IMPROVEMENT OF FUNCTIONAL SITTING POSITION FOR CHILDREN WITH CEREBRAL PALSY

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Children with cerebral palsy (CP) are encouraged to take an active part in daily life, while spending a major portion of their time sitting in various types of chairs. This requires that the chairs and positioning be arranged to ensure optimal functional sitting—a position in which postural control is such that the child can obtain the maximum degree of independent function when moving the arms and hands.

These children are generally affected by spasticity and persisting tonic reflexes. In contrast to this hypertonicity, there is often hypotonus of the trunk (Trefler *et al.* 1978, Bobath 1980, Levitt 1982, Wilson 1984, Bergen and Colangelo 1985, Shumway 1986). Children sitting with the trunk and head flopped forward usually are unable to correct themselves because they lack righting or equilibrium reactions (Levitt 1982). The children are often secured to their chairs by means of neck supports and straps of various sorts, with seats and backrests in a reclining position; even if the recommendation is for backrests to be reclined only when absolutely necessary (Trefler *et al.* 1978). However, in this seemingly stable position, hypotonus of the trunk is frequently replaced by hypertonus and tonic reflexes, particularly tonic labyrinthine reflexes when the child sits with the head against the neck support, or asymmetrical tonic neck reflex when the child tries to turn the head to one side. In such a position, also, they must struggle against gravity to raise their heads, which also increases abnormal tone (Trefler *et al.* 1978).

Is is possible instead to exploit gravitational forces in a beneficial way, by finding a position that enhances postural control? And if so, what ingredients must be included in this position?

In inhibiting spasticity in children with CP, it was long thought that the angles of hip and knee flexion were decisive. This was questioned by Nwaobi and co-workers (Nwaobi *et al.* 1983; Nwaobi 1986, 1987), who showed that body orientation relative to gravity played as great or greater a role in controlling muscle hyperactivity as the angle of hip flexion. They found that pathological tonic muscle activity in back extensors and adductors was lower in an upright position than in a reclining sitting position.

When a person is seated, the lumbar lordosis is flattened (Schoberth 1962) and weight-bearing is mostly on the ischial tuberosities and surrounding soft tissue (Åkerblom 1948, Pheasant 1986, McClenaghan 1989). In an upright sitting position, the gravity line is above the ischial tuberosities (Åkerblom 1948, Andersson 1974). The ischial tuberosities act as a fulcrum (Åkerblom 1948, Pheasant 1986) and the location of the

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line of gravity in relation to the ischial tuberosities is an important factor in evaluating the muscular effort necessary to maintain equilibrium (McClenaghan 1989).

When a person sits with a forward-tipped pelvis and a straight back, with the line of gravity located anterior to the ischial tuberosities, the posterior muscles of the back contract to counteract the effect of gravity on the trunk (Andersson *et al.* 1974).

The forward-leaning position should aid upright balance of a hypotonic trunk, provided the pelvis is tipped forward and the back kept straight. Tipping the seat forward facilitates anterior tilting of the pelvis and prevents the pelvis from sliding backward (Mandal 1981, 1984; Frey and Tecklin 1986).

Another factor in creating functional sitting is the symmetrical distribution of weight on the ischial tuberosities. On sitting down, main rotation of the pelvis does not occur until the buttocks rest on the seat of the chair (Åkerblim 1948). Symmetrical weight distribution is accomplished by fixation with a hip-belt (Trefler *et al.* 1978, Bergen and Colangelo 1985, Liston 1986, Mulcahy and Pountney 1986) and by the use of an abduction orthosis (Fig. 1) (Odeén 1986, Myhr and von Wendt 1990).

The main purpose of this study was to find a functional sitting position for children with CP. Our hypothesis was that the position of the upper half of the body (head, trunk and upper extremities) anterior to the fulcrum at the ischial tuberosities is important for postural control, defined as attainment of postural alignment of head and trunk against gravitational forces and adjustment of parts of the body in relation to each other.

We designed a functional sitting position which incorporates these essential factors, and we compared this position with the children's original sitting positions and various experimental positions. Each position was evaluated by observation techniques especially designed for this study.

