Refinement, Reliability, and Validity of the Segmental Assessment of Trunk Control

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Purpose: The Segmental Assessment of Trunk Control (SATCo) provides a systematic method of assessing discrete levels of trunk control in children with motor disabilities. This study refined the assessment method and examined reliability and validity of the SATCo. **Methods:** After refining guidelines, 102 video recordings of the SATCo were made of 8 infants with typical development followed longitudinally from 3 to 9 months of age and 24 children with neuromotor disability with a mean age of 10 years 4 months. Eight researchers independently scored recordings. **Results:** Intraclass correlation coefficient values for interrater reliability were more than 0.84 and 0.98 across all data sets and all aspects of control. Tests of concurrent validity with the Alberta Infant Motor Scales resulted in coefficients ranging from 0.86 to 0.88. **Conclusion:** The SATCo is a reliable and valid measure allowing clinicians greater specificity in assessing trunk control. **(Pediatr Phys Ther 2010;22:246–257)** *Key words: activities of daily living, child, developmental disabilities, diagnositic techniques and procedures, infant, motor skills disorders, postural balance, psychometrics, reliability and validity, spine*

INTRODUCTION AND PURPOSE

The ability to control sitting balance gradually emerges in children with typical development (TD) during the period from about 2 to 9 months of age, with head control developing first, followed by progressive development of trunk control.[1-5] In children with neuromotor disability, development of sitting balance is delayed, and depending on the level of disability, children may continue to show constraints on sitting balance throughout their lives, with some never gaining independent control of the trunk and head.[6-10]

Laboratory tests of sitting and standing balance control in both children with TD and children with neuromotor disability have examined 3 aspects of balance control, all of which are important to mastering functional balance and reaching skills involved in activities of daily living. These include tests of (1) static or steady-state balance, examining the child's ability to maintain a steady posture without support; (2) active or anticipatory balance adjustments, examining the child's ability to balance while reaching; and (3) reactive balance, examining the child's ability to maintain or regain balance following a brief perturbation, such as a translation of the base of support.[10,11]

Previous research on the development of sitting balance models the entire trunk as a single unit, ignoring the fact that the trunk is made up of many muscular and skeletal subunits.[1,3-5] This approach does not take account of the neuromuscular coordination that must be achieved to sit independently, including coordinating the many sacral, lumbar, abdominal, thoracic, and cervical muscles used in maintaining equilibrium.[12,13]

To determine the constraints on balance abilities in children with neuromotor disabilities and to determine

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whether rehabilitation therapies are efficacious in improving balance in these populations, a variety of clinical movement assessments have been created. These assessment tools measure a wide range of balance functions, from sitting through walking abilities, and incorporate evaluation of trunk control as one of the subtests within the assessment.[14,15] Although these tools are helpful in assessing balance control as a broadly defined ability, they have limitations in the assessment of sitting balance. In common with the research studies on balance development, they also tend to model the entire trunk as a single unit. This approach ignores the fact that development of trunk control in sitting may occur in a progressive manner, with initial development of head control, followed by gradual incorporation of thoracic, lumbar, and sacral segments. Treatment directed at improving control of the trunk as a whole, rather than identifying and addressing problems within the various trunk subsections, may contribute to the difficulty in improving trunk control and sitting balance that is seen in the child with more severe motor disability.[16]

For example, trunk stability is assessed in terms of the child's general ability to sit quietly or to move in and out of a sitting position.[17] Thus, the Gross Motor Function Measure (GMFM)[14,15,18] and Chailey Levels of Ability[19,20] include items for quiet sitting, which comprise measures of trunk control but do not differentiate between different levels of trunk control. The Slump Test[21] is a more specific test of trunk control, evaluating treatment efficacy over time; yet, it also limits trunk control measurement to sitting trunk angles, pelvic tilt, and kyphosis. Similarly, the Seated Postural Control Measure includes assessment of pelvic, trunk, and head inclination but does not examine subunits of trunk control.[22] A more recent assessment tool, the Spinal Alignment and Range of Motion Measure, evaluates the child's ability to actively or passively achieve alignment of the cervical, thoracic, or lumbar spine.[23] However, most of these tests assess only static (steady state) and active (or anticipatory) balance control through evaluation measures of ability to hold a particular posture or to reach for an object while in that posture. Thus, they do not include the ability to recover balance (reactive control), an important aspect of balance control in activities of daily living.

