child's ability to co-ordinate both in gross and fine motor actions. This part of the protocol allows an assessment of the child's motor performance when the child is changing from one motor activity to another, both simple and complex, as in ordinary life.

The predominant performance of the child with respect to his developmental level determined to which category the child was assigned. The co-ordination was ranked as: good co-ordination, and minor or pronounced incoordination in relation to the optimal performance as described in category 1. Motor performance in accordance with categories 1-3 of the protocol was considered as *good co-ordination*, categories 4 and 6 as *minor incoordination*, categories 5 and 7 as *pronounced incoordination* and category 8 as a *definite motor impairment*, e.g. in children who were judged to be at risk of having a cerebral palsy syndrome (23) rather than a developmental co-ordination disorder or clumsiness (2, 30, 44, 51); category 9 was reserved for children whose co-ordination was difficult to assign to a particular category because of deviant behaviour.

Assessment of attention (C)

Analogously to the assessment of co-ordination, the child's attentional behaviour was also observed. Different categories of attention developed during the follow-up study (KP) were described and included in the protocol (Appendix III). The entire assessment situation was designed so as to allow observation of the child's attentional behaviour. Firstly a calm and very

structured session was created in which the child sat occupied with fine motor activities for about 45-60 minutes. A session then followed in which the child could move freely but still needed to keep his attention on the tasks given by the examiner (45-60 min). This second part ended in a situation in which the child sat calmly for a few minutes, to allow the examiner to observe the child's ability to shift the activity level when required. These sessions allowed observation of attentional behaviour, such as the child's ability to focus upon the examiner and the given tasks, to maintain attention, to complete his task and to shift attention (39).

It was intended that the different categories of attention described in the present protocol should allow recognition of an optimal attention (category 1) and different suboptimal attentional behaviours (categories 4-7). If the child's behaviour was dominated by shyness, insecurity or a strong will, this had to be taken into account by the examiner, and categories for these behaviours were therefore included in the protocol (categories 2-3).

The predominant behaviour with respect to the child's developmental level determined to which category the child was assigned. Consideration was paid to the child's need to become accustomed to the situation in the beginning and to the fact that he could lose his attention because of tiredness at the end of the whole session. The attention was ranked as: good attention, and a minor lack or pronounced lack of attention in relation to the optimal performance as described in category 1. Performance in accordance with categories 1-3 was considered as a *good* attention, categories 4-5 as a *minor lack* of attention, and categories 6-7 as a *pronounced lack* of attention; category 8 was reserved for children whose ability to concentrate was difficult to determine because of an obvious impairment or deviant social behaviour.

Assessment of social behaviour (D)

The child's predominant social behaviour during the assessment was evaluated by means of a scale described by Touwen (54) (Appendix IV). One level was added (category 2) to this scale, since the impression was obtained that a 3-year-old child might need some direction or support to carry out a 1.5 hour long assessment session. The behaviour was ranked as: adequate behaviour, or slightly or markedly deviant behaviour in relation to the optimal performance as described in category 1. Social behaviour in accordance with categories 1-2 was considered as *adequate behaviour*, categories 3-5 as *slightly deviant* behaviour and categories 6-9 as *markedly deviant* behaviour.

Overall evaluation of the child's performance (E)

At the end of the assessment an overall evaluation of the child's performance in five areas, i.e. gross motor, fine motor and facial-mouth motor function, perception and attention, was made. This evaluation was based on the impression obtained from the whole examination and, in the case of perception, on assessments based on the MPU scale. The performance in each area was recorded as good, slightly deviant (performance unlikely to require any therapeutic intervention) or markedly deviant (performance needing therapeutic intervention of different types and intensities).

Description of the assessment procedure

All children were assessed in a specially equipped examination room. A table with a chair, a specially made screw-capped tube containing small beads, and the equipment required for the MPU assessment were used for the fine motor and the perceptual assessment. The equipment for gross motor assessment consisted in a flight of stairs attached to the wall with a set of wall bars and a slide, a free-standing flight of stairs with 4 steps near a wall but without handrails and a large thick gym-mat which allows jumping and running. A specially made box for the assessment of eye preference was also used.

The parents were asked to be present during the whole session and were briefly informed about the procedure. At the end of the assessment they were asked to evaluate the child's performance and to compare it with their everyday performance to find out whether the child was behaving as usual during the assessment. The motor function, the language, the attention and the ability to succeed in the MPU were rated much better, a little better, equal, a little worse or much worse, compared with the everyday performance.

The assessment was divided into two successive parts. During the first part the child sat at a table performing fine motor tasks for 45-60 minutes. The second part involved gross motor activities for 45-60 minutes. The examiner began by giving the child a picture-book. This gave the examiner an opportunity to adjust the time of the start of the formal assessment, and the child had the possibility of starting the co-operation at his own functional level.

Two physiotherapists (EH,KP) alternated as examiner and observer. The observer recorded the assessment on videotape. One of the examiners (EH) had previously treated one of the children in the control group. The other examiner (KP) had examined the children in earlier assessments up to the age of 18 months. The examiners were careful not to give each other any information about the child and neither of them had access to the child's medical history or results from previous examinations before the assessment. The protocols were filled in directly after the

assessment in consensus. In the event of any disagreement, a reassessment of that item could be made with the help of the videotape. This was seldom needed and if it was, this was mostly at the beginning of the follow-up. The statistical program (SPSS) for Windows was employed (41).

Interobserver reliability

An interobserver agreement study of 20 consecutive children was made at the beginning of the follow-up study by the examiners (EH, KP). The same assessment situation as above was used. After the whole assessment (1.5-2 hours) the two examiners filled in a protocol separately. The rate of agreement was 95% for the MPU scale. These items are assessed on a pass/fail basis. In the detailed assessment of motor performance (part A), the rate of agreement reached 96% for gross motor performance and 93% for fine motor performance when the degree of deviations was dichotomised, i.e. with clear deviation versus no or suspected deviation. The rates of agreement in the assessments of co-ordination, attention during fine motor activity, attention during gross motor activity and social behaviour (parts B-D) were 70%, 90%, 80% and 75% respectively, when the categories were grouped as described in sections B, C and D. In the overall evaluation of gross, fine and facial-mouth motor function (part E), the agreement was 95%, 93% and 100% respectively when the performance was dichotomised as markedly deviant versus good or slightly deviant.

RESULTS

All children completed the assessment. Most parents estimated their children's performance during the assessment as equal to or better than that expected; 83% in motor performance, 75% in attention and 77% in the ability to perform the tasks in the MPU scale. For the first 12 assessed children these data are missing.

Detailed assessment of gross and fine motor performance (A)

Degree of deviations in gross motor function

As shown in Table 1, only a small proportion of the children displayed *clear deviations* from the described gross motor performance (Appendix I). Exceptions were motor performance in the shoulders in the standing position with outstretched arms and motor performance in the shoulders and feet during running.

Suspected deviations were common in all parts of the body except for the head and the hips. Differences between boys and girls were chiefly observed in motor performance in the trunk and

pelvis in the sitting position during fine motor activity (36% of the boys and 10% of the girls showed suspected deviations) and in the knees during walking (suspected deviations only noted in girls). On the whole, deviations in motor performance were mostly seen during standing and running.

Table 1. Percentage numbers of children with no deviations, suspected deviations and clear deviations in gross motor performance in the different parts of the body .
See Appendix I for a detailed description, in sitting position only head, trunk/pelvis and shoulders were assessed.

