Article

CLINICAL REHABILITATION

Clinical Rehabilitation
1–8

DOI: 10.1177/0269215515593612
cre.sagepub.com
SAGE

Psychometric evaluation of the Posture and Postural Ability Scale for children with cerebral palsy

Elisabet Rodby-Bousquet[1,2], Måns Persson-Bunke[2] and Tomasz Czuba[3]

Abstract

Objective: To evaluate construct validity, internal consistency and inter-rater reliability of the Posture and Postural Ability Scale for children with cerebral palsy.

Design: Evaluation of psychometric properties.

Setting: Five child rehabilitation centres in the south of Sweden, in November 2013 to March 2014.

Subjects: A total of 29 children with cerebral palsy (15 boys, 14 girls), 6–16 years old, classified at Gross Motor Function Classification System (GMFCS) levels II ($n = 10$), III ($n = 7$), IV ($n = 6$) and V ($n = 6$).

Main measures: Three independent raters (two physiotherapists and one orthopaedic surgeon) assessed posture and postural ability of all children in supine, prone, sitting and standing positions, according to the Posture and Postural Ability Scale. Construct validity was evaluated based on averaged values for the raters relative to known-groups in terms of GMFCS levels. Internal consistency was analysed with Cronbach's alpha and corrected Item–Total correlation. Inter-rater reliability was calculated using weighted kappa scores.

Results: The Posture and Postural Ability Scale showed construct validity and median values differed between GMFCS levels ($p < 0.01$). There was a good internal consistency (alpha = 0.95–0.96; item–total correlation = 0.55–0.91), and an excellent inter-rater reliability (kappa score = 0.77–0.99).

Conclusion: The Posture and Postural Ability Scale shows high psychometric properties for children with cerebral palsy, as previously seen when evaluated for adults. It enables detection of postural deficits and asymmetries indicating potential need for support and where it needs to be applied.

Keywords

Posture and Postural Ability Scale, posture, postural control, cerebral palsy, reliability, validity, psychometric evaluation

Received: 21 March 2015; accepted: 7 June 2015

[1]Centre for Clinical Research, Uppsala University, County Hospital, Västerås, Sweden
[2]Department of Clinical Sciences, Lund University, Lund, Sweden
[3]National Musculoskeletal Competence Centre for Quality Registers, Lund University, Lund, Sweden

Corresponding author:
Elisabet Rodby-Bousquet, Centre for Clinical Research, Uppsala University, County Hospital, SE-721 89 Västerås, Sweden.
Email: elisabet.rodby_bousquet@med.lu.se

Introduction

Asymmetric postures can cause contractures, bone and joint deformities in immobile children with cerebral palsy.[1–4] Most of these deformities can be prevented via active surveillance and therefore identification of asymmetries and postural deficits should be used to screen for contractures.[5–9]

The Posture and Postural Ability Scale (PPAS)[10] is the only clinical assessment tool designed to assess 'quality' and 'quantity' of posture separately, in the four basic body positions: supine, prone, sitting and standing. 'Quality' of posture, relates to the shape of the body, that is, the particular alignment of body segments in relation to each other and to the supporting surface. 'Quantity' refers to postural ability, that is, the ability to stabilize the body segments relative to each other and to the supporting surface. This means control of the centre of gravity relative to the base of support during both static and dynamic conditions.[11,12] The levels of postural ability are based on the original work by Noreen Hare[13] to assess children and adolescents with severe motor impairments and scoliosis. Her Physical ability scale has been evaluated for inter-rater and intra-rater reliability in children.[13] The levels are also based on the related Chailey levels of abilities[14] evaluated for validity in children with cerebral palsy.[15] Pauline Pope modified these scales and added items for quality of posture for use with people with disabilities regardless of age and diagnosis. All three scales have been used by trained therapists in England since the 1990s. In 2011, Pope and colleagues in Iceland and Sweden expanded and revised the assessment tool into the PPAS. It has shown excellent inter-rater reliability (kappa 0.85–0.99), high internal consistency (alpha 0.96–0.97) and construct validity ($p<0.02$) for adults with cerebral palsy when used by trained professionals, but it has not previously been evaluated for use with children or for less experienced raters. It is currently used in National follow-up programmes for adults with cerebral palsy in Sweden and Iceland.