A more recent clinical evaluation tool for assessing the degree of trunk control[24,25] was designed to approach the assessment of trunk control by considering the many subunits that must be coordinated to achieve control when sitting and to include tests of static, active, and reactive control. It is based on the biomechanics of control of vertical trunk posture.[26] It tests the child's trunk control as the evaluator progressively changes the level of trunk support from a high level of support at the shoulder girdle to assess cervical (head) control, through support at the axillae (upper thoracic control), inferior scapula (mid thoracic control), lower ribs (lower thoracic control), below the ribs (upper lumbar control), pelvis (lower lumbar control), and, finally, no support, in order to measure full trunk control. This evaluation tool has the advantage over the previously mentioned tools of assessing all 3 aspects of trunk control: (1) static (or steady state) control, (2) active (or anticipatory) control, and (3) reactive control (maintaining or regaining trunk control following a threat to balance produced by a brisk nudge). This test, now called the Segmental Assessment of Trunk Control (SATCo), enables a more in-depth analysis of a child's trunk control abilities, and in turn, this enables a new perspective on the treatment of deficiencies of trunk control. Current tools that assess the trunk as a single unit will inevitably lead to treatment methods that address the trunk as a single unit. A test such as the SATCo allows close definition of the level at which trunk control difficulties present and leads to a "level-by-level" treatment approach to the development of trunk control.

Although this test has been used clinically by staff at The Movement Centre for the past 13 years, consistent methods of administration and guidelines for scoring the SATCo were required for general use by clinicians. Although interrater reliability study had been conducted (87% point-by-point agreement),[24] the test has not been rigorously tested for inter- and intrarater reliability, validity, or its sensitivity. Thus, the purpose of this study is (1) to refine the SATCo to ensure consistent methods of administration and guidelines for scoring, (2) to examine its reliability, and (3) to examine its concurrent validity.

METHODS

The data for this study were generated as part of an ongoing study of trunk control that examined both infants developing typically and children with motor disabilities. As part of this larger study, parents were invited to share their child's SATCo video data between 2 research teams, one at The Movement Centre and the other at the University of Oregon.

The assessment procedure and the score form are detailed in Appendix 1 and also available online at www.the-movement-centre.co.uk. For each trunk segmental level, static, active, and reactive control are scored as present, absent, or not tested (NT). Static control is credited if the child can maintain a neutral trunk posture above the level of hand support; active control is credited if the child can maintain a neutral posture during head movement; and reactive control is credited if the trunk above the support remains stable during an external perturbation (a nudge). It should be noted that, depending on the child evaluated, these various aspects of control may or may not be simultaneously present at the same or even at adjacent levels. The child's ability to maintain or quickly regain a vertical position of the unsupported trunk in all planes is assessed during testing of static, active, and reactive control, and accordingly scored as present or absent. The nudge is applied once from each principal direction (front, back, left, and right), and the point of nudge application remains at the same horizontal level throughout. This means that as the support level is lowered, the number of joints free of support, which thus require control, will increase. At the same time, the disturbing moment increases at the joint directly above the support as the length of the moment arm increases. In cases when vertical collapse of the trunk (where the center of mass of the head remains within the base of support) is noted during administration of the test, an additional, true sagittal video view is recommended. This aspect is discussed in greater detail in the "Results" section.