	Standing n=70	*Walking* n=72	*Running* n=72	*Sitting* n=72
Head				
No deviations	96	99	89	99
Suspected deviations	4	1	11	1
Clear deviations				
Trunk and pelvis	(n=69)			
No deviations	57	89	69	75
Suspected deviations	39	11	26	25
Clear deviations	4		4	
Shoulders	(n=69)			
No deviations	30	94	43	94
Suspected deviations	42	6	38	6
Clear deviations	28		19	
Elbows	(n=69)			
No deviations	64	100	51	
Suspected deviations	26		44	
Clear deviations	10		4	
Hands				
No deviations	70	96	64	
Suspected deviations	20	4	32	
Clear deviations	10		4	
Hips	(n=69)		(n=70)	
No deviations	91	97	89	
Suspected deviations	9	1	10	
Clear deviations		1	1	
Knees	(n=69)		(n=70)	
No deviations	62	93	96	
Suspected deviations	38	7	4	
Clear deviations				
Feet				
No deviations	66	63	40	
Suspected deviations	27	32	38	
Clear deviations	7	6	22	

Total number of deviations in gross motor performance: The largest possible number of clear and/or suspected deviations that could be attained by the individual child in gross motor performance was 27. Half of the children (51%) showed no clear deviations at all and 95% showed 5 or fewer clear deviations in motor performance (Fig. 2). The largest total number of clear deviations, 7, was noted in one girl. More girls than boys showed a gross motor performance without any clear deviations at all (67% and 39% respectively).

The distribution of *suspected deviations* was quite different. Only 3% of the children displayed no suspected deviations at all and 95% of the children showed 10 or fewer. The largest total number of suspected deviations in gross motor function was 14, observed in one boy. Data are missing for one boy in the standing position because of concealing clothes and for two another boys because of refusal to co-operate; for two of those boys data during running are missing because of concealing clothes (Table 1).

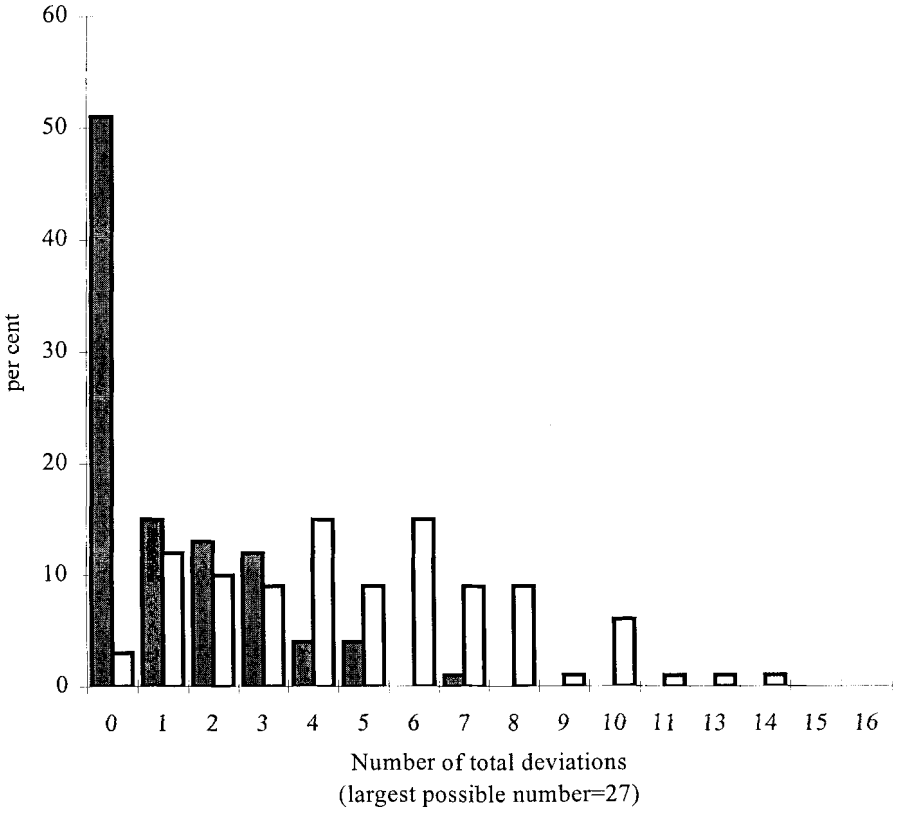

Fig. 2. Percentage distribution of children by their total number of clear (filled bars) and suspected (unfilled bars) deviations in gross motor performance (n=69).

Degree of deviations in fine motor function

The majority of the children showed no *clear deviations* in fine motor performance in the active or passive hand during the different tasks (Table 2) as compared with the described motor performance (Appendix I). *Suspected deviations* in fine motor performance were quite common in both hands.

Table 2. Percentage numbers of children with no deviations, suspected deviations and clear deviations in fine motor performace in the active and passive hand.
See Appendix I for a detailed description.

	Inserting beads into a tube		*Tower-building*	*Pouring water*	*Drawing*
	active: right hand n=71	active: left hand n=71	preferred hand n=72	preferred hand n=72	preferred hand n=72
Active hand					
no deviations	69	63	38	44	56
suspected deviations	23	31	57	40	35
clear deviations	9	6	6	15	10
Passive hand					
no deviations	56	42	68	92	46
suspected deviations	35	42	31	8	53
clear deviations	9	16	1		1

Total number of deviations in fine motor performance: The largest possible number of clear and/or suspected deviations in fine motor performance was 10. The majority of the children (66%) showed no clear deviations in fine motor performance at all (Fig. 3), and 95% showed 3 or fewer clear deviations. The largest total number of clear deviations, 8, was found in one boy. More girls than boys showed a fine motor performance without any clear deviations at all (87% and 51% respectively). Only 6% of the children showed no *suspected deviations* in fine motor performance at all and 95% of the children showed 7 or fewer such deviations. The largest total number of suspected deviations, 9, was noted in one girl. The data for one boy are missing, as he refused one task.

Type of pencil grasp: All types of pencil grasp described in the protocol appeared among the children (Table 3). The pronated digital grasp was used more than the supinated digital grasp and the cross thumb grasp was only seen in one boy. Eleven children (15%) still used the more immature palmar grasp. The more mature grasp with the static tripod position (with unsupported

or supported hand) was used by 46% of the children, while the mature dynamic tripod was observed in only one girl.

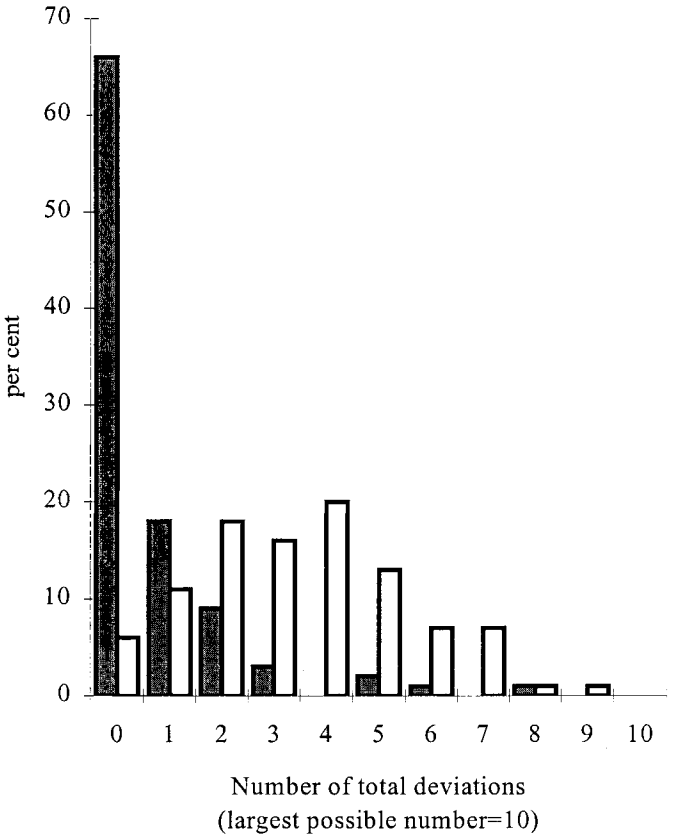

Fig. 3. Percentage distribution of children by their total number of clear (filled bars) and suspected (unfilled bars) deviations in fine motor performance (n=71).

