

Clinical assessments designed to measure body alignment posture in children with cerebral palsy – a systematized review

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ABSTRACT

Background and Aims

The purpose of this review is to critically review the clinical assessments used by health care professionals to assess and measure body alignment posture in children with Cerebral Palsy (CP). To determine if assessments have psychometric properties specifically measured for this population, their main characteristics and application into clinical practice.

Method

A systematic search across 5 electronic databases along with hand searching. The search included articles in English from inception to March 2019. Key terms included: Cerebral palsy, posture, body alignment, assessment(s) measure(s), outcome(s), child(ren).

Screening of titles, reviewed abstracts and identified full-text articles that met the inclusion criteria. Data extraction included study design, tool description and psychometric properties.

Results

This review identified 7 assessments used by health care professionals to assess body alignment changes in children with CP. The search identified 10 publications of which six papers examined the assessment's psychometric properties.

Conclusion

Evidence supporting the use for measures of body alignment is limited, as is the evidence supporting the strength of the assessment properties.

What this adds to the evidence:

In children with CP, many of the clinical assessments used to measure body alignment have limited psychometric properties.

Assessments which demonstrate validity, reliability and responsiveness are required to support therapists in their assessment of body alignment.

Shorten form of title: Clinical body alignment assessments in cerebral palsy

Introduction

Disorders in movement and posture observed in children with CP (Rosenbaum et al, 2007) lead to adoption of asymmetrical body alignment (Pountney et al, 2009; Pountney et al 2002).

Postural orientation is defined as the alignment of body segments (head, trunk, pelvis, arms, legs and feet) in relation to one another and with respect to the support surface, gravity and the environment (Pope, 2007; White, 1999). For individuals with CP Gross Motor Function Classification Scale (GMFCS) levels IV and V Postural orientation can be an issue (Palisano et al, 2008). This makes achieving symmetrical body alignment against gravity extremely difficult and therefore is of interest to health professionals (Pope, 2007). Musculoskeletal issues such as limited joint range, hip dislocation, chest asymmetry and spine scoliosis are commonly associated with poor postural alignment (Hill and Goldsmith, 2010; Pountney et al, 2009; Porter et al 2008; Pountney et al, 2002). The development of postural deformities can result in movement and function being severely compromised (Scrutton, 2008; Porter et al 2007), hence early identification of postural misalignment is important in the clinical management of posture in children with CP.

Posture management programmes can be extensive; though they primarily focus on supporting body alignment through the use of adaptive equipment (Farley et al, 2003). Posture management is an integrated part of a child and families' life, applying to positions a child wants to adopt, and environments and situation they wish to access (Hong, 2005). As an approach, posture management correlates directly to the International Classification of Functioning, Disability and Health (ICF) (Baxter, 2004) as an integration and interaction of body structure and function with personal factors. As such, measures which quantify body alignment among children with CP should encompass total body alignment accurately and with specificity (Scrutton, 2008).

The use of observational assessments in assessing body alignment is part of everyday clinical practice (Hong 2005). However, the evidence of standardised clinical measurements of body alignment in children with CP is relatively sparse. Current standardised assessments of body alignment concentrate on body linkages rather than total body alignment. Development and severity of postural alignment asymmetry is identified through hip and or spine x-ray analysis to determine degrees of curvature or hip displacement (Gaston, 2019). Although the psychometric properties of this approach are well documented, applicability of into clinical practice and therapist's daily assessment of total body segment alignment is limited.

To accurately quantify body alignment of children with CP, assessments must be valid, reliable and have usability within a clinical setting (Fawcett, 2013). All these factors must be considered when selecting the most appropriate available assessment to use in clinical practice. There is a lack of appropriate clinical tools which address entire body posture (Fortin et al, 2011), as is the evidence supporting the strength of clinical measurement properties (Field and Livingstone, 2013).

Aims

This review aimed to;

- Identify clinical measures/assessments used by therapists to assess body alignment in children with CP
- Determine if assessments have psychometric properties specifically measured for this population, and
- To identify the assessments main characteristics

This review focused on assessment of body alignment, but also included outcome measurement of posture alignment intervention, as the author noticed a tendency for assessment use to be identified and established alongside providing effectiveness of postural alignment interventions.

Method

To support the identified aims, a systemised review was conducted (Grant and Booth 2009).

A literature search was performed using the databases AMED, CINAHL, MEDLINE, PeDro and the Cochrane Library with the search string described in Table I. In addition, reference lists of selected articles were reviewed along with a manual search of journals which published identified assessments over last year of publication was undertaken. Searchers were carried out from inception to March 19.