The purpose of this study was to evaluate construct validity, internal consistency and inter-rater reliability of the PPAS for children with cerebral palsy.

Methods

Children between 6 and 16 years old who participated in the Swedish national cerebral palsy healthcare programme called CPUP,[5,16] were recruited from five child rehabilitation units in southern Sweden. Invitation letters and written information about the study was given to the families by their local physiotherapists. Written consent from all families who agreed to participate was sent to the Department of Orthopaedics at Lund University. Those who accepted were examined once during a period from November 2013 to March 2014. All children who participated had cerebral palsy verified by a neuropaediatrician, with a non-progressive brain injury before the age of 2 years, and motor impairment and specific neurological signs, defined by the inclusion criteria of the Surveillance of Cerebral Palsy in Europe (SCPE) network.[17]

Children were invited consecutively until at least six children at each level II–V of the Gross Motor Function Classification System (GMFCS)[18] had accepted. The classification has five levels based on self-initiated movement. The level of gross motor function was classified by each child's local physiotherapist. The selection of six subjects at each GMFCS level was based on a previous psychometric evaluation of the PPAS for use with adults.[10] In order to evaluate construct validity, we used known groups based on the GMFCS levels, assuming that posture is likely to be more asymmetric and postural ability more impaired in children at lower levels of motor function, such as GMFCS level IV and V. The study was approved by the Medical Research Ethics Committee at Lund University, number D467/2013.

The PPAS[10] is designed to assess postural control and asymmetries in people with severe disabilities in four basic body positions; supine and prone lying, sitting and standing. Quality of posture is rated for position of head, trunk, pelvis, legs, arms and weight distribution in the frontal plane, and the sagittal plane. Symmetry and alignment scores 1 point for each item, while asymmetry or deviation from midline scores 0 points. The total score varying from 0–6 points for each position in the frontal and the sagittal plane is calculated separately. Quantity is rated on an ordinal scale, where postural ability ranges from 'unplaceable in an aligned posture' (level 1), to 'placeable in an aligned posture but needs support' (level 2), 'able to maintain position when placed but cannot move' (level 3), 'able to initiate flexion/extension of trunk' (level 4), 'able to transfer weight laterally and regain posture' (level 5), 'able to move out of position' (level 6) and the highest level of ability 'able to move into and out of position' (level 7). It is important to note that levels 1 and 2 relate to the person with little or no postural ability. Thus it is possible to have a person with a high level of ability, that is, 'able to move into and out of position' who scores 0 for quality of posture owing to contracture, deformity or strategies used to gain stability.

All children were examined at their local child rehabilitation units on one occasion by three independent raters: two physiotherapists and one paediatric orthopaedic surgeon. All raters had many years of experience working with children with cerebral palsy, but only one of the physiotherapists had previous experience of the PPAS. The other two raters got brief instructions before assessing the children. The children were instructed by one of the physiotherapists to get into and out of supine, prone, sitting positions on a plinth and into and out of a standing position. If they were unable to do this by themselves, they were placed in the position and instructed or guided according to their cognitive abilities to maintain position, initiate flexion of the trunk (in supine) or extension (in prone), transfer weight laterally and regain position, and move out of position, according to the levels of the PPAS. If needed, children were provided with manual support to stay in position. The children were also instructed to sit, stand or lie down in prone or supine as straight as possible, or were placed as straight as possible in the specified position and allowed to settle. The experienced physiotherapist gave instructions and handled the children, and the other two raters observed. All three raters recorded their observations simultaneously and independently on separate scoring sheets. All assessments took less than 10 minutes to complete for each child.