Table 3. Percentage numbers of children with different types of pencil grasp (n=72).

Pronated or supinated palmar grasp	7
Pronated palmar grasp with stabilising index finger	8
Pronated digital grasp	26
Supinated digital grasp	10
Cross thumb grasp	1
Static tripod position with unsupported hand	24
Static tripod position with supported hand	22
Dynamic tripod	1

Types of deviations in gross and fine motor functions

The types of suspected and clear deviations in gross motor function shown by the children are presented in Table 4 a+b and in fine motor function in Table 5. Note that one child can achieve more than one deviation in each motor function in the protocol.

In *gross motor performance* the most frequent deviations from the described performance were observed when the child was running, with other co-movements than swinging movements in the shoulders (e.g. abduction and outward rotation) in 34 children, extension of the elbows in 33 children, irregular footsteps in 30 children and inadequate strength of foot-strikes in 31 children.

In *fine motor performance* the most frequent deviations from the described performance in one-handed object manipulation were dysmetria in the active hand in tower-building, and inco-ordination in the passive hand in drawing (29 and 35 children respectively). In two-handed object manipulation the most frequent deviations were also dysmetria in the active hand though to a lesser extent, and a need for support from the table in the passive hand while the left hand inserted beads into a tube (21 and 28 children respectively).

Side differences were also described in the protocol for each deviation, but will not be presented in this paper.

Dominance

Clear right-hand preferences in drawing, tower-building and pouring water were found in 46% of the children. Eleven per cent of these children also showed right-eye preference.

Hand preference in drawing: The majority of the children showed right-hand preference, which was clear in 71% and uncertain in 18%. Clear left-hand preference was shown by 10% of the children, while ambidexterity was quite unusual, and was shown by only one child.

Hand preference in tower-building and pouring water: Right-hand preference was also exhibited by the majority of the children in tower-building and pouring water; this was clear in 53% and uncertain in 29%. No child showed clear left-hand preference, but the preference was uncertain in 11%. A few children (7%) displayed ambidexterity.

Eye preference: The majority of the children, 61%, showed no clear eye preference; 24% had a preference for the right eye and 15% for the left eye.

Co-ordination of mouth motor activity.

Forty-two per cent of the children were able to change easily between blowing and drinking through a straw (category 1), and 24% showed only slight problems (categories 2-3) by spilling water or blowing outside the straw. Twenty-five per cent of the children were able to drink but

could not blow (categories 4-6). Only 9% could neither blow nor drink through a straw (category 8). Data for one boy are missing because of refusal to try.

Table 4a. Number of children with different types of suspected (s) and clear (c) deviations in gross motor performance in the head, trunk/pelvis and shoulders (n=72).

Types of deviations in the	*Standing*		*Walking*		*Running*		*Sitting*	
different parts of the body	s	c	s	c	s	c	s	c
Head								
Instability	1		1		5			
Lateral flexion	1				2		1	
Rotation	1				1			
Trunk and pelvis								
Tremor	1						1	
Instability	16	3	2		6	3	11	
Flexion		1	1		1		1	
Hyperextension	9				3			
Lateral flexion	1					1		
No rotation					17	3		
Pelvis tilted backwards	1		2				1	
Pelvis tilted forwards	7		4		3			
Inadequate posture in the trunk							12	
Arm support against the table							1	
Trunk support against the table							2	
Shoulders								
Sparse movements							1	
Instability	9	10						
Protraction	15	11	1		4	3	2	
Outward rotation			1		3	5		
Inward rotation		2	1		2	2		
Flexion		1	1			1		
Extension	7	3	2			2		
Abduction	6	3			10	3		
Adduction	5	4						
Arm support against the table							1	
Arm support against the trunk	3	4						
Other co-movements								
than swinging movements			4		20	14		

Data for 3 boys are partly missing, see Table 1.

Table 4b. Number of children with different types of suspected (s) and clear deviations in gross motor in the elbows, hands, hips, knees and feet (n=72).

Types of deviations in the different parts of the body	*Standing*		*Walking*		*Running*	
	s	c	s	c	s	c
Elbows						
Instability	1	1				
Flexion	15	7			11	3
Extension					30	3
Hyperextension	2					
Hands						
Sprawled fingers	7	4	3		16	3
Adducted thumb	1				2	
Fisted hand	1				11	1
Pronated hand	3	5			4	
Dorsal flexion, wrist	2	4				
Volar flexion, wrist	3					
Hips						
Sparse movements					2	
Instability	4				2	
Abduction	2					
Flexion	1			1	2	1
Inward rotation			1	1	1	1
Knees						
Instability	5		1		1	
Flexion	2					
Hyperextension	17		2		1	
Valgus	12		2		1	
Feet						
Instability	7	2				1
Outward rotation	1	1	4	1	1	
Inward rotation	4		5	2	5	1
Valgus	8	2	7	1	1	3
Adducted feet		1		1		1
Deviant weight bearing	3		1			
Walks on tip-toes			7			
Incomplete heel-toe gait			10	2		
Irregular footsteps					18	12
Inadequate strength in foot-strikes					15	16
Limps						2

Data for 3 boys are partly missing, see Table 1.

Table 5. Number of children with different types of suspected (s) and clear (c) deviations in fine motor performance in the active and passive hand (n=72).

Types of deviations in the hands	*Inserting beads into a tube*				*Tower-building*		*Pouring water*		*Drawing*	
	active: right hand		active: left hand							
	s	c	s	c	s	c	s	c	s	c
Active hand										
Sparse movements	1									
Tremor	9	3	11	2	16	3	13	5		1
Dysmetria	7	6	17	4	26	3	2	3	1	
Finger grasp	1	1		1						
Deviant pencil grasp									14	4
Sprawled fingers	1	1		1	16	1				
Pronation									1	
Inadequate strength	1	3	5	2	6	1	6	4	14	6
Difficulty in directing the pen									13	4
Overfills glass							11	9		
Pours beside glass							15	4		
Incoordination								1		
Passive hand										
Tremor	2	3	2	1	4	1	1			
Dysmetria					1					
Sprawled fingers		1		1	15				3	
Pronation				1						
Adducted thumb					1				2	
Fisted hand							1		6	
Associated movements					4		3		3	
Inadequate grasp	11	4	8	6						
Inadequate strength	5	2	5	3	1	1				
Incoordination	6	4	10	7	2		2		34	1
Arm support against the table	14	4	23	5						
Arm support against the trunk	1		2							

Data for one boy are missing in the task of inserting beads into a tube.

Assessment of co-ordination (B)

The results were distributed among all categories of co-ordination, except category 8, as no child had a definite motor impairment (Fig. 4). The girls were mostly assigned to category 1, and the boys mostly to category 3 or 7. *Good co-ordination* (categories 1-3) was more frequently observed in girls (67%) than in boys (43%). *Minor incoordination* (categories 4 and 6) was observed in 20% of the girls and 24% of the boys.