Participants

Study participants were a cohort of 8 infants with TD, each of whom was followed twice a month from 3 to 9 months of age to capture the period during which independent sitting was acquired, and 24 children with neuromotor disability (1 year 6 months to 17 years 1 month; mean age, 10 years 4 months). The ratio of males to females was 1:1 both for the infants with TD and for the children with neuromotor disability. Table 1 shows subject demographics for the children with neuromotor disability. Both the Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System levels are given to describe each child's functional level more fully. The inclusion criterion was neuromotor disability resulting in problems of postural control in sitting. No specific exclusion criteria were applied. Infants with TD were recruited by advertisement within the University of Oregon, and the children with neuromotor disability were recruited by advertisement to medical and educational professionals throughout the state of Oregon. The study was conducted in accord with the Declaration of Helsinki guidelines and had ethical approval from the Human Subjects Committee at the University of Oregon. Written consent to participate in research and use data in publication was obtained from participants and/or their legal guardians prior to data collection.

Raters

Both research teams were involved as raters both for the refinement phase and for the reliability evaluation. The raters thus included 3 physical therapists—1 with 27 years of experience in pediatrics who had previous exposure to the test, 1 with 20 years of experience in pediatrics who originally created the assessment, and 1 with 6 years of experience in pediatrics with clinical experience using the test—a physical therapist assistant with 7 years of experience and experience in clinical use of the test; 1 graduate and 3 undergraduate research assistants studying Human Physiology, none of whom had clinical background; and a professor (Department of Human Physiology) with more than 30 years of experience in posture control research.

TABLE 1
Subject Demographics

Subject	Age	Sex	Diagnosis	Mobility Skill Level (Gross Motor Function Classification System)[a]	Manual Skill Level (Manual Ability Classification System)[b]
1	8 y 5 mo	M	CP spastic quadriplegia/dystonia	5	5
2	11 y 2 mo	F	CP asymmetric quadriplegia	5	4
3	1 y 6 mo	F	Neurodevelopment delay/cortical visual impairment	4	Too young
4	7 y 8 mo	M	CP spastic quadriplegia/dystonia	4	3
5	15 y 3 mo	M	CP spastic triplegia/dystonia	4	4
6	11 y 8 mo	F	Neurological deficit postencephalitis Upper and lower motor neuron lesions	4	3
7	7 y 6 mo	M	CP spastic quadriplegia	5	5
8	12 y 4 mo	F	CP spastic quadriplegia	4	3
9	9 y 10 mo	M	CP spastic quadriplegia/extrapyramidal	5	5
10	6 y 6 mo	M	CP hypotonia/seizure disorder	5	4
11	6 y 7 mo	F	CP spastic quadriplegia	5	4
12	16 y 4 mo	F	CP extrapyramidal dystonia	4	5
13	8 y 10 mo	F	CP spastic quadriplegia	4	3
14	4 y 3 mo	F	CP hypotonia/mild dystonia/cortical visual impairment	5	4
15	5 y 0 mo	F	Aicardi syndrome, severe visual impairment	5	5
16	8 y 1 mo	M	CP spastic quadriplegia/seizure disorder	5	4
17	8 y 7 mo	F	CP spastic diplegia	4	4
18	12 y 5 mo	M	CP spastic quadriplegia/seizure disorder	4	4
19	8 y 1 mo	M	CP spastic diplegia/seizure disorder	3	3
20	17 y 1 mo	M	CP spastic diplegia	1	2
21	17 y 0 mo	F	CP spastic diplegia	2	3
22	16 y 7 mo	F	CP extrapyramidal	1	2
23	14 y 1 mo	M	CP asymmetric diplegia	1	1
24	14 y 0 mo	M	CP spastic diplegia/seizure disorder	3	2

Abbreviation: CP, cerebral palsy.
[a]www.canchild.ca.
[b]www.macs.nu.

Procedure

The refinement phase of the project consisted of an initial 6-month pilot period commencing October 2007, in which 30 video assessments, including both infants with TD and children with neuromotor disability, were used to aid further development of this measure. These video assessments were additional to those that were used for reliability testing but drawn from the same groups of children. Numerous discussions occurred between the research teams at The Movement Centre and the University of Oregon about uncertainty and discrepancies in scoring specific children, which contributed to the process of ensuring consistent methods of administration and guidelines for scoring the SATCo. This process continued until consensus was reached. Interactive oral presentations were then given to pediatric therapists in both clinical and educational settings. Audience comments and suggestions were used to further refine the SATCo instructions.