The second purpose of the study was to test the reliability of the techniques used, so the techniques were used by two physiotherapists with considerable experience of children with cerebral palsy. In the absence of an accepted standard, validation of the method had to be by interrater reliability.

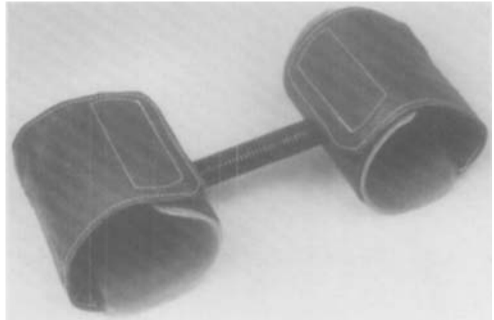

Fig. 1. Abduction orthosis.

TABLE I
Main clinical characteristics of 23 children with cerebral palsy

Diagnosis	*N*	*Severity*	*N*
Spastic diplegia	15	Mild	3
		Moderate	5
		Severe	7
Spastic tetraplegia	3	Mild	
		Moderate	
		Severe	3
Dystonic syndrome	5	Mild	
		Moderate	
		Severe	5

Subjects

Twenty-three children (eight female, 15 male), all treated and followed by the paediatric rehabilitation unit in the county of Norrbotten, Sweden, were enrolled in the study. A prerequisite for referral was that the treating physiotherapists deemed the child's seating arrangement to be unsatisfactory, despite extensive attempts at intervention. At the time of the study the mean age of the children was eight years (range 2·6 to 16·2). Informed parental consent was obtained.

Diagnosis and severity of the children's CP are shown in Table I. Six children also had visual impairments and two had hearing impairments. Five children could communicate verbally, another five used Bliss symbol language and one child communicated by manual signs.

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Fig. 2. Typical examples of four groups of chairs listed in Table II. (Left to right) (above) *'Maxit,' 'Hea-Koj';* (below) *'Rida', 'Akema'.*

TABLE II
Sitting positions studied

1. Original position	Children seated in their usual adapted chair
2.	As 1, plus cut-out, level table in front of child*
3.	As 6, minus abduction orthosis and table
4.	As 1, plus abduction orthosis**
5.	As 6, minus table
6. Functional sitting position	11 children under seven years sat in a 'Maxit' chair†; 12 children over seven sat in a 'Real' chair‡

*For children with a shell in position 1, shell was removed when table was added.
**For children using chairs of the 'Rida' category, abduction orthosis was not possible when sitting on saddle-type seat.
†Figure 2.
‡Figure 4.

The hips were dislocated in 12 children, two of whom had anterior dislocation of their abducted hips. Four children had developed windblown hip syndrome. The youngest child had bilateral pes equinovarus. Only one child was able to walk independently.

Method

The children were filmed and photographed individually in six positions (Table II). In position 1, their original position, they were seated in their own chair, usually one of nine commonly used adapted chairs (Table III, Fig. 2). The seat-surface and the backrest inclinations were the child's usual ones (Table III, Fig. 3).

In position 6, the functional sitting position (Table II), the seat sloped forward relative to the horizontal plane for all but two children (mean 8°, range 0° to 15°). They sat leaning forward, so that only the pelvis was supported by the backrest. They were symmetrically fastened to the chair by a hip-belt, attached at a 45° angle to and secured under the seat. No other straps were used, but an abduction orthosis and foot-rests were obligatory. The foot-rests were arranged so as not to hinder backward movement of the feet. The children were supported by a cut-out, level table. The line of gravity of the childrens' trunks was anterior to the fulcrum at the ischial tuberosities (Fig. 4).