Pronounced incoordination (categories 5 and 7) was more frequent in boys (31%) than in girls (10%). In the group of children with minor or pronounced incoordination (categories 4-7), 53% could not always adjust their movements according to visual input as described in categories 6-7. These categories of performance were observed more often in boys than in girls. The co-ordination ability of one girl and one boy could not be determined on account of deviant behaviour (category 9).

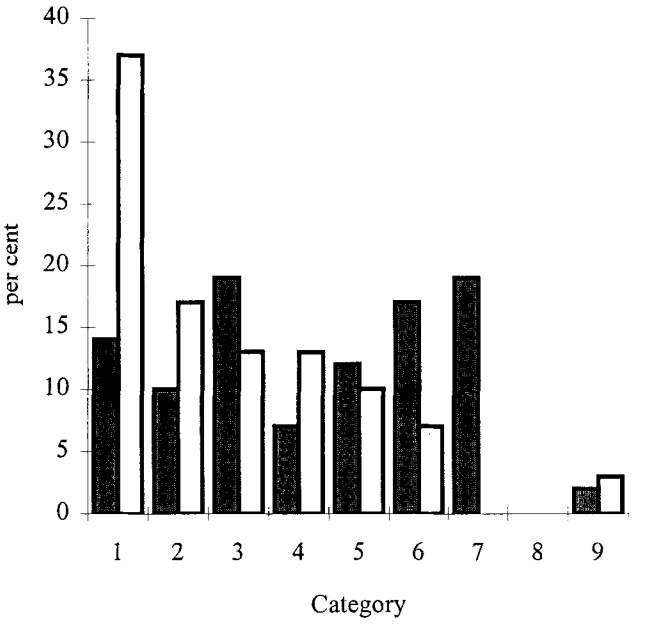

Fig. 4. Results of the assessment of co-ordination. Percentage distribution of results in boys (filled bars) and girls (unfilled bars) according to the different categories of co-ordination; n=72 (42 boys and 30 girls).

Assessment of attention (C)

The results were distributed among all categories of attention (Table 6). The girls were mostly assigned to category 1 during both fine and gross motor activity, while the boys were mostly assigned to category 1 during fine motor activity and to category 4 during gross motor activity. The majority of the girls showed *good attention* (categories 1-3), more so during fine motor activity (73%) than during gross motor activity (60%). The boys also showed good attention, but more during gross (45%) than during fine motor activity (38%).

A minor lack of attention (categories 4-5) was noted in 13% of the girls and 36% of the boys during fine motor activity and in 30% of the girls and 36% of the boys during gross motor activity. A *pronounced lack* of attention (categories 6-7) was shown by 24% of the boys during the fine motor sequence and by 14% of the boys during the gross motor sequence. Only 4 boys showed a pronounced lack of attention during both sequences. One girl displayed a pronounced lack of attention during the fine motor sequence and none of the girls during the gross motor sequence. Three girls and 2 boys were assigned to category 8 on account of deviant behaviour.

Table 6. Results of the assessment of attention. Percentage distribution of children to the eight different categories of attention, n=72 (42 boys and 30 girls).

	During fine motor activity			During gross motor activity		
Category	Boys	Girls	Total	Boys	Girls	Total
1	24	43	32	19	43	29
2	0	7	3	12	10	11
3	14	23	18	14	7	11
4	14	0	8	26	13	21
5	22	13	18	10	17	13
6	19	3	12	5	0	3
7	5	0	3	9	0	5
8	2	10	6	5	10	7

Assessment of social behaviour (D)

The results were distributed among all categories of social behaviour except for category 3 (Fig. 5). The girls were mostly assigned to category 1 and the boys to category 2. The majority of the children (71%) showed *adequate social behaviour* during the assessment (categories 1-2), and this was found for 83% of the girls and 62% of the boys. *Slightly deviant behaviour* with anxiety and withdrawal (categories 4-5) was seen in 14% of the boys and 3% of the girls. *Markedly deviant behaviour* as described in categories 6-8 was unusual (3 boys, 1 girl). Seven boys and 3 girls were assigned to category 9, mainly because of hyperactivity and/or aggressiveness. Additionally, among the 11 children assigned to categories 4-8 (reluctance, refusal or withdrawal and resistance) and the 10 children assigned to category 9, the majority (9 and 7 children respectively) had slightly or markedly deviant performance in motor function and/or perception according to the overall evaluation.

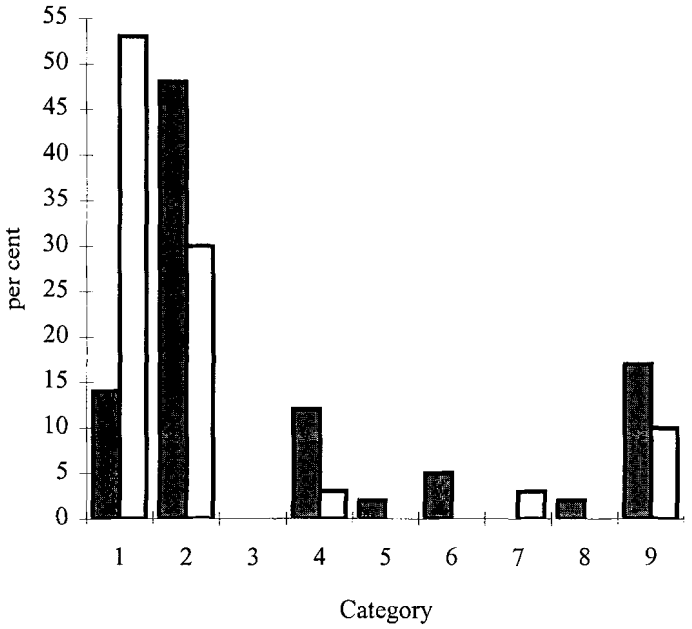

Fig. 5. Results of the assessment of social behaviour. Percentage distribution of results in boys (filled bars) and girls (unfilled bars) according to the different categories of social behaviour; n=72 (42 boys and 30 girls).

Overall evaluation (E)

The numbers of children judged as having good performance, slightly deviant performance or markedly deviant performance in the overall evaluation are shown in Table 7. The majority of the children showed good performance in the areas of motor function, perception and attention (65-72%). Slightly deviant performance was noted for 18-28% of the children among the different areas studied. Markedly deviant performance was noted for 11% of the children in gross motor function, 6% in fine motor function, 6% in facial-mouth motor function, 8% in perception and 11% in attention.

Table 7. Percentage number of children showing good performance, slightly deviant performance and markedly deviant performance according to the overall evaluation (n=72).

Performance	*Gross motor*	*Fine motor*	*Facial-mouth motor*	*Perception*	*Attention*
Good	65	72	67	69	70
Slightly deviant	24	22	28	22	18
Markedly deviant	11	6	6	8	11

Data are missing for one boy in the overall evaluation of attention.

A total of 17 children, 13 boys and 4 girls, in this study group of neonatally healthy children born fullterm showed a marked deviation in at least one of the three areas motor function, perception or attention, as seen in Figure 6. Twelve of these 17 children exhibited markedly deviant performance in at least one of the areas *gross, fine and facial-mouth motor function.* Only 3 of these showed a marked deviation in motor function alone (without parentheses in Fig. 6), while 3 children also had slightly deviant perception and/or a slight lack of attention and another 6 children showed marked deviations in these areas. Four boys and one girl (7%) displayed marked deviations in *motor performance* and/or *perception* in combination with a pronounced lack of *attention.* Two children showed a pronounced lack of attention without any motor-perceptual dysfunction and one child showed slight deviations in these areas. The types of deviations in the overall evaluation and the side differences will not be presented in this paper.