Table I: Search strings and key words

Study group	Posture terms	Assessment	Age of interest
Cerebral palsy OR	Postur* OR	Measure* OR	Infant* OR Child*
AND	Body Alignment OR	AND	OR Teen*
CP	Body Position* OR	Outcome* OR	
	Anatomical	Tool* OR	
	Alignment OR	Assessment*	
	Body Orientation OR		

Original articles were selected if they fulfilled the following inclusion criteria: (1) assessed children aged 0-18 with cerebral palsy, (2) assessed whole body, (3) description of assessment related to body alignment or position, (4) article included description & development or psychometric testing of assessment, (5) usable within health care-professional clinical practice, and (6) publication in English.

Papers were excluded if: (1) the primary intention of the tool was not to assess body alignment, the assessment was part of a wider assessment of other therapy interventions (i.e. postural control, balance, gait, postural stability), (2) children with CP comprised less than 30% of the total population, (3) The assessment were lab based, (4) the assessment were not used by therapists reviews, and (5) the papers were reviews.

Article selection and data extraction

The author independently reviewed titles and abstracts against the inclusion and exclusion criteria. The author extracted data and performed the quality assessment of the data based on the CanChild Outcome Measures Rating Form (Law, 2004). The methodological qualities of the studies were examined according to the McMasters critique forms (Law et al, 1998; Letts et al, 2007). Two authors (FG and AB) examined quality; if agreement could not be reached a third author (LG) was consulted.

Data extraction retrieved the following information: study objectives, study design, participants' selection and characteristics, measurement tool description, findings and conclusions. The psychometric quality of the instruments were examined in terms of reliability (inter-rater, intra-rater, test retest, internal consistency), validity (content, criterion and construct). Quality was rated on a three-point rating scale poor, adequate or good. Reliability was graded using bands proposed by Fleiss et al (2013); less than 0.40 being poor, 0.41-0.75 adequate and greater than 0.75 good. Validity used McMaster Ratings (Law, 2004) to give an overall rating based on the number of studies completed. The validity of an assessment was judged to be excellent when more than two well-designed studies supported the instrument, adequate when there were one or two well-designed studies and poor when validity studies were poorly completed or when one or two well-designed studies did not support the instrument (Law, 2004).

Results

The search resulted in 696 articles; out of these 205 were duplicate titles. Figure 1 shows the PRISMA process of identifying relevant articles (Moher et al, 2009). After reading the titles and abstracts, 135 studies were excluded according to the inclusion and exclusion criteria. Of the remaining 491 articles, 352 were excluded after a complete reading. Stage one of the search identified 6 articles utilising 5 clinical assessment instruments to assess body alignment in children with CP. Stage 2 involved a manual search of the reference list and

journals the assessments had been identified in, 91 records were identified. Of these 87 were excluded leading to a total of 10 articles and 7 assessments identified and included in this review.

Description of the psychometric properties of each clinical assessment is described for all 7 assessments (Table II & III). Firstly, an overview of the 7 clinical assessments properties is provided. Following this the psychometric properties and assessment characteristics are discussed. Finally, these findings are discussed taking into account the findings of assessment properties, clinical usability, overall utility and literature on the development of body alignment posture problems in children with CP.