In order to make it possible to calculate

Fig. 3. Sitting in original position, in own adapted 'Relax' chair. Line of gravity (arrow) *is posterior to fulcrum at ischial tuberosities* (circle). *Postural control and arm and hand function were worst on this position and pathological movements (asymmetric tonic neck reflex) were most frequent.*

Fig. 4. Same girl in functional sitting position in 'Real' chair, with line of gravity (arrow) *anterior to ischial tuberosities* (circle). *Asymmetric tonic neck reflex is inhibited and postural control enhanced, so she is able to use arms and hands to learn computer programme.*

TABLE III
Characteristics of original position, children seated in their own adapted chair (N = 23)

Child	*Category of chair*†				*Neck support*	*Shell or safety belt in front of trunk*	*Adductor wedge*	*Foot support*	*Back inclination*	*Seat inclination*
	'Maxit' 'Real'	*'Hea Koj' Moulded seat*	*'Rida' 'ITM'*	*'Relax' 'Comfort' 'Akema'*						
1	X				X	X	X	X	90°	−15°
2	X					X	X	X	90°	−20°
3			X			X	X*	X	90°	−10°
4		X			X	X	X		120°	−15°
5			X			X	X*	X	90°	0°
6				X	X	X	X	X	105°	−10°
7	X				X	X	X		90°	−5°
8		X				X	X	X	120°	0°
9		X			X	X	X		105°	−5°
10		X			X	X	X		100°	−5°
11	X					X			90°	−15°
12	X				X	X	X	X	100°	0°
13				X	X	X	X	X	105°	−20°
14	X						X	X	90°	−5°
15				X		X		X	95°	0°
16	X					X	X	X	90°	0°
17				X	X	X	X	X	120°	−15°
18		X			X	X	X	X	130°	−30°
19			X			X	X*	X	90°	0°
20	X					X		X	90°	0°
21		X			X	X	X		110°	−10°
22	X					X		X	105°	0°
23				X		X		X	105°	0°
	9	6	3	5	11	22	17	17	mean 101° (range 90°-130°)	mean 8° (range 0°- −30°)

*Children seated on saddle-type seat.
†See Figures 2, 3 and 4.

angles on photographs, anatomical landmarks were marked on the children with pieces of adhesive paper. These were placed as follows: (1) in front of the ear; (2) at the centre of the palpable part of the humeral head; (3) on the lateral humeral epicondyle; (4) on the ulnar styloid process; (5) on the greater trochanter, used as an approximate marking point for the fulcrum at the ischial tuberosities; (6) on the convexity of the lateral epicondyle of the femur; and (7) on the lateral malleolus.

Where possible, a specially constructed Plexiglas side-panel and arm-support were used to facilitate observation of the marking on the greater trochanter. Where this was not possible, the marking was placed on the outside of the side-panel at a level corresponding to the greater trochanter.

The sitting positions were documented and analysed as follows:

WRITTEN DOCUMENTATION. Notes on the six different seating positions were made on a sheet prepared especially for this assessment.

PHOTOGRAPHY. Photographs were taken during each of the six video-filmed positions. One of the authors (U.M.) photographed situations in which the children's trunks were positioned in front of and behind the marking point for the fulcrum at the ischial tuberosities. A Hasselblad 6×6cm camera and TRI-X 400 ASA film were used. The distance between the centre of the camera and the centre of the child's chair was 3·8m. Crosses marked on the floor were used to indicate the centre of the table, camera and chair. The camera stood at right-angles to the child's position, facing forward.

VIDEO-RECORDING. Each of the six positions was video-filmed for five minutes in constant external surroundings. The filming order for positions 1 to 6 was decided by lottery, and varied for each child. A teacher or parent sat in front of the child and encouraged the child to: hold up the head; turn the head to one side; reach out to grasp, hold and release a familiar toy or object; and in positions in which the table was used (2 and 6), to support him/herself with forearms or hands against the table and perform the above simple operations.

Data analysis

Four different observation techniques were used, three for analysing the video-films and one for analysing and assessing the photographs.

The techniques for analysis of the video-films were as follows:

(A) Recording the duration of head control in the two positions with a table in front of the child (2 and 6). Head control in these positions involved the ability to maintain equilibrium by holding the head in an upright position within its base of support, with or without forearm support against the table. When head control was lost, help to adjust position was given from the person in front of the child. The stopwatch was stopped at these moments and was started again when the child regained head control. Total time in seconds for each five-minute period was determined. Times for head control in the two different positions were compared.