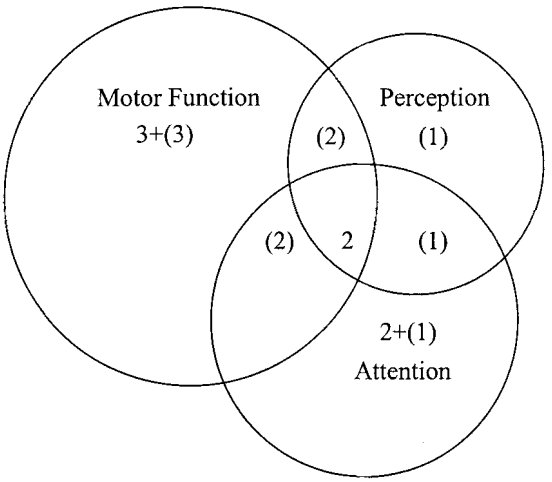

Fig. 6. The 17 children with markedly deviant performance in motor function and/or perception and/or attention according to the overall evaluation. The numbers in brackets represent children who had additional dysfunction in the other area or areas but only to a slight degree. Each child is presented only once in the figure. Data is missing for one child in the overall evaluation of attention.

DISCUSSION

In this paper we present a new model for combined assessment of motor performance and behaviour (CAMPB) for use in 3-year-old children. This model allows a detailed and comprehensive evaluation of the child's motor performance during goal-directed activity and is

intended for simultaneous use with a motor-perceptual development scale. By this means, information can be obtained on both the developmental level and the quality of performance in the gross and fine motor areas. The assessment situation allows an evaluation of both simple and complex motor activity and is also designed to provide information on the child's attentional behaviour in two different situations. The aims of the assessment model are to characterize the motor performance and behaviour of 3 year-old children and to identify children with deviations in motor performance with or without deviations in other areas such as perception and attention. The evaluation of social behaviour gives information about the child's ability to cope during the whole assessment procedure. The results show that the majority of the 72 neonatally healthy children born fullterm displayed good co-operation during assessment with the CAMPB model used simultaneously with the MPU scale at the age of 3 years.

Detailed assessment of gross motor performance (A)

Assessment methods which allow comparisons with detailed descriptions of motor performance are few. Recently a new neurological examination technique for toddler-age which permits detailed assessment of basic motor functions in normal children, was developed (24). However, less obvious deviations in motor performance, e.g. developmental co-ordination disorders or clumsiness, are usually not observed in basic motor functions such as sitting, standing and walking but more often in complex motor performance with increased demands on postural control, speed or movement accuracy (27, 48). In the present protocol walking is the only motor function which can be regarded as a basic function without an increased demand on children at 3 years of age (53). The other gross motor functions included in the protocol are more demanding for children at this age.

Sitting position for fine motor activity: The majority of the children showed good postural control of the head and trunk, with the shoulders in an adequate position (Table 1). A few children needed support from the table, but none needed support from the back of the chair (Table 4a). Only 25% showed a slightly inadequate position and/or instability. This is in agreement with the study of Hempel (24), who found no deviations in postural control in a group of normal children at the age of 3 years. Only 4% of these showed non-fluency movements in the trunk. In our study the children at this age had a good postural capacity even when they had to sit for 45 minutes.

Standing with forward-stretched arms: This position proved to be demanding at this age. The majority of the children were unable to maintain the position of the shoulders and showed both

suspected and clear deviations (Table 1), mostly in the form of protraction and/or instability (Table 4a). On the whole this performance is in accordance with the descriptions of motor function in standing in 3-year-old children made by Touwen (54). In the study by Hempel (24) the group of healthy children was observed during free standing, a more basic function, and showed a posture without any deviations in the head, trunk and legs at 3 years of age. In our study instability of the trunk was seen in 28% of the children and hyperextension of the knees in 25%, but this was mostly noted as a suspected deviation (Table 4a+b). Despite the more demanding position used in our study, the majority of the children showed a good posture of the head, trunk and legs.

Walking is considered to be mature in normal children at the age of 3 years with heel-strike and reciprocal arm-swing (53). Our results are in conformity with this observation. Only four boys showed clear deviations from the description in the protocol (Table 1). Suspected deviations were noted primarily in the feet, with an incomplete heel-toe gait, walking on tip-toes, pronounced valgus and/or inward and outward rotation in a few children (Table 4b). The proportion of children who showed a clear heel-toe gait in our study (83%) is almost the same as that reported by Hempel (24).

Running is an exaggerated form of walking, with the same pattern of interlimb co-ordination but with a flight phase between the foot-strikes (11, 56) and a higher dependency on postural control due to the increased need of force (11). Still most of the children showed good head control and slight diagonal rotation in the trunk (Table 1). Only about half of the group displayed reciprocal movements of the arms throughout the running phase (Table 4a). An excess of movements in the hands was observed in some children. This was mainly in the form of sprawled fingers or fisted hands (Table 4b). This might be normal at this age (13), but the majority of the children showed no associated movements at all. Clear deviations were commonly observed in the feet (22%), and were mostly noted as irregular footsteps and/or inadequate strength in foot-strikes (Table 4b). This corresponds to the report by Whitall (56) that children below the age of 4 years had slightly less stable phasing patterns than at later ages. The large number of deviations in the shoulders and feet may indicate the intense progress of development at this age. However, the majority of the children showed no clear deviations at all while running (Table 1).

Detailed assessment of fine motor performance (A)

The ability to grip with different grasps, depending on the object, and the ability to use tools, are well established motor functions at 3 years of age (12, 17, 18). However, the refinement of the

movements is in a progressing phase and is highly dependent on the task (28). The selected fine motor tasks in our protocol require different grasps, movement accuracy, eye-hand co-ordination and bimanual co-ordination.

Grasp: The majority of the children were able to use the required grasp for the different tasks. In the drawing task 46% of the children used a static tripod posture (Table 3). Only one girl used the dynamic tripod posture. These results are supported by Rosenbloom and Horton (45) who studied a group of normal children at 3 - 3.5 years. The static tripod grip was used by 33% and none used the dynamic tripod. On the other hand, our results differ from a later study of non-dysfunctional children at the age of 3 to 3.5 years (46), in which the dynamic tripod posture was found to be the most frequently used grasp. However, our results support their findings that children at 3 years of age can be expected to use pencil grasps ranging from primitive to more mature and that the cross thumb grasp is a quite unusual grasp. Furthermore, we did not find the sex differences in our group of children that were noted in the studies by Egan and Brown (16) and Schneck and Henderson (46). In their studies girls showed more mature grips than boys.

Movement accuracy in the active hand: One-handed object manipulations: In spite of the fact that the tasks in our study demanded well-timed movements, clear deviations were quite uncommon (Table 2). According to Campbell (10), 3-year-old children may show excessive dysmetria in tasks requiring good eye-hand co-ordination. This deviation was also frequently observed in our study, mostly during tower-building, but was obvious (clear deviation) in only very few children (Table 5). Most of the children also showed good control of their movements in the task of pouring water into a glass, a task which needs a well-functioning perception-action system. The different deviations of suspected degree in the observed tasks may confirm the intense developmental phase in the fine motor performance at this age (13, 28).
Two-handed object manipulation: The task of inserting beads into a tube demanded not only good eye-hand co-ordination, but also good bimanual co-ordination. The two-handed strategy with complementary roles of the hands is already developed during the second year of life (12). Our results show that 3-year-old children were able to change between the right and left hand as the active hand in spite of a strong right-hand preference. Only a slight increase in the number of suspected deviations was observed, noted as dysmetria for the active hand and the need for arm support against the table for the passive hand (Table 5).