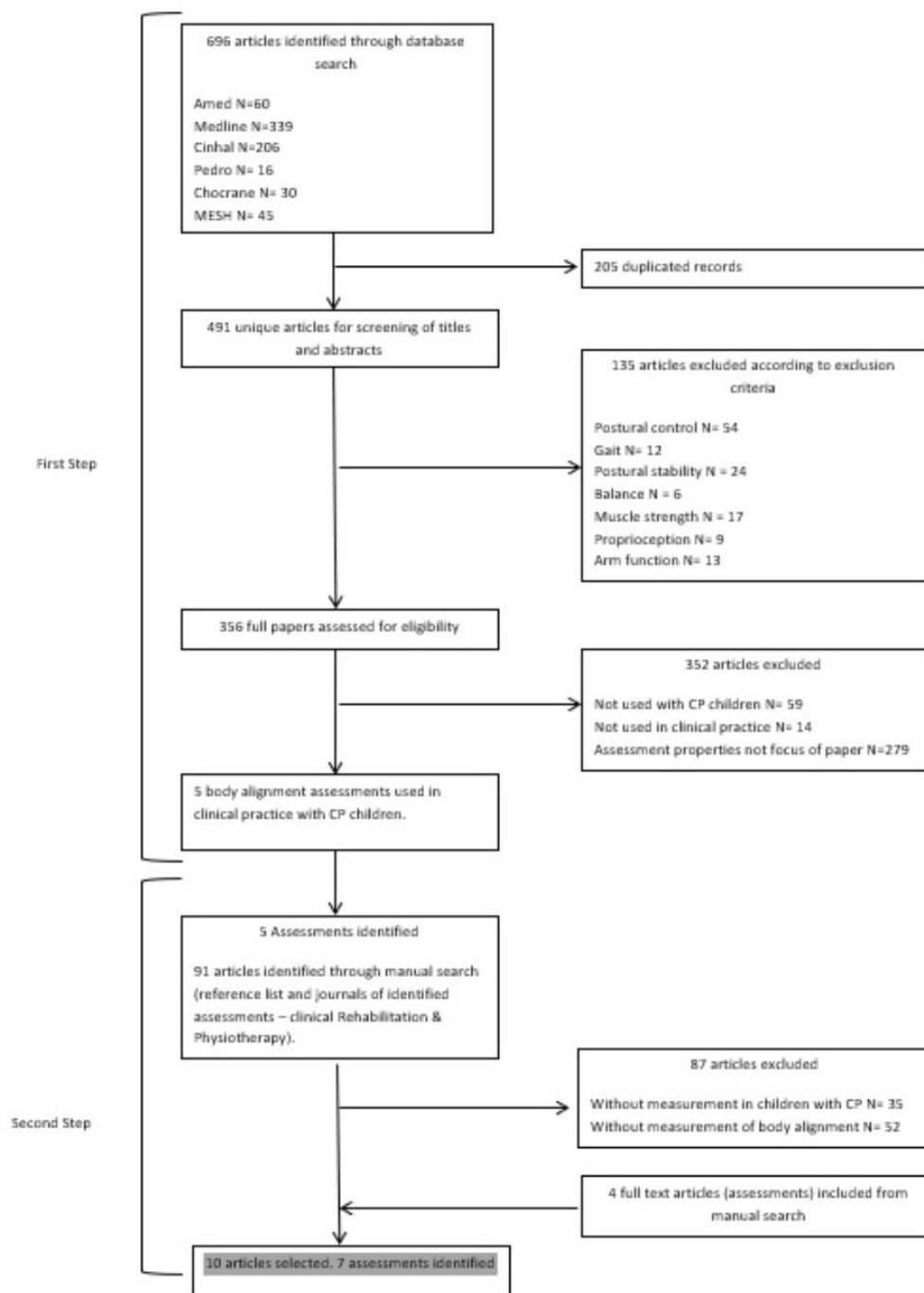


Figure 1. PRISMA flowchart (Moher et al, 2009)

Clinical assessments used by HCP to assess body alignment

The search identified 7 clinical assessments which meet the criteria. The included assessments were: The Chailey Levels of Ability Scale (CLAS), Goldsmith Indices, the Goldsmith Index of Windswept Deformity, Mansfield Checklist, Posture and Posture Ability Scale (PPAS), the Spinal Alignment and Range of Motion Measure (SAROMM) and the Seated Postural Control Measure (SPCM).

Of the assessments identified 6 were observational measurements; 5 observed body alignment (Goldsmith Indices, Goldsmith Index of Windswept Deformity, PPAS, SAROMM, SPCM), and 1 observed gross functional movement (CLAS). One assessment (Mansfield Checklist) was a checklist, providing a set of 5 questions relating to posture. The PPAS and SPCM combined observational measurement across 2 components of posture quality and function ability, whilst the SAROMM combines observational measurement of the spine in the sagittal and frontal planes with range of motion assessment of upper and lower limbs.

All the articles included participants with CP, 6 studies had participants aged from 0 - 18 years. Whilst two studies (Pountney et al, 1999; Goldsmith et al 1992) included participants with CP over the age of 18, 1 study (Pountney et al, 1999) had a sample age range of 4.5-19 years old, and 1 (Goldsmith et al 1992) ranged from 10 -48 years. Only two articles (Rodby-Bousquet et al, 2016; Bartlett and Purdie, 2005) described the participants by their type and CP presentation, using the GMFCS to clearly classify groups of children. Whereas 1 article (Fife et al, 1991) included participants with neuromotor disabilities (n=40), 19 of which had CP, described in terms of body area affected e.g. Hemiplegic.

Assessment characteristics

6 assessments primary purpose was to measured body alignment (Rodby-Bousquet et al, 2016; Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009; Bartlett and Purdie, 2005; Goldsmith, 2000; Goldsmith et al, 1992; Fife et al, 1991). The PPAS scored quality of posture through observation of the individuals body alignment; a score of 1 given for midline/symmetrical or a score of 0 for asymmetry. Six body items are scored: head, trunk, pelvis, legs, arms and weight distribution, in sitting, standing, supine and prone from both the frontal and sagittal view (Rodby-Bousquet et al, 2016).

The SAROMM (Bartlett and Purdie, 2005) has 6 items; 4 items for spinal alignment and 11 for range of motion. Each item is scored on a five point ordinal scale ranging from 0 (representing ability to align normally with no passive limitations) to 4 (severe deviations in spinal alignment or limitations in joint range of motion).