(B) Identifying and counting a typical pathological movement (a spastic or tonic reflex pattern), which each child exhibited in each position. The pathological movements counted were: stretching the legs in a pattern of extension spasticity (N = 12); drawing up the knees in a pattern of flexion spasticity (N = 4); pressing the neck and/or back against the neck or back support, as a result of the tonic labyrinthine reflex (N = 6); and triggering the asymmetric tonic neck reflex when turning the head (N = 1).

(C) Postural control (head, trunk and foot control) and arm and hand function were assessed with a specially designed four-point rating scale, called the Sitting Assessment Scale, in all six video-filmed positions (Table IV).

The method for analysing the photographs was assessment of the orientation of the upper half of the child's body relative to the fulcrum at the ischial tuberosities in the different positions. Transparent film was placed over the photographs and lines were drawn between the anatomical landmarks (see Myhr and von Wendt 1990). In addition, the fulcrum was determined on the photograph by means of a line drawn vertically through the landmark at the greater trochanter (see Figs. 3 and 4). The line of gravity for the upper half of the body was approximated, and the child's body orientation relative to the fulcrum in the different positions was compared with positions in which postural control was best and pathological movements least. Finally, the seat and back inclinations were measured on the photographs, using a goniometer.

Reliability
Two physiotherapists unknown to the children in the study spent 10 hours during the consecutive days learning the techniques used. They were instructed by one of the authors (U.M.) and provided with written copies of general rules for the procedure and lists of the Sitting Assessment Scale. For training purposes, they were provided with video-films of four children, randomly selected from those in the study.

For the final assessment they were given randomly chosen video-films of five children for independent study. For each child, a typical pathological movement to be evaluated was indicated in the testers' instructions. Analysis of the first two children's video-films was by technique A, followed by C and B. For the next two children the order was A, B, C, and for the fifth it was C, A, B. Each rater was instructed to: view the video-films of each child, once, without making any evaluations; judge each child individually, in the order given; note their evaluation in each child's protocol; and evaluate one variable at a time for the Sitting Assessment Scale—head control first in all six positions, then trunk control in each position, *etc.*

The protocols were sent directly from the raters to the authors for computer analysis. Spearman rank correlation coefficients were used to evaluate interrater reliability for the two physiotherapists, as well as criterion validity as judged by correlations between the physiotherapists and the author.

Results

Evaluation of functional sitting
Postural control and arm and hand function were best and pathological movements least in the functional sitting position. The duration of postural control increased markedly in position 6 compared with original position 2 ($p = 0 \cdot 001$) (Table V). Pathological movements were significantly reduced when original position 1 was compared with position 6 (Table VI).

The functional aspects of the modified sitting positions were assessed by the Sitting Assessment Scale (see Table IV). In position 6, head control improved from 'none' (in the original position) to 'fair' for the whole group. Foot control improved from 'poor' in the original position to 'fair' in positions 5 and 6, as did trunk control (Table VII).

TABLE IV
Sitting Assessment Scale

Head control	
1. None:	unable to hold head erect, or needs neck support
2. Poor:	holds head erect for ≤2 minutes*—easily loses control
3. Fair:	holds head erect, but displaces with acceleration/rotation
4. Good:	holds head upright and able to rotate
Trunk control	
1. None:	lacks control of trunk or needs back support
2. Poor:	holds trunk erect only when supported by forearms or hands
3. Fair:	holds trunk erect supported by one forearm or hand, some degree of lateral flexion can occur
4. Good:	holds trunk erect with and without forearm or hand support, with pelvis supported or unsupported
Foot control	
1. None:	unable to hold feet against underlying surface without fixation
2. Poor:	holds feet against underlying surface ≤2 minutes*
3. Fair:	good control of one foot, poorer of other
4. Good:	holds feet against underlying surface for entire period
Arm function	
1. None:	unable to control arms by will
2. Poor:	uses arms for support, but easily loses control; stretches arms toward objects, but in uncontrolled movements
3. Fair:	uses one arm for support and stretches other toward objects intentionally
4. Good:	uses one or both arms for support, stretches arms toward objects intentionally or uses arms for functional movements
Hand function	
1. None:	unable to grasp objects, knocks object with one hand
2. Poor:	grasps and holds objects, but very uncontrolled movements
3. Fair:	good function in one hand, poorer in other
4. Good:	good function in both hands or able to consciously grasp, hold and release objects

*Accumulation duration, maximum two minutes out of five.