Statistical analyses

Construct validity was evaluated for known-groups validity based on the GMFCS levels using Jonckheere-Terpstra for analysis of arithmetic average values given by the raters. Inter-rater reliability for three independent raters was calculated using weighted Kappa scores[19] with 95% non-parametric bootstrap confidence intervals calculated based on 1000 re-samples.[20,21] The levels of agreement were set to poor (⩽0.40), fair to good (0.40–0.75), and excellent agreement (⩾0.75).[22] The internal consistency was evaluated through Cronbach's alpha,[23] a measure of item inter-relatedness calculated with averaged values for the three raters, and corrected Item–total correlation,[24] indicating the correlation between each item and the total score. Cronbach's alpha, if item is deleted, corresponds to the value achieved if a specific item is removed and the level should exceed 0.2.[24] For all statistical computing an R software environment was used.

Results

In total 29 children with cerebral palsy (15 boys, 14 girls), born 1997–2007, median age 12 years (6–16 years) were assessed. Their gross motor function was classified as GMFCS levels II (n=10), III (n=7), IV (n=6) and V (n= 6).

Distribution of scores for all raters varied between each GMFCS level in all four positions (Figure 1). The median score was higher in supine or prone positions, which require less postural ability, compared with a sitting or standing position (Table 1). The PPAS showed construct validity based on the ability of the assessment tool to differ between known groups represented by GMFCS levels II–V, where children at GMFCS level II present higher scores than children with lower levels of motor function (Table 1, Figure 1). It could differ in postural ability between individuals at different levels of gross motor function and was able to identify postural asymmetries in children at all the GMFCS levels II–V. There were no differences in scores for posture and postural ability related to the age of the children.

The PPAS showed excellent inter-rater reliability for three independent raters with weighted Kappa values of 0.77–0.99 (95% CI 0.60–1.0) (Table 2). There was a high internal consistency for all items where Cronbach's alpha if item deleted ranged from