The Goldsmith Index of Windswept Deformity (Goldsmith et al, 1992) involves 3 measurements of pelvis, hips and leg position in supine crook lying. Each measurement is repeated 4 times and an average calculated for the overall score. The Goldsmith Indices (Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009) is a further development of this assessment; 3 measurements repeated 4 times, taken of chest proportion, symmetry of movements of knees, symmetry of range of movement at the hips.

The Mansfield Checklist (Goldsmith, 2000) is a set of 5 'yes' 'no' questions; the questions ascertain if the body stays in a limited number of positions, if the knees fall to one side, if the head turns to one side, if the body tends to flex or extend or both and if so to which side and if the body shape is asymmetric.

The SPCM (Fife et al, 1991) assess sitting position in two sections. Section one measures posture alignment and consists of 22 items. Assessment is carried out through visual observation and palpation. A score of 0-3 is given defined by arbitrary angles representing mild, moderate and severe abnormal alignment. Section two, measures functional movement and consists of 12 items scored from zero to complete.

Finally, the CLAS (Pountney et al, 1999) primary purpose is measurement of a child's motor and postural ability in relation to function. Body alignment posture is measured as a sub- section of the assessment which is an observational assessment of a child's motor ability scored from level 1 -8. A child is assigned a level of ability based on their overall skill performance of motor tasks following normal developmental movements. Each movement is measured across 9 constructs: loadbearing when still and moving, ability to move areas of loadbearing, position of pelvis, trunk and legs, position of the shoulder girdle, arms and trunk, the position of the head and chin, lateral body profile, effect of movement on body parts, ability to isolate movement, predominant joint positions.

Psychometric properties

Among articles identified, 6 examined the assessment's psychometric properties (Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014; Field and Roxborough, 2011; Bartlett and Purdie, 2005; Pountney et al, 1999; Fife et al, 1991). All 7 clinical assessments applied to children with CP. Only 3 assessments reported on both validity and reliability properties: the PPAS (Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014), SAROMM (Bartlett and Purdie, 2005) and SCPM (Fife et al, 1991). Validity properties were reported for 1 further assessment: CLAS (Pountney et al, 1999). Studies investigating the psychometric properties for children with CP were not found for the 3 following assessments: Goldsmith Indices (Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009), Goldsmith Index of Windswept Deformity (Goldsmith et al 1992) and The Mansfield Checklist (Goldsmith, 2000).

Strength of reported psychometric properties are shown in Tables II and III. A study's psychometric quality is rated on a three-point rating scale of poor, adequate or good.

Reliability

Evidence of Inter-rater reliability was found for all 3 assessment which reported reliability; the PPAS (Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014), SAROMM (Bartlett and Purdie, 2005) and SCPM (Fife et al, 1991) see table II. Excellent reliability was demonstrated for the SAROMM and PPAS with intraclass correlation coefficient (ICC) exceeding 0.80. The PPAS also reported a weighted Kappa which range exceeded 0.80. The SCPM reported excellent reliability for the function section (Kappa coefficient 0.85) but only adequate for alignment (Kappa coefficient 0.45).

Both the SAROMM (Bartlett and Purdie, 2005) and SCPM (Fife et al, 1991) showed evidence for Test retest reliability. Excellent reliability was demonstrated by the SAROMM, intraclass correlation coefficient (ICC) exceeded 0.80, whilst the SCPM alignment demonstrated poor test-retest reliability with a Kappa coefficient of 0.35 and 0.29 for alignment and function sections respectively.

Evidence of internal consistency and Intra-rater reliability was found in 1 assessment. The PPAS (Rodby-Bousquet et al, 2014) reported cronbach's alpha and ICC scores exceeding 0.80 indicating excellent internal consistency and intra rater reliability.

No evidence could be found for the reliability of the CLAS (Pountney et al, 1999), Goldsmith Indices (Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009), Goldsmith Index of Windswept Deformity (Goldsmith et al 1992) or Mansfield checklist (Goldsmith, 2000). The Goldsmith Index of Windswept Deformity reported P values of <0.001 and >0.1 in regards to reliability. As a P value is not a measure of reliability, the evaluation of its reliability remains inconclusive.

Validity

Validity was reported in 4 of the assessments these are shown in table III.

The CLAS established content validity through use of a review by a panel of experts and field testing among CP children. The SPCM (Pountney et al, 1999) indicates adequate content validity with description of development and expert panel review.

¹ . For ease of interpretation a traffic light colour scheme is utilised; Green indicated a good level of evidence, amber indicated adequate level, red indicated poor and blue denoted not reported.

Criterion validity was established for the CLAS through comparison with the Alberta Infant Motor Scale (AIMS) and Gross Motor Function Measure (GMFM), showing a high correlation between both assessment and the CLAS GMFM = 0.85 AIMS = 0.90.