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TABLE V
Duration of head control for children sitting in original position with table and in functional sitting position (N=23)

	Duration (secs) of head control/5min periods					
Position	*Median*	*Mean*	*(SD)*	*Range*	*95% confidence intervals*	*p**
Original (2)	0	81	(113·7)	0–300	32–130	0·001
Functional (6)	129	156	(109·7)	0–300	109–204	—

*Wilcoxon matched-pairs signed-ranks test.

TABLE VI
Pathological movements in six different positions (N=23)

	N pathological movements/5min periods		
Position	*Median*	*Range*	*p**
1	24	1–111	0·000
2	13	0– 54	0·002
3	10	0– 85	0·008
4	13	0–110	0·006
5	9	0– 38	NS
6	6	0– 42	

*Wilcoxon matched-pairs signed ranks test: positions 1 to 5 compared with position 6.

TABLE VII
Median scores for head, trunk and foot control, and arm and hand function in six positions, using Sitting Assessment Scale* (N=23)

	Sitting position					
	1	*2*	*3*	*4*	*5*	*6*
Head control	1	1	2	1	2	3
Trunk control	1	1	1	1	2	2
Foot control	2	2	2	2	3	3
Arm function	2	2	2	2	2	3
Hand function	2	2	2	1	2	3
Total score	8***	9***	11***	8***	12**	14

*See Table IV for interpretation of scores. Total score: min. 5; max. 20.
**$p<0·001$. ***$p<0·001$, positions 1 to 5 compared with position 6 (Wilcoxon matched-pairs signed ranks test).

Arm function improved for 16 of the 23 children and hand function improved for eight children. No change was noted for the other children. For the whole group, arm function improved from 'poor' and hand function improved from 'none' or 'poor' in all other positions to 'fair' in position 6 (Table VII).

The median total score for postural control and arm and hand function improved from 8 in position 1 to 14 in position 6, the difference being highly statistically significant ($p<0·001$) (Wilcoxon matched-pairs signed ranks test) (Table VII).

Photographs revealed that the gravity line of the upper half of the body of all children was anterior to the fulcrum at the ischial tuberosities in position 6 (see Fig. 4).

Seat and backrest inclination were important. When the seat inclination was 10° forward (N=14) in position 6, mean pathological movements were six and the median for postural control and arm and hand function was 13. These values contrast with corresponding figures of 35 and five, respectively, for the group (N=8) with seat inclination backward −5° to −30° and backrest inclination backward 95° to 130° in the original position.

Interrater reliability

Interrater reliability for judging duration of head control was 0·90 for positions 2 and 6. Spearman rank correlation coefficient between the physiotherapists and the author was high for position 2 (0·90 and 1·0, respectively) and low for position 6 (0·31 and 0·46, respectively).

For counting pathological movements,

TABLE VIII

Interrater reliability between physiotherapists and author for counting pathological movements of five children (all positions counted together) and for six different positions (all children counted together)

	PT1-PT2**	*M**-PT1**	*M**-PT2**
	Spearman rank correlation coefficient		
Children			
1	0·97	0·87	0·94
2	0·96	0·90	0·99
3	0·90	0·88	0·89
4	0·41	0·81	0·75
5	1·0	0·98	0·98
Position			
1	0·98	0·98	1·0
2	1·0	0·82	0·82
3	0·98	0·98	0·95
4	0·80	0·90	0·50
5	0·82	0·95	0·67
6	0·72	0·87	0·76

*Physiotherapists 1 and 2; **author assessment.