The second phase of the project was to test the reliability of the refined measure. Data analysis for reliability purposes included a total of 102 assessments, all of which were evaluated by at least 6 of the raters over a 6-month period commencing April 2008. Forty-three of the assessments consisted of data collected from the 8 infants with TD. The remaining 59 assessments were from 24 children with neuromotor disability, with 2 or 3 tests for each child spread evenly over a 6-month period. Raters had no knowledge of previous scores. Each assessment was recorded on video and scored retrospectively and independently by each rater. No video assessments generated for this study were excluded. The raters observed the physical behavior of the child during the SATCo and scored the assessment on the basis of the set of detailed instructions (Appendix 1) and established rules (Appendix 2) that resulted from the refinement phase. Data and comments for each level of support were documented on the assessment form. At the end of the assessment, the rater produced a summary indicating the level(s) of trunk support at which static, active, and reactive control was lost. For the purpose of reliability testing, each trunk level was assigned a numerical value by designating head control as 1, upper thoracic control 2, through to lower lumbar control 7, and full trunk control 8. Following reliability testing, video review was conducted for each assessment in which either “present” control or “absent” control was spread over 4 or more adjacent levels among the 6 to 8 raters. This was repeated for static, active, and reactive control. As an example, one rater may have assessed loss of static control at upper thoracic level, another at lower thoracic level, and a third at upper lumbar level. From this review, possible sources of rater discrepancy were identified.

For the purposes of establishing validity, the Alberta Infant Motor Scale (AIMS)[27] was completed at the same time SATCo video recordings were made in 52 sessions with the 8 infants with TD. The Sitting Dimension (B) of the GMFM was video-recorded at the same session as a SATCo recording of the 24 children with neuromotor disability. The Mobility Domain (Child scores and Caregiver scores) of the Pediatric Evaluation of Disability Inventory (PEDI)[28] was also administered at this session.

Statistical Analysis

The intraclass correlation coefficient (ICC) was chosen as the most appropriate for this inter- and intrarater reliability study. The random set Shrout-Fleiss[29] ICC(2, 1) assumes that the variance of interest is the variance due to the difference in subjects, whereas the residual variance is the variance due to the difference in raters. The raters (minimum of 6 raters for each of the 102 videos) are assumed to be a random sample of a greater population of raters. An intraclass correlation of 0.75 or more was considered acceptable for all reliability coefficients and is comparable with other reported measures of motor function in children with neuromotor deficits.[15] Intrarater reliability was evaluated by 2 raters rescoring the same 22 randomly selected videos (10 infants with TD and 12 children with neuromotor disability). For this analysis, time was considered a “fixed” factor (time 1 and time 2) and subjects and raters were considered random factors. An ICC analysis was then completed comparing time 1 with time 2 across both raters and all aspects of control. A Pearson product moment correlation coefficient was used to examine the concurrent validity between the SATCo and the functional tests of the AIMS and GMFM Dimension B. Correlation was also examined between the SATCo and the GMFCS and the PEDI Mobility Domain to establish whether the SATCo reflected the severity of neuromotor disability.

RESULTS

Refinement Phase

The final version of the SATCo form and scoring guidelines are given in Appendixes 1 and 2.

Reliability of the SATCo

Interrater reliability was excellent for the total data set at 0.84 and for both subsets of infants with TD and children with neuromotor disability (Table 2). Intrarater

TABLE 2
Reliability Statistics[a]

	Interrater Reliability		
	Static ICC(2, 1)	Active ICC(2, 1)	Reactive ICC(2, 1)
Total data set	0.84	0.84	0.84
Infant with TD	0.88	0.85	0.88
Children with neuromotor disability	0.80	0.82	0.80

Abbreviations: ICC, intraclass correlation coefficient; TD, typical development.
[a]Shrout-Fleiss ICC for Segmental Assessment of Trunk Control scores (static, active, and reactive) for combined data set and for each subgroup (infants with TD and children with neuromotor disability). Raters: n = 8. Videos: infants with TD (n = 43), children with neuromotor disability (n = 53).

reliability was also excellent at 0.98 across all data sets and aspects of control.