Construct validity Both the PPAS and SAROMM used the GMFCS to establish construct validity, showing an ability to detect gradations in disability.

The available evidence indicates that the CLAS has adequate content and criterion validity (Pountney et al, 1999) and the PPAS (Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014) and SAROMM (Bartlett and Purdie, 2005) have adequate construct validity based on each having one study reporting on their validity.

There is no direct evidence available which reports on validity aspects for the Goldsmith Index of Windswept Deformity (Goldsmith et al 1992), Goldsmith Indices (Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009) or Mansfield checklist (Goldsmith, 2000).

Discussion

This review focused on assessments of body alignment which are applicable to everyday clinical practice and settlements. This approach is consistent with the ICF (WHO, 2007) model which has been widely used to guide service delivery and clinical thinking for children with CP. The ICF model views body structure as an integral part of movement and participation, as well as an interaction with social and environmental factors (WHO, 2007). Postural alignment is targeted by therapists in order to support activity and participation through posture management interventions (Pope, 2007). Supporting body alignment occurs in various environmental settings across a child's social environment such as home and school, often encompassing support of body alignment in lying, sitting and standing (Field and Roxborough, 2011; Goldsmith, 2000). The use of postural equipment to correct total body alignment is generally considered to be related to improvements in a child's participation and function (Gericke, 2006; Pountney et al, 2002). However, this assumption has not been validated with clinical data; hence accurate clinical measurement of a child's postural alignment is important in the provision of posture management equipment.

Whilst assessments of body alignment only measure one aspect of health as defined by the ICF, the association this has with the components of activity and participation in relevant and meaningful contexts is clear. Consequently, assessments which aim to measure the construct of body alignment among children with CP needs to be reflective of how this varies in respect to environmental factors such as support surface, gravity, postural position as well as applicable to real life settings.

Methodological properties of the assessment

Currently the most common method used for assessment of body alignment in research is x-rays and motor function. Obtaining an accurate assessment of body alignment as part of clinical practice can be rather challenging (Hill and Goldsmith, 2010) because established assessments methods have been mostly derived from lab based techniques or movement based measurement. This critical review found 7 assessments of body alignment that are usable within clinical settings. Evidence supports adequate to poor overall reliability and validity of most of the instruments. The overall methodological properties of the studies that support these assessments were found to be limited. The PPAS (Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014) and SAROMM (Bartlett and Purdie, 2005) are supported by published studies which demonstrate good to excellent validity and reliability in samples which include children with CP, in addition to established evidence for construct validity.

The unique characteristics of the population being assessed are important considerations in measurement selection (Sarathy et al, 2019). This critical review found few true validated measures of body alignment in children with CP are available. Although both the PPAS (Rodby-Bousquet et al, 2016) and SAROMM (Bartlett and Purdie, 2005) were able to demonstrate excellent to adequate construct validity. Detail on the development and validity of the assessments content is not report in detail. Although the SAROMM (Bartlett and Purdie, 2005) provides limited detail on content detail is imprecise and ambiguous in terms of specificity when examining the development process. As such the validity of the test items and criterion limits the assessment applicability as a measurement of clinical outcome. Furthermore in regards to reliability the number of raters is small for the PPAS (Rodby-Bousquet et al, 2014) and SAROMM (Bartlett and Purdie, 2005) with 3 and 2 raters uses respectively. Only the SAROMM clearly outlines the model used to detriment ICC scores. Therefore, the accuracy of the reliability of the PPAS is questionable and the values related to these assessments must be interpreted with caution.

Therefore, those instruments that do have established psychometric properties for assessment of body alignment among children with CP have limitations in their methodological approach needed to address clinical assessment and monitoring within this population. No assessment that measures specific variation of total body alignment symmetry has been validated nor found reliable for children with CP.

Clinical usability and overall utility

An assessments validity and reliability does not mean it is automatically usable within a clinical setting; many named 'clinical' assessment are unused for practical reasons such as cost, administration time, training requirements, score interpretation, portability and ease of use (Fawcett, 2013). The clinical assessments reviewed in this paper are judge to have adequate to poor clinical utility. This review identified (Pountney et al, 2009) assessments; the PPAS and SAROMM as having adequate clinical overall utility with both demonstrating, adequate to excellent reliability, adequate to excellent validity and are easily available. Both assessments use a paper based format, are observational with relatively low cost, easily portable and assessment applications require no specific equipment, environment or training need in order to be administered. The PPAS and SAROMM are associated with either symmetry alignment or joint positions. The SAROMM appears to have discriminatory assessment of spinal alignment and then focuses on assessment of joint range of motion not body alignment position. Whilst the PASS assesses total body alignment it only identifies symmetry and therefore is unable to detect changes or variation in symmetry which CP children often present with. As such, their utility in children with CP may be limited by the child's variation in to body alignment position. Nevertheless, these two assessments appear to have some capability in observing and evaluating components of body alignment. These may enable HPC to determine an overview of a child's current body alignment, however have a reduced capability to assess changes or adaptations to symmetrical body alignment.