TABLE IX

Interrater reliability—correlation coefficients for Sitting Assessment Scale (N = 5)

	PT1-PT2	*M-PT1*	*M-PT2*
	Spearman rank correlation coefficient		
Position			
1	0·98	1·0	0·98
2	1·0	1·0	1·0
3	0·98	0·95	0·98
4	0·80	1·0	1·0
5	0·82	1·0	1·0
6	0·98	0·98	0·90
Scale items			
Head control	0·98	0·98	0·98
Trunk control	0·90	0·90	0·70
Foot control	0·82	0·82	0·76
Arm function	0·87	0·87	0·95
Hand function	0·98	0·98	0·98

TABLE X

Interrater reliability. Average scores of Sitting Assessment Scale, comparison of physiotherapists' scoring with author's original assessment*

Child	*Rater*	*Positions* 1	2	3	4	5	6
Medians of head, trunk and foot control							
1	PT1	1·3	2·0	1·7	2·0	2·0	3·0
	PT2	1·6	1·7	2·0	2·0	2·3	3·0
	M	2·0	2·0	2·7	2·0	2·7	3·7
2	PT1	2·0	2·0	2·3	2·3	2·7	3·0
	PT2	2·0	2·3	2·3	3·0	2·7	2·7
	M	2·3	2·3	2·3	2·7	3·3	3·7
3	PT1	2·0	2·0	3·3	2·0	3·7	3·3
	PT2	2·7	2·3	4·0	2·3	4·0	3·7
	M	2·7	2·7	4·0	2·7	4·0	4·0
4	PT1	2·3	2·7	2·3	2·3	2·3	2·7
	PT2	2·7	3·3	2·3	2·7	2·3	2·7
	M	3·3	3·3	3·3	3·3	2·7	3·7
5	PT1	1·3	1·3	2·0	2·0	2·0	2·7
	PT2	1·7	1·7	2·0	2·0	2·0	2·3
	M	1·7	1·7	2·0	1·7	2·0	2·3
Medians of arm and hand function							
1	PT1	2·0	2·0	2·0	2·0	2·0	2·5
	PT2	1·5	1·5	1·5	1·5	1·5	2·5
	M	1·5	1·5	1·5	1·5	2·0	2·5
2	PT1	2·0	2·5	2·5	2·0	2·0	2·5
	PT2	2·0	2·5	2·5	2·5	1·5	2·5
	M	2·5	3·0	2·5	2·5	2·0	3·0
3	PT1	4·0	3·5	3·5	4·0	4·0	4·0
	PT2	4·0	4·0	4·0	4·0	4·0	4·0
	M	4·0	3·0	3·0	4·0	4·0	4·0
4	PT1	4·0	3·5	4·0	4·0	4·0	4·0
	PT2	4·0	4·0	4·0	4·0	4·0	4·0
	M	4·0	4·0	4·0	4·0	4·0	4·0
5	PT1	1·5	1·0	1·5	1·5	1·5	1·5
	PT2	1·0	1·0	1·0	1·0	1·0	1·0
	M	1·0	1·0	1·0	1·0	1·0	1·5
Median of all items (child 1 to 5)							
	PT1	2·0	2·2	2·4	2·2	2·4	2·8
	PT2	2·0	2·4	2·4	2·8	2·4	2·8
	M	2·4	2·6	2·4	2·6	3·0	3·4

*Five children in six positions were evaluated and 450 observations were assessed.

the correlation coefficient was between 0·87 and 1·0 for all raters for four of five children (Table VIII).

For the Sitting Assessment Scales, the Spearman rank correlation coefficient varied between 0·80 and 1·0; 14 of 18 correlations were between 0·98 and 1·0. Evaluation of scale items (head, trunk and foot control, and arm and hand function) yielded correlations of between 0·70 and 0·98, seven of 15 being ≥0·95 (Table IX). The evaluations made by the two physiotherapists further substantiated earlier results (Table X). The comparisons between the two physiotherapists and the author show that the criteria have validity (see Tables VIII to X).

Discussion

This study showed that children with cerebral palsy sat considerably better in the functional sitting position than they had in their original positions. The advantage of the forward-tipped seat was that, by tilting the pelvis forward, it moved the line of gravity anterior to the fulcrum at the ischial tuberosities (see Fig. 4). The extensor muscles of the back and neck contracted to counteract gravity, which in turn led to a better upright position for the child with CP and a hypotonic trunk. This agrees with previous findings concerning normal seating (Schoberth 1962, Andersson *et al.* 1974, Mandal 1981), that an upright sitting position is obtained by rotating the pelvis forward, thereby changing the lumbar spine toward lordosis and the line of gravity anterior to the ischial tuberosities.