Complete agreement of raters occurred across each of the trunk levels defined in Appendix 1 for 17% of assessments. Review of these assessments with complete agreement in scores (present or absent) indicated that children with either definite control or total loss of control at a specific level were easier to score. Where control loss was distributed throughout the trunk, for example with loss of reactive control at upper thoracic level but loss of static control at upper lumbar level, scoring was subject to more discrepancy between scorers. Inspection of those assessments in which scores spread over 4 or more adjacent levels (12% of videos) revealed similar sources of rater discrepancy in infants with TD and children with neuromotor disability. In these cases, children used a variety of strategies to assist in balance when trunk control became compromised. Discrepancy in scores was attributed to poor methodology in conducting or scoring the SATCo (Appendix 2): (1) failure of the supporting therapist to adequately align and extend the trunk; (2) failure of raters to note compensatory strategies used by the child, particularly of trunk alignment and hand placement; and (3) failure of raters to accurately determine the level of control being assessed in children with immaturity of the skeletal structure (ribs not yet elongated) and/or obscuration by adipose tissue. Two additional areas of disagreement occurred only in rating children with neuromotor disability: (1) discriminating loss of head control from habitual posture and (2) difficulty in discriminating between true loss of trunk control and head movement/posture related to cortical visual impairment. Children with cortical visual impairment may use a preferred head posture such as side flexion of the cervical spine to maximize their visual abilities.

The use of compensatory strategies was noted when trunk control was compromised, and interestingly, both groups of children used similar strategies with no strategy unique to either group (see Appendix 2). Strategies were incorporated by infants with TD primarily at the level where control became compromised with total loss of control occurring if support was further lowered. However, in some children with neuromotor disability, strategies incorporated at one level could be continued below this level giving an illusion of greater control than actually existed. The 3 most commonly observed strategies were (1) using hands for support (Figure 1), (2) inclining the trunk forward or backward (Figure 2), and (3) vertically collapsing into excessive kyphosis and/or lordosis (center of mass of head remained centered over the base of support) (Figure 3).

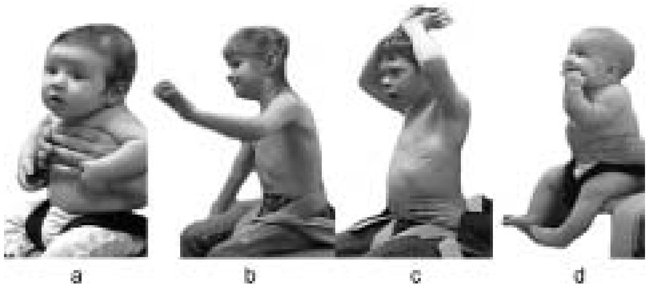

Fig. 1. Strategies for gaining support from hands and arms included exerting pressure from arms or hands against the evaluator's hands (a), placing a hand on the bench (b) or on any part of the child's own body (legs, trunk, head/mouth, or other arm) (c and d) that has the effect of cross-bracing the trunk.

Fig. 2. Strategies of inclining the trunk forward or backward allow a child to reduce the complexity of active control.

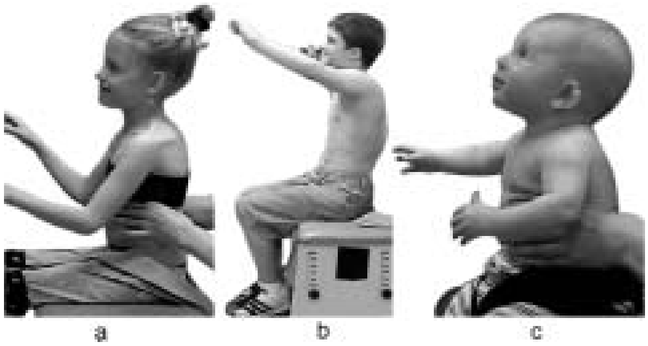

Fig. 3. Collapsing the trunk over several specific segments was an active strategy rather than a passive collapse that presented as either a generalized rounding or with angulation. It can feature throughout the trunk as lordosis or kyphosis. This strategy was used more frequently in children with neuromotor disorder and seen briefly in only 1 infant with typical development.