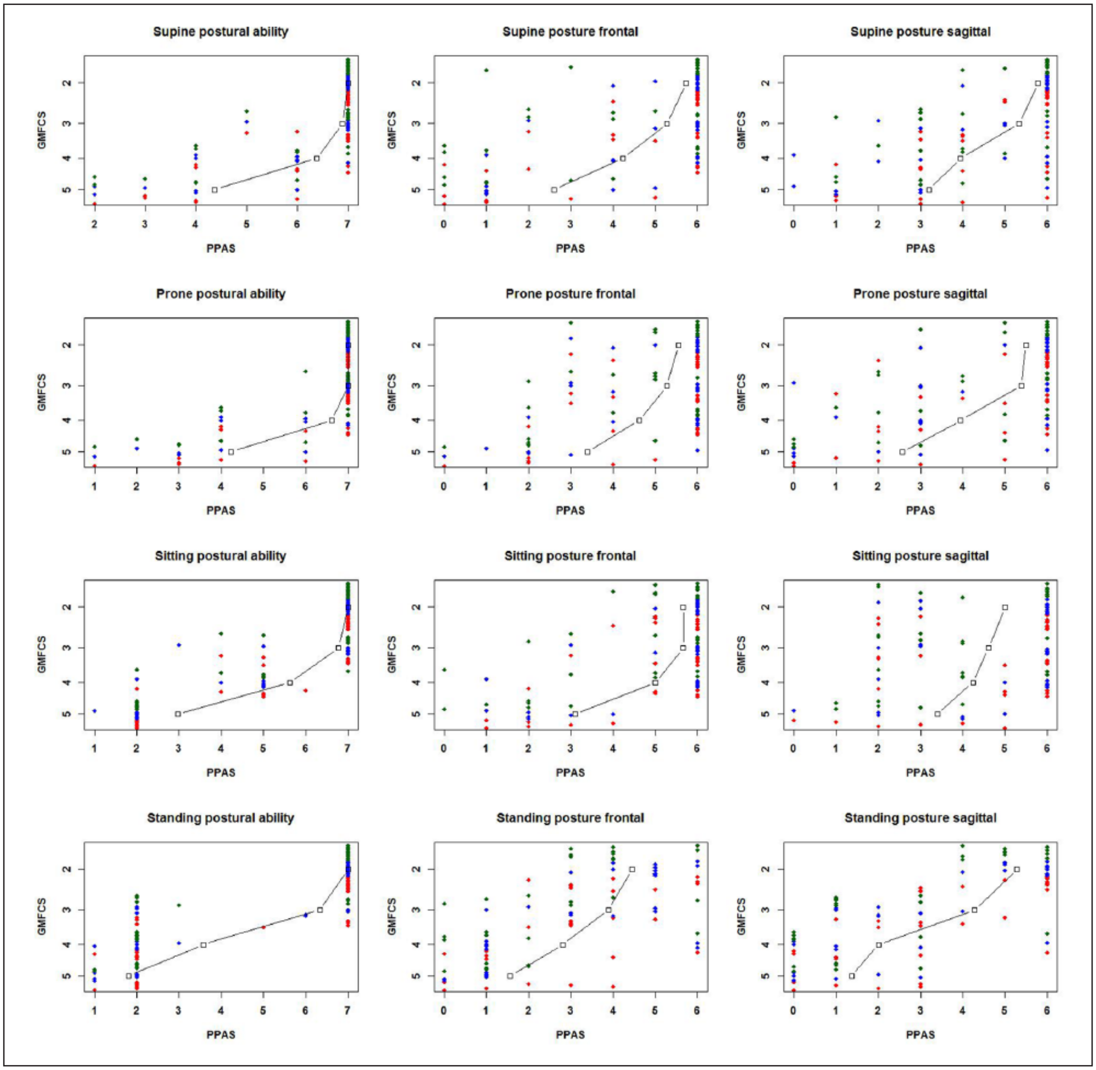

Figure 1. Distribution of scores for PPAS at each GMFCS level in all four positions.
All observations are marked with a different colour for each rater, red = rater A, blue = rater B, green = rater C. The squared points connected with a line are means of each GMFCS level.
GMFCS: Gross Motor Function Classification System; PPAS: Posture and Postural Ability Scale.

0.95–0.96 with a 95% confidence interval (CI) of 0.90–0.98 for all items. Corrected item-total correlation varied between 0.55–0.91 (95% CI 0.20–0.95) (Table 3).

Discussion

The PPAS shows sound psychometric properties for children and adolescents with cerebral palsy, comparable with a previous study with adults.[10]

There are several limitations to this study. One of the raters had special training and long experience using the PPAS, while the other raters had many years of clinical experience working with children with disabilities but no previous experience or knowledge of rating posture or postural ability. All three raters observed the children at the same time, but the children were only instructed and handled by the experienced physiotherapist. This may have affected the outcome for raters with

Table 1. Known-groups validity of the PPAS. Median, minimum and maximum values for each level of the GMFCS level II to V, and *p*-values calculated with Jonckheere-Terpstra for averaged values for the three raters.

		GMFCS II			GMFCS III			GMFCS IV			GMFCS V			*P*-value
		Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	
Supine	Postural ability	7	7	7	7	5	7	6	4	7	3.5	2	6	<0.001
	Posture frontal	6	1	6	5	2	6	5	0	6	1	0	5	0.001
	Posture sagittal	6	4	6	4	1	6	4	0	6	3	0	6	<0.001
Prone	Postural ability	7	7	7	7	6	7	6	4	7	3	1	6	<0.001
	Posture frontal	6	3	6	5	2	6	6	2	6	2	0	6	0.003
	Posture sagittal	6	2	6	4	0	6	3	1	6	1.5	0	6	0.001
Sitting	Postural ability	7	7	7	7	3	7	5	2	7	2	1	2	<0.001
	Posture frontal	6	4	6	6	2	6	6	0	6	2	0	4	0.002
	Posture sagittal	6	2	6	4	2	6	5.5	2	6	2	0	5	0.009
Standing	Postural ability	7	7	7	5	2	7	2	1	3	2	1	2	<0.001
	Posture frontal	4	2	6	3	0	6	1	0	6	1	0	4	<0.001
	Posture sagittal	6	3	6	2	1	5	1	0	6	1	0	3	<0.001

GMFCS: Gross Motor Function Classification System.

Table 2. Weighted kappa scores for the PPAS. Inter-rater reliability for three raters calculated with weighted Kappa scores, and non-parametric bootstrap confidence intervals (95% CI).