The low backrest of the functional sitting position was superior to the original, since it permitted individual adjustment to support the pelvis. In addition to the hip-belt, this fixed the children in the intended position and prevented them from sliding (see Fig. 4). This position also enabled forward movements.

Our findings agree with previous observations that hip-belts placed as described above assist good pelvic positioning (Trefler *et al.* 1978, Bergen and Colangelo 1985, Liston 1986, Mulcahy and Pountney 1986). They are also in agreement with Bergen and Colangelo (1985) and Mulcahy and Pountney (1986), who found that a sacral pad maintains the pelvis in an anterior/neutral tilt, allowing the child to develop an upright sitting position. This position, which was further enhanced by the use of the abduction orthosis, gave symmetrical weight-bearing on the ischial tuberosities, probably preventing the development of hip luxation, pelvic obliquity and scoliosis (Letts *et al.* 1984).

The importance of a stable base for an optimal functional sitting position was obvious for three of the children sitting on a saddle-type seat designed to hold the legs in a position which inhibited spasticity. When they attempted to move, secured to their chairs as they were by belts over the lower abdomen and by ankle-straps to the footrests, the only possible result was opisthotonus-like movement, greatly increasing extension spasticity. These pathological patterns of movement were probably caused by the type of fixation used.

The forward-tipped seat necessitated a support in front of the child. Although there was very little difference between positions 5 and 6 (see Tables VI and VII), it was obvious that having a table in front of the child was an advantage, since it provided additional support: when sitting with the line of gravity anterior to the fulcrum and the arms on the table, weight was distributed through the arms. This support made head control, a necessary first step toward improved function, possible for the children with even the most severe forms of cerebral palsy. Furthermore, it was possible for the child to use one arm for movement while the other was used as a support. We agree with McClenaghan (1989) that this support could limit the use of the arms and hands for activities other than maintenance of stability. However, this might be overcome by the use of a chest-plate, anterior to the fulcrum, which would liberate the arms for voluntary activities not influenced by the tonic reflexes and spasticity characteristic of the reclining position.

To make functional sitting possible, appropriate adjustments to the footrests must be made. In this study the footrests were individually adjusted to permit the feet to slide backward, posterior to the knee joints, when the trunk moved forward. Conversely, in all of the children's original positions/chairs, straps at the back of the footrests prevented the feet from sliding back if the child leaned forward, preventing the child from tilting the pelvis forward. In addition, the footrests seemed to be placed too far anteriorly.

Although spasticity was not measured directly in the present study, the practical advantages of the functional sitting position can be interpreted at least partly as having a favourable effect on spastic movement patterns. In this position there seemed to be a stretch effect on the spastic muscles as soon as the pelvis was tilted forward. This could be in agreement with the argument about 'key points of control' (Bobath 1980): proximal points, from which one can influence postural tone and patterns of movement throughout the body, leave more distal parts free to move actively (Bryce 1976). However, this hypothesis needs to be proven by measurement of the myoelectric activity of the muscles involved.

There is a lack of validated measures

that are responsive to clinically functional changes in children with CP (Campbell 1985, 1987; Russell *et al.* 1989; Rosenbaum *et al.* 1990). The use of video-film and photography to collect information, and to analyse and assess sitting problems was very revealing. For example, small manifestations of 'lurking spasticity', not always noticed by an observer but visible on video-film, were revealed many times during the present study.

The observation techniques constructed for and used in this study were aimed at detecting change in children's sitting position before and after intervention. The two techniques—duration of head control and counting pathological movements—failed to measure arm and hand function. As a consequence, the Sitting Assessment Scale was developed, which included assessment of all previously described tonus problems, as well as control of the child's whole body, arm and hand function. The importance of observing the entire body simultaneously is supported by Stengel *et al.* (1984), who noted that an abnormal or compensatory component in one part of the body will disturb the quality of movement and control in another part.