Application to body alignment in children with CP

The body position of a child with CP results in an array of problems which affect the whole body (Fortin et al, 2011; Porter et al, 2008), leading to the adoption of various degrees of asymmetrical postures (Hill and Goldsmith, 2010). Subsequently assessment of body alignment in children with CP needs to be able to measure both symmetrical and asymmetrical posture alignment and discriminate between changes in asymmetry.

Of the 7 assessments reviewed in this paper only 2 (PPAS, SAROMM) demonstrated adequate valid and reliable assessment of body alignment. These two assessments are observational of body alignment position, which implies that they are able to detect changes in body posture. The PPAS allows for observation of 5 parts of the body to be assessed as being symmetrical or not. This gives limited responses to body symmetry, making it unresponsive and unable to detect changes in asymmetrical body alignment. As such, ability to assess and measure change in body alignment are lost. The SAROMM has one section devoted to body alignment, which offers a detailed and systematic way to examine and monitor emerging changes in spinal alignment. However it is limited to a measure of body alignment due to an emphasis on body linkage position (joint range) and does not encompass body segment position in relation to body alignment. The PPAS and SAROMM application methods vary; the PPAS presents a more comprehensive body alignment measure of a CP child's body alignment in sitting, standing and lying across all GMFCS levels; whilst the SAROMM offers a specific and accurate analytical approach to measurement of body alignment (Spine).

Only the SCPM (Field and Roxborough, 2011) examined responsiveness to change, identifying that the assessment lack discrimination when assessment a change in alignment. The SCPM validity adequate and reliability are reported as adequate to poor; as such its strength as a clinical measure of change remains questionable.

Furthermore, the Goldsmith indices adapted from the Goldsmith Index of Windswept Deformity assess a limited number of items related to body alignment. Whereas the Mansfield Checklist appraises movement and body alignment, reflective of a non-specific screening on an individual's position, movement and body shape. These 3 assessments lack psychometric properties to support assessment accuracy and reliability of measurement of body alignment.

Assessments of body alignment need to take into consideration the child's entire body alignment (Fortin et al, 2011). Being sensitive and applicable to the complex presentation and wider social and environmental issues which impact on body alignment in children with CP is essential if an assessment is able to measure change and determine outcomes of intervention which effect postural alignment.

Conclusion

Although this critical review identified a number of assessments which are available, evidence supporting their use for entire body alignment measurement is limited, as is the evidence supporting the strength of their measurement properties. Few assessments address sensitivity, accuracy and responsiveness to change in body alignment in children with CP.

It has already been established that impairment in body alignment impacts on body functions, participation and quality of life in children with CP (Scrutton, 2008; WHO, 2007). Accurate measurement of a child's postural alignment is important in the provision of posture managing equipment to prevent postural deformities, optimise functional potential and improve a child's overall quality of life.

There is a need for further research to establish the evidence for the development and use of a clinical assessment of body alignment for children with CP. The ability for therapists to accurately measure changes they make to a child's body alignment through the provision of postural equipment will enable the impact and effectiveness of postural management, in terms of alignment to be evaluated.

References

- Bartlett, D. and Purdie, B., 2005. Testing of the spinal alignment and range of motion measure: a discriminative measure of posture and flexibility for children with cerebral palsy. *Developmental medicine and child neurology*, 47(11), pp.739-743.
- Baxter, P., 2004. ICF: health vs disease. *Developmental medicine and child neurology*, 46(5), pp.291-291.
- Farley, R., Clark, J., Davidson, C., Evans, G., Maclennan, K., Michael, S., Morrow, M. and Thorpe, S., 2003. What is the evidence for the effectiveness of postural management?. *British Journal of Therapy and Rehabilitation*, 10(10), pp.449-455.
- Fawcett, A.L., 2013. *Principles of assessment and outcome measurement for occupational therapists and physiotherapists: theory, skills and application*. John Wiley & Sons.
- Field, D. and Livingstone, R., 2013. Clinical tools that measure sitting posture, seated postural control or functional abilities in children with motor impairments: a systematic review. *Clinical rehabilitation*, 27(11), pp.994-1004.
- Field, D.A. and Roxborough, L.A., 2011. Responsiveness of the Seated Postural Control Measure and the Level of Sitting Scale in children with neuromotor disorders. *Disability and Rehabilitation: Assistive Technology*, 6(6), pp.473-482.
- Fife, S.E., Roxborough, L.A., Armstrong, R.W., Harris, S.R., Gregson, J.L. and Field, D., 1991. Development of a clinical measure of postural control for assessment of adaptive seating in children with neuromotor disabilities. *Physical Therapy*, 71(12), pp.981-993.
- Fleiss, J.L., Levin, B. and Paik, M.C., 2013. *Statistical methods for rates and proportions*. John Wiley & Sons.
- Fortin, C., Ehrmann Feldman, D., Cheriet, F. and Labelle, H., 2011. Clinical methods for quantifying body segment posture: a literature review. *Disability and Rehabilitation*, 33(5), pp.367-383.
- Gaston, M.S., 2019. CPIPS: musculoskeletal and hip surveillance for children with cerebral palsy. *Paediatrics and Child Health*.
- Gericke, T., 2006. Postural management for children with cerebral palsy: consensus statement. *Developmental Medicine and Child Neurology*, 48(4), pp.244-244.
- Goldsmith, J. and Goldsmith, L., 2009. Goldsmith Indices of Body Symmetry: Protecting Body Shape. *European Seating Symposium*, pp.122-124.