		Weighted Kappa	95%	CI
Supine	Postural ability	0.99	0.96	1.00
	Posture frontal	0.86	0.74	0.94
	Posture sagittal	0.90	0.84	0.95
Prone	Postural ability	0.98	0.94	1.00
	Posture frontal	0.94	0.88	0.98
	Posture sagittal	0.93	0.83	0.97
Sitting	Postural ability	0.97	0.89	0.99
	Posture frontal	0.85	0.73	0.93
	Posture sagittal	0.82	0.66	0.90
Standing	Postural ability	0.97	0.96	1.00
	Posture frontal	0.77	0.60	0.88
	Posture sagittal	0.87	0.78	0.94

different professions and varying previous knowledge of using the PPAS. The weighted kappa coefficient was 0.77–0.99 indicating an excellent inter-rater reliability, in agreement with results previously reported for experienced raters (0.85–0.99).[10] From our experience, we would recommend some training to minimize errors and make the assessment smoother. Securing reproducible measures is important for any assessment tool. This could be evaluated either by repeated measures on different occasions or by different raters on the same occasion.[24] We chose to evaluate agreement between raters on the same occasion. The reason for that is that posture in children with cerebral palsy may change over time and any disagreement between two occasions could represent responsiveness to change rather than measurement error. In the previous evaluation of the PPAS,[10] the ratings were based on photos and videos, however the present study shows similar results in spite of different

Table 3. Internal consistency of the PPAS. Cronbach's alpha if item deleted with 95% CI for three independent raters followed by corrected item-total correlation with 95% CI showing the correlation between each item and the total score.

		Cronbach's α	95%	CI	Item-total	95%	CI
Supine	Postural ability	0.95	0.91	0.97	0.84	0.68	0.92
	Posture frontal	0.95	0.91	0.97	0.83	0.56	0.92
	Posture sagittal	0.95	0.91	0.97	0.79	0.49	0.91
Prone	Postural ability	0.95	0.91	0.97	0.85	0.72	0.93
	Posture frontal	0.95	0.91	0.97	0.78	0.40	0.89
	Posture sagittal	0.95	0.91	0.97	0.82	0.55	0.91
Sitting	Postural ability	0.95	0.90	0.97	0.91	0.82	0.95
	Posture frontal	0.95	0.91	0.97	0.87	0.73	0.94
	Posture sagittal	0.96	0.92	0.98	0.55	0.20	0.79
Standing	Postural ability	0.96	0.92	0.97	0.70	0.44	0.83
	Posture frontal	0.95	0.91	0.97	0.77	0.58	0.87
	Posture sagittal	0.95	0.91	0.97	0.72	0.50	0.83

methodology. The numbers are quite small, particularly for the children with more severe impairments, with a total of 12 children at GMFCS level IV–V compared with a total of 17 children at GMFCS II–III. However, the results are statistically significant, but a bigger sample might have provided a narrower confidence interval.

The internal consistency represents the average of the correlations among all items. It was 0.95–0.96, which by far exceeds the recommended 0.8.[24] We anticipated a high homogeneity since all items assess aspects of posture and postural ability. For the same reason, methods such as factor analysis, often used to differentiate between items in different domains in questionnaires, would not be appropriate in this case. Corrected item-total correlation showed a slightly lower value for sitting posture in the sagittal view. This is an important consideration when using the PPAS in clinical practice. It can be difficult to assess whether or not the hips are flexed to approximately 90° depending on the position of the pelvis and the height of the plinth. In sitting, if the plinth is not adjustable or if using a chair, provision of additional support for the feet is necessary, especially for children at different heights. The results are comparable with the findings of a similar previous study using the PPAS to assess posture in adults with cerebral palsy.

Construct validity of the PPAS was evaluated through its ability to differ between known groups in terms of the GMFCS levels in children with cerebral palsy. There are many tools to assess balance for individuals who are ambulant, but most of them require at least the ability to maintain sitting or standing independently. The PPAS is designed for use with people at a lower level of gross motor function. Children at GMFCS level II can walk and stand unsupported. The highest level of ability is to move into and out of position, therefore, an anticipated ceiling effect in postural ability was seen for children at GMFCS level II. The strength of the PPAS is that it identifies postural asymmetries and deviations at all GMFCS-levels presented in this study.