Concerning validity and interrater reliability, independent results of the physiotherapists and the author show that the observation techniques were reliable and valid, except for duration of head control, when comparison between the physiotherapists' results and the author (as a 'gold standard') revealed a lack of validity. Definition of boundaries for head control was difficult, especially for the functional sitting position where the children also had to be able to look down at their hands on the table.

As a single, well-defined method, the Sitting Assessment Scale seems to fulfil the requirements for analysis and assessment of the sitting positions of children with CP. In addition, the scoring is simple enough to be learned with limited instruction.

Relatively simple adaptations of their traditional seating, taking into account basic biomechanical and neurophysiological factors, had a significant impact on the children's sitting position, and also on their ability to use their upper extremities for voluntary purposeful activities. The original position of many of the children reinforced pathological movements, which probably had serious effects on their potential for motor development. As an example, six children habitually pressed their head or back against the neck supports and backrests, as a result of the tonic labyrinthine reflex. Thus use of neck supports seemed to reinforce the reflex, even when sitting in upright positions. Sitting for just one day in such a position can tremendously reinforce pathological movements.

To maintain postural control over a period of time, the position of the pelvis is an important factor to consider when adapting chairs for children with cerebral palsy. The location of the line of gravity above the supporting surface and anterior to the fulcrum at the ischial tuberosities seems to be a prerequisite for a functional sitting position for these children.

Accepted for publication 21st August 1990.

Acknowledgements
We are grateful to the Norrbotten County Council, the Swedish Multiple Sclerosis Foundation, the First of May Flower Annual Campaign for Children's Health, the Joint Committee, North Health Region, University of Umeå, the Norrbacka-Eugenia Foundation, the Sven Jerring Foundation and the Folke Bernadotte Foundation for financial support.

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SUMMARY
Twenty-three children with cerebral palsy were photographed and video-filmed in six different sitting positions—including a hypothetical functional position—and the video-films and photographs were analysed. It was found that pathological movements were minimised and postural control and arm and hand function best when the child was sitting in a forward-tipped seat, with a firm backrest supporting the pelvis, arms supported against a table and feet permitted to move backward.

RÉSUMÉ
Vers une position assise fonctionnelle pour les enfants IMC
Vingt-trois enfants IMC ont été photographié et pris en vidéo dans six positions différentes—

incluant une position fonctionnelle hypothétique—et vidéos et photographies ont été analysées. Il a été observé que les mouvements anormaux étaient minimisés, le controle postural et les fonctions des mains et des bras optimisés, lorsque l'enfant était assis dans un siège incliné vers l'avant, un point d'appui ferme pour supporter le bassin, les bras supportés par une table et les pieds libres de se déplacer vers l'avant.

ZUSAMMENFASSUNG

Funktionelle Sitzposition bei Kindern mit Cerebralparese

23 Kinder mit Cerebralparese wurden in sechs verschiedenen Positionen photographiert und mit der Videokamera gefilmt—einschließlich einer hypothetischen funktionellen Position. Die Videofilme und Photographien wurden analysiert. Man fand heraus, daß die pathologischen Bewegungen abnahmen und die Haltungskontrolle und die Arm—und Handfunktion am besten waren, wenn das Kind in einem nach vorn geneigten Sitz saß, mit einer festen Rückenstütze zur Stützung des Beckens, die Arme gegen einen Tisch gestützt und mit rückwärtiger Bewegungsfreiheit der Füße.

RESUMEN

Hacia una sedestación funcional en niños con parálisis cerebral

Veintitrés niños con parálisis cerebral fueron fotografiados y videofilmados en seis posiciones diferentes, incluyendo una hipotética posicion funcional, analizándose las imagenes obtenidas. Se halló que los movimientos patológicos se minimizaban y que el control postural y la funcion del brazo y la mano mejoraban cuando el niño estaba sentado en un asiento inclinado hacia adelante, con un firme soporte dorsal para descansar la pelvis, los brazos apoyados sobre una mesa y con los pies pudiéndose mover hacia atrás.

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