Movements in the passive hand: Associated movements were quite unusual except for some children who showed an overflow of sprawled fingers in the precision task of tower-building. This finding is in congruence with the report by Hempel (24) that none of the studied children at 3 years of age showed associative movements during free manipulation with different objects. In contrast to the method used by Hempel, our assessment allowed an observation of the co-operative ability of the passive hand. In almost half of the children incoordination was observed to a suspected degree during drawing but was more uncommon in the other tasks (Table 5).

Dominance: A well established hand preference in drawing, mostly for the right hand, was found in our study, with clear preference in 81% of the children and ambidexterity in only one child. Most of the children with an immature pencil grasp also showed clear preference, which differs from the finding in the study by Rosenbloom and Horton (45) that the children's hand dominance appeared parallel to the development of a more mature grasp. In the other fine motor tasks the children showed a more uncertain preference, but only 7% displayed ambidexterity, a frequency lower than the 9% found by Hempel (24).

Assessment of co-ordination (B)

This part of the new assessment model was intended to give a general description of the child's performance whenever he was moving. Smooth and continuous motor performance when shifting between positions and during new positions requires an anticipatory control of posture and goal-directed movements (28, 36). Co-ordination is dependent on developmental factors, environmental conditions and the requirements of the tasks (34, 50). The equipment in the assessment room prompted many shifts of movements in space, direction and speed. In addition, many of the presented tasks required postural control and movement accuracy.
Descriptions of the quality of movement as smooth, fluent, goal-directed and well co-ordinated are common (24, 54). According to Henderson and Sugden (26), motor performance can be defined qualitatively in terms involving body control and adjustments to task requirements. In our definition of optimal motor co-ordination these considerations are included (Appendix II, category 1). Moreover, behaviours that can affect the co-ordination ability are also included (categories 2-3). Minor impairment in the quality of movements is often expressed as clumsiness (30, 48, 51) or with expressions such as awkward, abrupt, jerky or inadequate (54). Efforts to describe incoordination as in categories 4-7 might be more discriminative in observations of motor performance in young children. Incoordination has also been described as performance of hyporeactive or hyperreactive movements (20), but this does not give a

description of the child's performance as in our protocol. Furthermore, deficits in visual-motor integration are frequently reported, especially in children born preterm (42). Usually this is assessed as visual co-ordination in fine motor activity and not for the whole body during gross motor activity as is described in our protocol (categories 6-7).

To make an instrument sensitive to motor dysfunction it should include a qualitative aspect (8, 20, 25, 43), and this was also the aim of the present assessment of co-ordination. It was expected that motor co-ordination difficulties would be identified to a higher degree than in other studies using other instruments at this age. In the present study the majority of the girls showed a good capacity for co-ordination (categories 1-3) and only three girls displayed pronounced incoordination (Fig.4). The boys, on the other hand, more frequently showed incoordination according to categories 5 and 7. An overrepresentation of clumsiness among boys has also been found in other studies (19, 48). The large number of children with a pronounced degree of incoordination might be the effect of a sensitive instrument for assessing motor dysfunction. The gender differences might also be due to differences in behaviour and maturity between boys and girls. The development of motor function is known to be highly variable (55) and the quality of motor performance at the age of 3 years is in a phase of strong and rapid development (13). The results from the follow-up study of the children at later ages will be important indicators of the predictive value of this instrument.

Assessment of attention (C)

The most commonly used definition of attention deficit is that proposed by DSM-IV (2). Several tests for children include checklists for attentional behaviour during the testing session of other areas (7). Specialised tests for measurements of attention need special equipment, but it is also necessary to be able to gain valuable information by observing the child's behaviour in a clinical assessment (7). Our model allows a structured observation of the child's attentional behaviour in situations designed to put different demands on his attention. A child who shows deficits under several conditions is more likely to have a dysfunction in attentional behaviour than a child who shows problems only under one condition.

As a motor-perceptual developmental scale (MPU) was used, the examiner had an opportunity to assess the attention in relation to the individual child's developmental level. This is of great importance, as too simple or too difficult tasks might have an influence on the child's attention. In our study 15% of the children showed a pronounced lack of attention (categories 6-7) during the fine motor session and 8% during the gross motor session, mainly among the boys (Table 6). According to Campbell (9), between 14% and 18% of kindergarten boys show hyperactive

behaviour (attention deficit disorder) as defined by the DSM-III scale (3). According to our results, 3-year-old children have a good capacity for attention (categories 1-5), some with slightly high motor activity (category 4) or very occasionally distracted by irrelevant stimuli (category 5), which cannot be regarded as an attention deficit as described in categories 6-7. Though this age may be a turbulent developmental phase, it is important to identify children at risk of developing an attention deficit disorder (9, 32).

Assessment of social behaviour (D)

It has been suggested that at the age of 3 years children are uncooperative and therefore difficult to examine (1, 27, 47). In contrast, it is our impression that children at this age are very interested and co-operative but also much aware of their limitations. They may use a number of ways to avoid difficult tasks and this may be misjudged as a lack of co-operation. Only 15% of the children, mostly boys, showed reluctance, refusal or resistance (categories 4-8) and a majority of those (9/11) also displayed slight or marked deviations in at least one of the areas of motor function and/or perception. This might well have been the reason for their uncooperative behaviour.

Overall evaluation (E)

The majority of the studied neonatally healthy children were judged to have good motor function, perception and attention (Table 7). A markedly deviant performance was observed mostly within the motor area, i.e. in gross, fine and facial-mouth motor function, in which it was noted in 11%, 6% and 6% of the children, respectively. Comparisons with other studies are difficult owing to differences in the methods used and in the definition of deviant motor performance (5). The prevalence of motor dysfunction such as a developmental co-ordination disorder or clumsiness has been estimated to range from 3 to 15% (27). In a population study of 3-year-old children Silva and Ross (47) found gross motor delay in 3.5%. Drillien and Drummond (14) reported from their population study that motor disorder was a principal problem in 2% and was combined with problems in other areas in a further 6% of the children at pre-school age. Hadders-Algra and Touwen (22) found that in a group of 4-year-old neonatally normal children, minor neurological dysfunction was present in 7.5%. The comparatively large number of children who were judged to show markedly deviant motor performance in this study might be attributable both to the criteria set for a deviating motor performance and to the detailed assessment of quality in motor performance made according to the CAMPB model. It cannot be predicted whether these children will continue to have deviant motor performance.

The combined assessment of different functions will provide an opportunity among 3-year old children to identify those who show deviations in one or more areas, thereby disclosing combined dysfunctions.

Four boys and one girl (7%) were identified as having motor and/or perceptual dysfunction in combination with a deficit in attention according to our assessment. Despite the difficulty in making comparisons, due to differences in assessment techniques and in the children's age at the assessment, it may be said that the results obtained with our model are similar to those of other studies in which many different functions have been assessed. In a population study, Köhler et al (33) found that 2% of 4-year-old children exhibited general clumsiness in combination with excessive mobility and a short attention span (MBD). Gillberg et al (19) estimated from their study that the frequency of motor-perceptual dysfunction combined with attentional deficits (MBD) was 7% in a total population. Additionally, an overrepresentation of combined problems in boys was also observed in their study.