Children with severe motor impairments frequently remain in a sitting or lying position for several hours a day. A sustained posture over longer periods of time leads to tissue adaptation and development of secondary complications, such as contractures, deformities and pain.[2,3,25] However, this can be prevented by early detection and appropriate interventions,[6,9,26,27] including provision of adaptive seating, standing or night-time support equipment.[27–29] The PPAS is sensitive to identify small asymmetries and deviations at all levels of motor function and is likely to detect asymmetries at an early stage. It is well recognized that persistent asymmetry will increase over time, leading to established contracture and deformity.[1–4] Early detection is essential if these problems are to be prevented or minimized.

The ability of the PPAS to identify problems of posture and postural ability at an early stage, not only highlights the need for early intervention, but provides information on what postural support is appropriate and where it needs to be applied. For example, children rated as level 1 (unplaceable) would require customized seating and standing support owing to fixed deformities and contractures. The quality of posture indicates if support or adaptations are required to improve weight distribution, or to get head, trunk, pelvis, legs, arms and feet in a neutral position. In addition, the assessment does not require any special equipment; it is easy to use in a clinical setting and takes about 10 minutes to complete. Its use should facilitate evaluation of those therapeutic interventions designed to increase functional ability and to prevent secondary complications.

The PPAS shows construct validity, internal consistency and excellent inter-rater reliability for raters with experience of children with cerebral palsy. It can detect postural deficits and asymmetries, which enable early detection of potential problems and provides information relevant to postural support solutions in order to improve function and prevent musculoskeletal deformities.

Clinical messages

- The Posture and Postural Ability Scale shows high psychometric properties for children with cerebral palsy.
- The Posture and Postural Ability Scale identifies asymmetries in children at varying levels of motor function and can be used for children with mild to severe postural deficits.

Acknowledgements

The authors would like to thank all the children and families for participating in this study, the physiotherapists in Eslöv, Helsingborg, Lund, Malmö and Trelleborg for assistance, and especially Anette Sällvik for assessing all children. We would also like to express our deep gratitude to Pauline Pope for valuable input and for proof reading and improving the manuscript.

Conflict of interest

The authors declare that they have no conflict of interests.

Contributors

ERB designed the study, examined the children, collected and analysed the data, and drafted the manuscript. MPB recruited and examined the children, analysed the data, improved and revised the manuscript. TC analysed the data, performed all statistical analyses, improved and revised the manuscript. All authors approved the final draft.

Funding

We would like to thank the Centre for Clinical Research Västerås, the Faculty of Medicine, Lund University and Stiftelsen för bistånd åt rörelsehindrade i Skåne, for financial support.

References

1. Brown K. Positional deformity in children with cerebral palsy. *Physiother Theory Practice* 1985; 1: 37–41.
2. Fulford FE and Brown JK. Position as a cause of deformity in children with cerebral palsy. *Dev Med Child Neurol* 1976; 18: 305–314.
3. Porter D, Michael S and Kirkwood C. Is there a relationship between preferred posture and positioning in early life and the direction of subsequent asymmetrical postural deformity in non ambulant people with cerebral palsy? *Child Care Health Dev* 2008; 34: 635–641.
4. Rodby-Bousquet E, Czuba T, Hägglund G and Westbom L. Postural asymmetries in young adults with cerebral palsy. *Dev Med Child Neurol* 2013; 55: 1009–1015.
5. Hägglund G, Alriksson-Schmidt A, Lauge-Pedersen H, Rodby-Bousquet E, Wagner P and Westbom L. Prevention of dislocation of the hip in children with cerebral palsy: 20-year results of a population-based prevention programme. *Bone Joint J* 2014; 96-B: 1546–1552.
6. Hägglund G, Andersson S, Duppe H, Lauge-Pedersen H, Nordmark E and Westbom L. Prevention of severe contractures might replace multilevel surgery in cerebral palsy: results of a population-based health care programme and new techniques to reduce spasticity. *J Pediatr Orthop B* 2005; 14: 269–273.
7. Novak I. Stand up and be counted. *Dev Med Child Neurol* 2013; 55: 974.
8. Persson-Bunke M, Hägglund G and Lauge-Pedersen H. Windswept hip deformity in children with cerebral palsy. *J Pediatr Orthop B* 2006; 15: 335–338.