- Goldsmith, J., Goldsmith, L., Hill, S., 2009. Working together to protect body shape. *Posture and Mobility*, 26(2), pp.9-13.
- Goldsmith, S., 2000. The Mansfield Project: Postural care at night within a community setting: A feedback study. *Physiotherapy*, 86(10), pp.528-534.
- Goldsmith, E., Golding, R.M., Garstang, R.A. and MacRae, A.W., 1992. A technique to measure windswept deformity. *Physiotherapy*, 78(4), pp.235-242.
- Grant, M.J. and Booth, A., 2009. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, 26(2), pp.91-108.
- Hong, C.S., 2005. Assessment for and provision of positioning equipment for children with motor impairments. *International Journal of Therapy and Rehabilitation*, 12(3), pp.126-131.
- Hill, S. and Goldsmith, J., 2010. Biomechanics and prevention of body shape distortion. *Tizard Learning Disability Review*, 15(2), pp.15-32.
- Law, M., 2004. OUTCOME MEASURES RATING FORM GUIDELINES.
- Law, M., Stewart, D., Letts, L., Pollock, N., Bosch, J. and Westmorland, M., 1998. Guidelines for critical review of qualitative studies. *McMaster University occupational therapy evidence-based practice research Group*.
- Letts, L., Wilkins, S., Law, M., Stewart, D., Bosch, J. and Westmorland, M., 2007. Critical review form—qualitative studies (version 2.0). *McMaster University*.
- Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*, 151(4), pp.264-269.
- Palisano, R.J., Rosenbaum, P., Bartlett, D. and Livingston, M.H., 2008. Content validity of the expanded and revised Gross Motor Function Classification System. *Developmental Medicine & Child Neurology*, 50(10), pp.744-750.
- Pope PM. 2007. Severe and complex neurological disability: management of the physical condition. Edinburgh : Elsevier Butterworth-Heinemann.
- Porter, D., Michael, S. and Kirkwood, C., 2008. 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 and development*, 34(5), pp.635-641.
- Porter, D., Michael, S. and Kirkwood, C., 2007. Patterns of postural deformity in non-ambulant people with cerebral palsy: what is the relationship between the direction of scoliosis, direction of pelvic obliquity, direction of windswept hip deformity and side of hip dislocation?. *Clinical rehabilitation*, 21(12), pp.1087-1096.
- Pountney, T.E., Mandy, A., Green, E. and Gard, P.R., 2009. Hip subluxation and dislocation in cerebral palsy—a prospective study on the effectiveness of postural management programmes. *Physiotherapy Research International*, 14(2), pp.116-127.
- Pountney, T., Mandy, A., Green, E. and Gard, P., 2002. Management of hip dislocation with postural management. *Child: care, health and development*, 28(2), pp.179-185.
- Pountney, T.E., Cheek, L., Green, E., Mulcahy, C. and Nelham, R., 1999. Content and criterion validation of the Chailey levels of ability. *Physiotherapy*, 85(8), pp.410-416.
- Rodby-Bousquet, E., Persson-Bunke, M. and Czuba, T., 2016. Psychometric evaluation of the Posture and Postural Ability Scale for children with cerebral palsy. *Clinical rehabilitation*, 30(7), pp.697-704.

Rodby-Bousquet, E., Ágústsson, A., Jónsdóttir, G., Czuba, T., Johansson, A.C. and Hägglund, G., 2014. Interrater reliability and construct validity of the Posture and Postural Ability Scale in adults with cerebral palsy in supine, prone, sitting and standing positions. *Clinical rehabilitation*, 28(1), pp.82-90.