Validity of the SATCo

The Pearson product moment correlation coefficient showed high correlation with all 3 aspects of control and the AIMS and GMFM Dimension B (Table 3). The high correlation with the GMFCS and the Mobility Dimension of the PEDI show that the SATCo reflects the severity of disability and motor function.

DISCUSSION

The SATCo is a clinical evaluation tool that tests a child's trunk postural control as the evaluator progressively reduces the level of trunk support from full support to free sitting. The purpose of this study was to ensure consistent methods of administration and guidelines for scoring the SATCo and to examine its reliability and concurrent validity. Evidence has been provided, showing that

TABLE 3
Concurrent Validity Statistics[a]

	Static Control	Active Control	Reactive Control
Infants with TD (n = 8)			
Alberta Infant Motor Scales (for infant videos) (sitting portion)	0.883	0.860	0.868
Children with neuromotor disability (24 children and 21 with cerebral palsy)			
Gross Motor Function Measure-66 Dimension B (sitting)	0.833	0.773	0.731
Gross Motor Function Classification System	−0.817	−0.726	−0.705
PEDI Mobility Domain Child	0.803	0.717	0.695
PEDI Mobility Domain Caregiver	0.784	0.691	0.656

Abbreviations: PEDI, Pediatric Evaluation of Disability Inventory; TD, typical development.
[a]Pearson correlation is shown between Segmental Assessment of Trunk Control scores (static, active, and reactive) and functional tests of sitting behavior (for infants with TD and for children with neuromotor disability). $P < .01$.

the SATCo is a reliable and valid clinical measure that can be used with infants with TD or children with neuromotor disabilities. This level of reliability confirms that the administration and scoring instructions are clear and consistent. The SATCo has the advantage that it allows documentation of trunk control in children who have not yet achieved independent sitting as well as those who are able to sit. It has excellent reliability both in infants with TD and in children with neuromotor disability. The high validity correlation strengthens the results presented showing that the SATCo reflects function and ability.

The limitations of this test are that specific equipment is necessary to administer the test accurately (see Appendix 1). This equipment includes a bench of appropriate height, which preferably has a strapping system attached to it to ensure that the child's pelvis is maintained in a neutral position. However, it is possible to support the smaller, lightweight child manually and maintain pelvic position without a strapping system. Two testers are needed, and the use of a video camera is helpful for later review of the test. Although the nudge used in the reactive component of the SATCo will vary between evaluators, provided that the nudge is brisk and not a gentle tap, the reaction of the child can still be assessed with confidence. When the test is used in the clinical situation, it is often the same evaluator who applies the nudge, giving a more consistent assessment.

To assess the reliability of a scaled measure, it is important to include assessments from children with a broad range of abilities. This data set had a minimum of 3 outcomes for each aspect of control (static, active, and reactive) for each level of support and thus allowed reliability assessment across the full range of trunk control (Table 2). It should be noted that the subset of data from infants with TD was secured from an ongoing longitudinal study that recruited infants at 3 months of age, by which time head control had been established. It was not felt reasonable to recruit infants below this age and thus infants with TD are less represented at the uppermost level of control.

Reliability studies commonly use a limited number of experienced or highly trained raters. Four of the raters in this study had no clinical background. All raters either had previous experience or were trained to administer SATCos during the pilot period of development of the test. Reliability might have been challenged by the inclusion of a large number of raters, some of whom had no clinical background, but ensured the development of clear and definitive scoring guidelines. The fact that raters had some training to administer SATCos may be perceived as a limitation to generalization of this test since they have more experience with the assessment than clinicians who might choose to use the assessment. However, provided that clinicians are diligent in following the test protocol and instructions, it is anticipated that they could reach the same inter- or intrarater reliability as reported for this study without extensive training or practice.