To conclude, the use of our CAMPB model, combining a detailed assessment of motor performance and behaviour, was found to be feasible in 3-year-old children. The different parts of the assessment provided in a protocol (A-E) were sensitive enough to differentiate between the children of the present study. With the use of this assessment model in this study of 72 neonatally healthy children at the age of 3 years, only 7% of the children were identified as having deviations in their motor function and/or perceptual ability combined with a deficit in attention, a figure in accordance with the prevalence of MBD found at 6 years of age (19). In the majority of the children the observed motor performance corresponded to the descriptions in the protocol (A), as the total number of clear deviations was small (Figs. 2 and 3). The children in this study will be followed up together with children who needed neonatal intensive care, born at and before term. The predictive value of the different assessments included in the new model can be estimated in comparison with data from studies at a younger and/or older age.

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APPENDIX I
DETAILED ASSESSMENT OF GROSS AND FINE MOTOR PERFORMANCE

Optimal performance in four gross motor and four fine motor functions is described below. If a child's observed performance does not correspond to these descriptions the deviation is coded as to degree (suspected or clear deviation) and type according to the predescribed list of deviations.

GROSS MOTOR FUNCTION

1. Sitting. The child sits on a chair in front of a table when performing fine motor activity.
Head: The head is held in alignment with the trunk or with the neck slightly flexed.

Trunk: The trunk is symmetrically extended and steady. The child is able to correct his position in order to fullfil the requirement. No support from the back of the chair or from the table is needed.
Shoulders: The shoulders are relaxed without protraction or retraction. The arms need no support from the trunk or the table.
2. Standing. The child is asked to stand facing the examiner with the arms supinated and stretched forward with the hands open. He has to maintain this position for at least 10 seconds in order to receive a large, soft toy dog.
Head: The head is held in alignment with the trunk.
Trunk-pelvis: The trunk is held symmetrically with the spine extended. The pelvis is tilted slightly forward.
Shoulders: The arms are flexed at 90 degrees and extended from the trunk. Slight abduction (less than 45 degrees) or slight adduction (the hands are not allowed to touch each other) is allowed. The shoulders are held without any protraction or retraction.
Elbows: The elbows are symmetrically extended or slightly flexed (less than 45 degrees).
Hands: The hands are open and supinated with the wrists in alignment with the forearm.
Hips: The hips are extended with no or slight abduction (less than the shoulder width) and without any rotation.
Knees: The knees are extended with no or slight valgus.
Feet: The child stands without any or with slight external rotation (less than a half foot width) of the feet. The weight is evenly distributed on the feet and slight valgus is allowed.
3. Walking. The child is observed while walking freely without any requests.
Head: The head is held in alignment with the trunk.
Trunk-pelvis: The trunk is symmetrically extended and shows slight diagonal rotation. The pelvis is not tilted towards either side, or backward or markedly forward.
Shoulders: There are slight reciprocal arm movements, i.e. the right arm swings forward with the left leg and vice versa. The arms are held close to the trunk without any protraction or retraction in the shoulders.
Elbows: The elbows are extended or flexed less than 90 degrees.
Hands: The wrists are in mid-position, with the hands open and the fingers slightly flexed.
Hips: The hips show reciprocal flexion and extension without marked abduction or adduction, or internal or external rotation.
Knees: Reciprocal flexion and extension of the knees.
Feet: 'Heel-toe gait' with even weight distribution on the foot. The foot is held in midline or slightly externally rotated (less than a half width of the foot). The footsteps are well entrained (equal in width and length).
4. Running. The child runs with equal and reciprocal movements. Only one foot at a time is on the floor, with a brief flight phase in each step.
Head: The head is held in alignment with the trunk.
Trunk-pelvis: The trunk is extended symmetrically and shows slight diagonal rotation.
Shoulders: Reciprocal arm movements, i.e. the right arm swings forwards simultaneously with the left leg and vice versa. The arms swing without abduction, protraction or retraction in the shoulders.
Elbows: The elbows are incompletely flexed.
Hands: The wrists are in mid-position with open or slightly fisted hands (no marked extension or flexion of the fingers).
Hips: Reciprocal flexion and extension in the hips.
Knees: Reciprocal flexion and extension in the knees.
Feet: The weight is taken on the whole foot or on the foot-pad without a splash. The steps are well entrained (equal in breadth and length).

FINE MOTOR FUNCTION

The fine motor performance is assessed by observing function requiring different grasps and one-handed as well as two-handed object manipulation. Both the active and the passive hand are observed.

1. Inserting beads into a tube. The child's ability for two-handed object manipulation with complementary roles of the hands is assessed while he inserts small beads into a plastic tube (30 cm in length, firm at both ends with a bendable part of 10 cm in the middle and 1.5 cm in diameter). At least 10 beads are to be inserted into the tube with each hand.

Active hand: The hand grasps a bead with a pincer grasp and puts it into the tube without any tremor or dysmetria. The bead is grasped between the tip of the flexed thumb and the tip of the flexed index or middle finger. The hand needs no support from the trunk or the table.

Passive hand: The tube is held by the hand with the wrist in mid-position or pronated (less than 90 degrees). The tube is held steadily and adjusted so that the beads can easily be put inside. The hand needs no support from the trunk or the table.

2. Tower-building. The fine motor performance is assessed while the child builds a tower with 12 cubes, each side measuring 2.5 cm.

Active hand: Radial grasp with the thumb on one side of the cube and the two radial fingers in opposition, without using the palm and without marked pronation of the wrist. The grasp and the release are performed with accurate direction and force. The fingers are extended just enough to easily grasp or release a cube.

Passive hand: The hand is relaxed and ready to co-operate without any associated movements.

3. Pouring water. The fine motor performance is assessed while the child pours water from a plastic jug into a glass. The jug contains enough water to overfill a glass.

Active hand: The hand can hold the jug steadily and pours without spilling or overfilling the glass.

Passive hand: The hand may support itself against the table, may support the glass or the jug, or be passive but without any associated movements.

4. Drawing. The most developed pencil grasp is noted if the child changes the grasp. The pencil is held with accurate force and handled easily and steadily.

Active hand; type of pencil grasp:

1. Pronated or supinated palmar grasp.
2. Pronated palmar grasp with stabilising index finger.
3. Pronated digital grasp with the pencil held between the thumb and the rest of the fingers without support of the palm.
4. Supinated digital grasp with the pencil held between the thumb and the rest of the fingers without support of the palm.
5. Cross thumb grasp. The fingers are flexed into the palm. The pencil is held with the extended thumb opposed to the radial side of the flexed index finger. The movements are seen mainly in the shoulder and elbow.
6. Static tripod position with unsupported hand. The pencil is held between the thumb, index and middle finger with the flexed thumb opposed to the radial fingers. The forearm is not supported by the table and the movements are seen mostly in the shoulder and/or the elbow.
7. Static tripod position with supported hand. The pencil is held as under point 6 but the forearm is supported by the table. The movements are seen mostly in the elbow and wrist.
8. Dynamic tripod. The pencil is held between the thumb and the index and middle finger at the tip of the pencil. The drawing movements are seen mostly in the wrist and fingers.

Passive hand: The hands are co-ordinated with each other in such a way that the passive hand stabilises the paper while the other hand is drawing, without any associated movements in the passive hand.

In the fine motor task number 1, the child had to perform the task with either hand as the active and passive hand. In the other fine motor tasks numbers 2-4 the child could choose which hand he would use as active.

Degree of deviations
No deviation
Suspected deviation
Clear deviation

Side differences
No difference between the sides
Right side deviates
Left side deviates
Both sides are deviating
Right side deviates more than left
Left side deviates more than right.