9. Persson-Bunke M, Hägglund G, Lauge-Pedersen H, Wagner P and Westbom L. Scoliosis in a total population of children with cerebral palsy. *Spine* 2012; 37: E708–713.
10. Rodby-Bousquet E, Agustsson A, Jonsdottir G, Czuba T, Johansson AC and Hagglund G. Interrater reliability and construct validity of the Posture and Postural Ability Scale in adults with cerebral palsy in supine, prone, sitting and standing positions. *Clin Rehabil* 2014; 28: 82–90.
11. Bouisset S and Do MC. Posture, dynamic stability, and voluntary movement. *Neurophysiol Clin* 2008; 38: 345–362.
12. Pope PM. *Severe and complex neurological disability: Management of the physical condition*. Edinburgh: Butterworth-Heinemann/Elsevier, 2007.
13. Hallett R, Hare N and Milner A. Description and evaluation of an assessment form *Physiotherapy* 1987; 73: 220–225.
14. Green EM and Nelham RL. Development of sitting ability, assessment of children with a motor handicap and prescription of appropriate seating systems. *Prosthet Orthot Int* 1991; 15: 203–216.
15. Pountney TE, Cheek L, Green E, Mulcahy C and Nelham R. Content and criterion validation of the chailey levels of ability. *Physiotherapy* 1999; 85: 410–416.
16. Westbom L, Hägglund G and Nordmark E. Cerebral palsy in a total population of 4–11 year olds in southern Sweden. Prevalence and distribution according to different CP classification systems. *BMC Pediatr* 2007; 7: 41.
17. (SCPE) SoCPiE. Surveillance of cerebral palsy in Europe: A collaboration of cerebral palsy surveys and registers. *Dev Med Child Neurol* 2000; 42: 816–824.
18. Palisano RJ, Rosenbaum P, Bartlett D and Livingston MH. Content validity of the expanded and revised Gross Motor Function Classification System. *Dev Med Child Neurol* 2008; 50: 744–750.
19. Conger AJ. Integration and generalization of kappas for multiple raters. *Psychological Bulletin* 1980; 88: 322–328.
20. Davison AC and Hinkley DV. *Bootstrap methods and their application*, Chapter 5 Confidence Intervals: 191–251. Cambridge: Cambridge University Press, 1997.
21. DiCiccio TJ and Efron B. Bootstrap confidence intervals. *Statistical Science* 1996; 11: 189–212.
22. Fleiss JL. *Statistical methods for rates and proportions*. 2nd ed. New York: Wiley, John and Sons, Incorporated, 1981, p. 321.
23. Cortina JM. What is coefficient alpha? An examination of theory and applications. *J App Psychol* 1993; 78: 98–104.
24. Streiner DL and Norman GR. *Health measurement scales: A practical guide to their development and use*. Oxford: Oxford University Press, 2008.
25. Saito N, Ebara S, Ohotsuka K, Kumeta H and Takaoka K. Natural history of scoliosis in spastic cerebral palsy. *Lancet* 1998; 351: 1687–1692.
26. Hägglund G, Andersson S, Duppe H, Lauge-Pedersen H, Nordmark E and Westbom L. Prevention of dislocation of the hip in children with cerebral palsy. The first ten years of a population-based prevention programme. *J Bone Joint Surg Br* 2005; 87: 95–101.
27. Pountney T, Mandy A, Green E and Gard P. Management of hip dislocation with postural management. *Child Care Health Dev* 2002; 28: 179–185.
28. Rodby-Bousquet E and Hägglund G. Sitting and standing performance in a total population of children with cerebral palsy: A cross-sectional study. *BMC Musculoskelet Disord* 2010; 11: 131.
29. Pope PM, Bowes CE and Booth E. Postural control in sitting the SAM system: Evaluation of use over three years. *Dev Med Child Neurol* 1994; 36: 241–252.