The results of this study suggest that scoring might be improved by providing raters with prior information regarding the presence of visual impairment, with recommendation to score the test on the basis of trunk alignment without regard for head position. Although, in this study only vertical collapse into thoracic kyphosis was observed, the first author noted a neutral thoracic posture, with vertical collapse into lumbar lordosis or lumbar kyphosis as an alternative strategy, particularly in children who become ambulatory.

Although the SATCo does not look at a "real-life" situation of sitting ability or take account of environmental or contextual influences, it contributes to the understanding of the child's specific disability. Current functional assessments of static and dynamic ability to sit provide some inference of trunk control,[16,20] whereas more specific tests of sitting posture[21,23] document static and active trunk alignment. None of these tests has directly assessed the level of control within the trunk. The SATCo complements and extends currently available tests by allowing discrete assessment of static, active, and reactive trunk control in children with and without the ability to sit independently. In addition, the SATCo allows reliable assessment of trunk control in very young children and/or children with cognitive deficits since little is required of the children in terms of cooperation.

In the context of the International Classification of Functioning, Disability and Health, the SATCo is a body function measure. A deficit in trunk control, defined by the SATCo, is likely to influence activity limitations and participation restrictions. It will affect all activities of mobility and will extend to major life areas such as education, because poor trunk control will affect stability of the head in space, thus affecting visual skills, eye-hand coordination, and reach and hand function. Poor trunk control may also interfere with eye contact and efficient respiratory support for verbalization and thus may adversely influence social interaction. Although compensatory strategies such as trunk collapse or hand support can be of value in daily functioning, the SATCo seeks to define the true level of trunk control. This will help to explain some of the functional limitations seen. For example, a child with control problems in the lower lumbar level is likely to be able to sit independently, if insecurely, whereas a child with control problems in the upper thoracic level will have much greater functional loss and be unable to sit independently. The more detailed information about control of the trunk provided by the SATCo helps with treatment planning, which can then be directed at improving control in the specific area of deficit rather than treating the trunk as a single unit. Once control has been acquired at the uppermost level of loss, therapy can then be directed at the next level of control loss in a caudal direction. This has been shown to be an effective strategy for gaining independent sitting ability in children with severe neuromotor disability.[24] The SATCo also allows a finer-grained documentation of progress, particularly if progress is slow.

A model of motor control will influence both assessment and treatment.[11] The value of assessing trunk control in this way, level by level, is that it can influence treatment planning, which can apply not only to the treatment of deficiencies of trunk control but also to activities in which trunk posture will be influential. The technique of analyzing trunk control on a level-by-level basis enhances observational skills so that knowledge of trunk control and trunk posture is incorporated into more generalized assessments, for example, of gait or upper limb activities. At The Movement Centre, the treatment of trunk control problems has coevolved on a level-by-level basis with this assessment tool.[24,25] Specially designed therapy equipment is adjusted to give support at the appropriate level determined by the SATCo and progressed by lowering the top support height of equipment according to the change in the SATCo. The clinical results achieved are most encouraging (see www.the-movement-centre.co.uk), and independent research into this method of treating trunk control problems is currently in process. As interest in this method of treatment increases, and manufacturers consider making the equipment generally available, knowledge and use of the SATCo by therapists will become increasingly important. The underlying philosophy of this assessment and treatment goes beyond specific therapy sessions and will affect, for example, classroom seating and/or standing frames to maximize trunk control training in a variety of situations.

The evidence presented here supports the use of the SATCo as a valid discriminative tool. To use it for evaluative purposes, sensitivity to change must be demonstrated. Testing for responsiveness in infants with TD and children with neuromotor disability is currently in progress.