Type of deviation
Movements are sparse
Instability
Tremor
Lateral flexion
Rotation
Hyperextension
Extension
Flexion
Abduction
Adduction
Outward rotation
Inward rotation
Pelvis tilted forwards
Pelvis tilted backwards
No rotation in the trunk
Retraction of the shoulders
Protraction of the shoulders
Other co-movements than swinging of the arms
Varus position
Valgus position
Equino-varus position of the foot
Adductus position of the foot
Plantar flexion of the foot
Stands on tip-toes
Walks on tip-toes
Deviant weight bearing
Incomplete heel-toe gait
Limps
Irregular footsteps in breadth and/or length
Inadequate strength of foot-strikes
The trunk is supported by the table
Inadequate posture of the trunk
The trunk is supported by the back of the chair

Type of deviation
The arm is supported by the trunk
The arm is supported by the table
Dorsal flexion of the wrist
Volar flexion of the wrist
Pronated hand
Supinated hand
Sprawled fingers
Fisted hand
Adducted thumb
Associated movements in the hand
Dysmetria
Inadequate strength in the hand
Deviant pencil grasp
Difficulty in directing the pen
Inadequate grasp
Palmar grasp
Finger grasp
Dysfunction in co-ordination of the hands
The glass overfills
Pours beside the glass
Hypertonus
Hypotonus
Mixed hyper- and hypotonus
Dysfunction in co-ordination (gross motor)
Delayed motor development
Associated movements in the mouth
Asymmetrical facial expressions
Dribbles
Dysfunction in co-ordination of the motor function of the mouth
Hypotonus in the muscles of the mouth
Dysfunction in eye co-ordination
Irregular breathing during activity

Additional observations:

Hand preference. Hand preference is observed separately while drawing and during the other fine motor activities (tower-building and pouring water).

1. Clear right-hand preference. 2. Clear left-hand preference.
3. Uncertain right-hand preference. 4. Uncertain left-hand preference.
5. Ambidexterity.

Uncertain preference means that the child has changed once or twice from the preferred hand.

Eye preference. The child is asked to look at least three times into a box, into which he can only look with one eye at a time. The examiner holds the box.

1. Clear right-eye preference. 2. Clear left-eye preference. 3. No clear eye preference.

Co-ordination of mouth motor activity. The child's ability to change between drinking and blowing water through a straw is assessed.

1. The child can change between drinking and blowing through a straw without dripping water from the mouth or giving a slight cough.
2. The child can drink and blow through a straw but gives a slight cough.
3. The child can drink and blow through a straw but spills water or blows outside the straw.
4. The child can drink but not blow through a straw.
5. The child can drink but not blow through a straw and gives a slight cough.
6. The child can drink but not blow through a straw and spills water.
7. The child cannot drink through a straw but can blow through it.
8. The child cannot drink or blow through a straw.

APPENDIX II
ASSESSMENT OF CO-ORDINATION
The categories of co-ordination

1. The child moves with confidence in the assessment room. He is able to carry out both the exact fine and gross motor, goal-directed movements required by the tasks requested of him. The child is able to stabilise his body in different positions to make these movements possible. He realises the position of his body in space and adjusts his movements according to visual input. The child also adjusts his pace of movement to his own ability and the requirements of the test situation.
2. The child moves as in category 1 but shows hesitancy throughout the assessment regarding the tasks requested. He adjusts his pace of movement to his own ability. The child therefore does not always succeed without showing associated movements and may stumble and fall occasionally.
3. The child moves as in category 1 and shows no hesitancy for the tasks requested, but tries too difficult tasks and does not always take the time to adjust his pace of movement. The child may therefore stumble and fall occasionally.
4. The child is able to carry out goal-directed movements, but sometime without proper precision and adjusted muscular force. He does not always have sufficient ability to stabilise his body and now and then shows extreme reactions in an attempt to maintain balance and may occasionally fall. The child shows an increased degree of associated movements, but often without specific side differences. These problems appear more often when the difficulty of the tasks is increased.
5. The child moves as in category 4, but the problems are more pronounced and are also evident in easier tasks. Associated movements are obvious and often asymmetrical e.g. sprawling fingers, fisted hand, tip-toeing and retracted arms. The child may also show tremor or instability.

6. The child moves as in category 4, but cannot or does not always have time to adjust his movements according to his visual input. The child may, for example, stumble, fall, step right out into the air or bump his head.
7. The child performs as in category 5, but has the same problems as in category 6.
8. The child cannot carry out the tasks or has great difficulty in doing so because of a definite motor impairment.
9. The child's ability to co-ordinate is difficult to decide for other reasons, e.g. deviant behaviour (for example anxiety, fearfulness, refusal and/or resistance) or his performance does not fit into any of the above categories.

APPENDIX III
ASSESSMENT OF ATTENTION
The categories of attention

1. The child has his attention focused on the examiner and is at the same time aware of his environment. The child reacts to irrelevant stimuli but adheres to his task. He examines the test objects and shows obvious interest. The child is able to complete his tasks and is attentive to the offer of a new task.
2. The child behaves as in category 1, but owing to the child's own will-power it can be difficult to carry out the assessment. The child can, however, be persuaded to complete the tasks.
3. The child behaves as in category 1, but is disturbed by his own shyness and/or anxiety. The child takes notice of changes in the room and needs support and encouragement to complete his tasks.
4. The child has his attention focused on the examiner and is at the same time aware of his environment. The child is not distracted by irrelevant stimuli but owing to high motor activity and a short attention span he may have difficulties in completing the tasks and being attentive to the offer of a new task. But with support by the examiner the child is able to complete his tasks and can show noticeable interest.
5. The child mostly has his attention focused on the examiner and is mostly aware of his environment. Now and then, however, he may be distracted by irrelevant stimuli. But he can easily be persuaded by the examiner to adhere to his task. The child examines the test objects with noticeable interest. After encouragement he is able to complete his tasks and is attentive to the offer of a new task.
6. The child has difficulties in focusing his attention on the examiner. He is distracted by his own impulses and by irrelevant stimuli, but can adhere to his task after encouragement by the examiner. The child examines the test objects. He completes the tasks with a short attention span and is not always attentive to the offer of a new task. However, the assessment can be carried out.
7. The child has difficulties in focusing his attention on the examiner and is constantly distracted by his own impulses and by irrelevant stimuli. He has difficulties in completing the tasks even when support and encouragement are given by the examiner. The child does not react to the offer of a new task. It is difficult to carry out the assessment.
8. The child's attentional behaviour may be difficult to determine on account of an impairment of vision, hearing and/or a motor function. Children with mental retardation or clearly deviant social behaviour can be placed in this category, but as far as possible the child should be placed in one of the categories described above.

APPENDIX IV
ASSESSMENT OF SOCIAL BEHAVIOUR
The categories of social behaviour

1. Interested, agrees with proposals, no stimulation needed, facial expression alert.
2. Interested, agrees with proposals. Stimulation, direction or support is needed. Facial expression alert.
3. Disinterested, but agrees with proposals. No particular encouragement needed, but not facially alert.
4. Reluctant, needs encouragement, appears anxious, tense facial expression.
5. Reluctant, needs encouragement, appears sullen, withdrawn.
6. Shrinks back on approach, refuses to fulfil demands, appears frightened.
7. Refuses to fulfil demands, appears impassive.
8. Resists by pushing the examiner away, tries to get away, struggles.
9. Other (e.g. hyperactivity, aggressiveness).