Rosenbaum, P., Paneth, N., Leviton, A., Goldstein, M., Bax, M., Damiano, D., Dan, B. and Jacobsson, B., 2007. A report: the definition and classification of cerebral palsy April 2006. *Developmental medicine and child neurology. Supplement*, 109, pp.8-14.

Sarathy, K., Doshi, C. and Aroojis, A., 2019. Clinical examination of children with cerebral palsy. *Indian journal of orthopaedics*, 53(1), p.35.

Scrutton, D., 2008. Position as a cause of deformity in children with cerebral palsy (1976). *Developmental Medicine & Child Neurology*, 50(6), pp.404-404.

White E. 1999. Wheelchair Users and Postural Seating: a Clinical Approach. *British Journal Occupational Therapy*, 07;62(7), pp.333-334.

World Health Organization, 2007. *International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY*. World Health Organization.

Table II: Reliability data for selected body alignment posture

Instrument	Study	Participant	Internal (Cronbach's)	Test-retest	Intrarater	Interrater
Chailey Levels of Scale (Chailey)	(Pountney et al,	2 sample	Not	Not	Not	Not
		85 children with CP aged 18 months- 18 years				
Goldsmith index of windswept deformity.	(Goldsmith et al, 1992)	30 children with no disabilities. 29 CP children aged 4.5 – 19 years				
		50 children and adults, 25 with movement difficulties (CP N= 14 age range <10 – 30y), 2 without disabilities. Ages <10– 48 years.	Not	Not	Not	Not
Goldsmith indices	(Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009)	None given	Not	Not	Not	Not
Mansfield check list	(Goldsmith, 2000)	31 CP children aged 9 months – 19 years (N=15 male, 16 female). Families of participating children.	Not	Not	Not	Not
Posture and Posture ability Scale (PPAS)	(Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014)	29 children with CP aged 6-16 years (N=15 male, 14 female).	0.95-		0.85-0.99	Weighted Kappa: 0.99
Spinal Alignment and Range of Motion Measure (SAROMM)	(Bartlett and Purdie, 2005)	25 children with CP aged 12-18 years (N=17 male, 8 female).		ICC:0.93 SEM:3.0		ICC: 0.89
Seated Postural Control Measure (SCPM)	(Field and Roxborough, 2011; Fife et al, 1991)	2 raters with 5 years' experience. 2 seated conditions with 40 children (n=19 CP)		Kappa Alignment = Function =		Kappa Alignment = Function =

ICC, Intraclass correlation coefficient; SEM, standard error of

For ease of interpretation a traffic light colour scheme is utilised; Green indicated a good level of evidence, amber indicated adequate level, red indicated poor and blue denoted not

Table III: Validity data for selected body alignment posture assessments

Instrument	Study	participants	Content validity	Criterion validity	Construct Validity
Chailley Levels of Ability Scale (Chailley)	(Pountney et al, 1999)	2 sample groups. 85 children with CP aged 18 months - 18 years. 30 children with no disabilities. 29 CP children aged 4.5 – 19 years.	Limited Literature (articles n=2). Assessment Review by a panel of (n=2) clinically observers. Field among CP children	Compared with the Alberta Motor Scale (AIMS) and Motor Function (GMFM). Pearson Moment correlations GMFM = 0.85 AIMS =	Not reported
Goldsmith index of windswept deformity.	(Goldsmith et al, 1992)	50 children and adults, 25 with movement difficulties (CP N= 14 age range <10 – 30y), 25 without disabilities. Ages <10– 48 years.	Not reported	Not reported	Not reported
Goldsmith indices	(Goldsmith and Goldsmith, 2009; Goldsmith et al, 2009)	None given	Not reported	Not reported	Not reported
Mansfield check list	(Goldsmith, 2000)	31 CP children aged 9 months – 19 years (N=15 male, 16 female). Families of participating children.	Not reported	Not reported	Not reported
Posture and Posture ability Scale (PPAS)	(Rodby-Bousquet et al, 2016; Rodby-Bousquet et al, 2014)	29 children with CP aged 6-16 years (N=15 male, 14 female).	Not reported	Not reported	Ability to detect gradations disability compared with Motor Function Scale ($p<0.01$)
Spinal Alignment and Range of Motion Measure (SAROMM)	(Bartlett and Purdie, 2005)	25 children with CP aged 2-18 years (N=17 male, 8 female).	Not reported	Not reported	Ability to detect gradations disability compared with Motor Function Scale ($r^2=0.44$)
Seated Postural Measure (SCPM)	(Field and 2011; Fife et al, 1991)	40 children (n = 19 CP)	Assessment reviewed panel of experts	Not reported	Not reported

For ease of interpretation a traffic light colour scheme is utilised; Green indicated a good level of evidence, amber indicated adequate level, red indicated poor and blue denoted not