CONCLUSIONS

The SATCo has been shown to be a reliable and valid clinical measure of trunk control in infants with TD as well as children with neuromotor disability, with overall scores for reliability of more than 0.80. The assessment provides a discrete examination from head control through thoracic, lumbar, and, finally, full trunk control and documents static, active, and reactive control at each level tested. An advantage of the SATCo is that it can be used for children with a broad range of abilities including those with more severe motor and cognitive deficits. By discriminating the specific level and aspect of trunk control, this assessment provides therapists with valuable information for creating an effective rehabilitation program.

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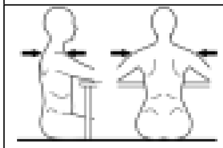
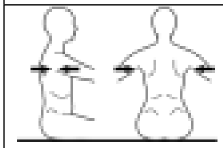
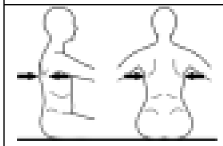
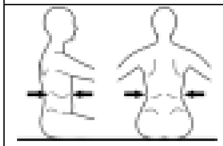
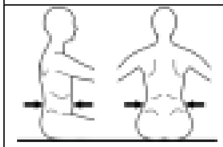
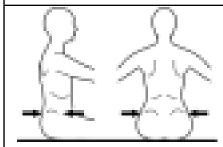
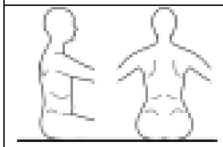
Appendix 1

Assessment of Trunk Control

Client Name: Ref #: Tester Name: Date:	**Level of Manual Support** Pelvic/thigh strap used except as indicated	**Functional Level** Arms and hands in air except as indicated	**Static**	**Active**	**Reactive**	**Comments**
			Maintain vertical neutral position of head and trunk above manual support level			
			minimum of 5 seconds	while turning head with arms lifted	Maintain/quickly regain following brisk nudge	
	Shoulder girdle Testers hand position may vary from horizontal	**Head control** Arms may be supported throughout			**NOT Tested for Head Control**	
	Axillae	**Upper Thoracic Control**				
	Inferior scapula	**Mid Thoracic Control**				
	Over lower ribs	**Lower thoracic Control**				
	Below ribs	**Upper lumbar Control**				
	Pelvis	**Lower lumbar Control**				
	No support given and pelvic/thigh straps removed	**Full trunk control**				

Fixed spinal deformity? Yes________No________Comments____________________________
Limitation of Cervical Rotation Left________Right________Comments____________________________

Instructions

Subject: The subject is seated on a bench, feet supported on the ground or on a stable surface and pelvis/thigh position controlled by the strapping system. The pelvis is orientated to neutral relative to vertical. The subject is supported in an upright posture "sitting up tall" with the presence of normal cervical, thoracic and lumbar curves. The head is upright. The subject's hands and arms should be free of all external contact including with own trunk, thighs, bench or the tester's arms/hands throughout the test except as indicated. The subject's hands should not be joined together.

Tester: The tester applies firm manual support horizontally around the trunk at each of the designated levels in turn.

The support given should be sufficient to ensure that the trunk is in a neutral vertical posture and that any collapse of the trunk is eliminated. The subject's hands/arms should be lifted so that they there is no contact with the subject's body or legs, the bench or the tester's hands. Toys can be used to motivate a child ensuring that the child stretches/turns towards the toy but does not grasp it. At each support level the tester encourages the subject to sit up tall and lift the hands/arms during testing of a) **static** control, b) **active** control, by turning the head slowly to each side (>45° or to limitation of range) and c) **reactive** control by remaining stable during nudges. This requires an assistant to apply a single brisk nudge from front (manubrium/sternum), from behind (~C7), and from each side (acromion) using the fingertips, sufficient to briefly disturb balance. If a subject has minimal balance impairments they sway excessively but can return to vertical. If, however, they have moderate to severe balance impairments they lose balance and go to the limits of their range of motion. The test continues with lowering of support level until the subject clearly cannot maintain or quickly return to the starting posture. The tester should be behind the subject, usually in kneeling depending on the size of the subject and height of the bench and the assistant ideally out of line of the subject's vision.

Scoring: At each level of support the presence (✓) or absence (–) of control is recorded. 'NT' indicates Not Tested. Presence of control is shown by:

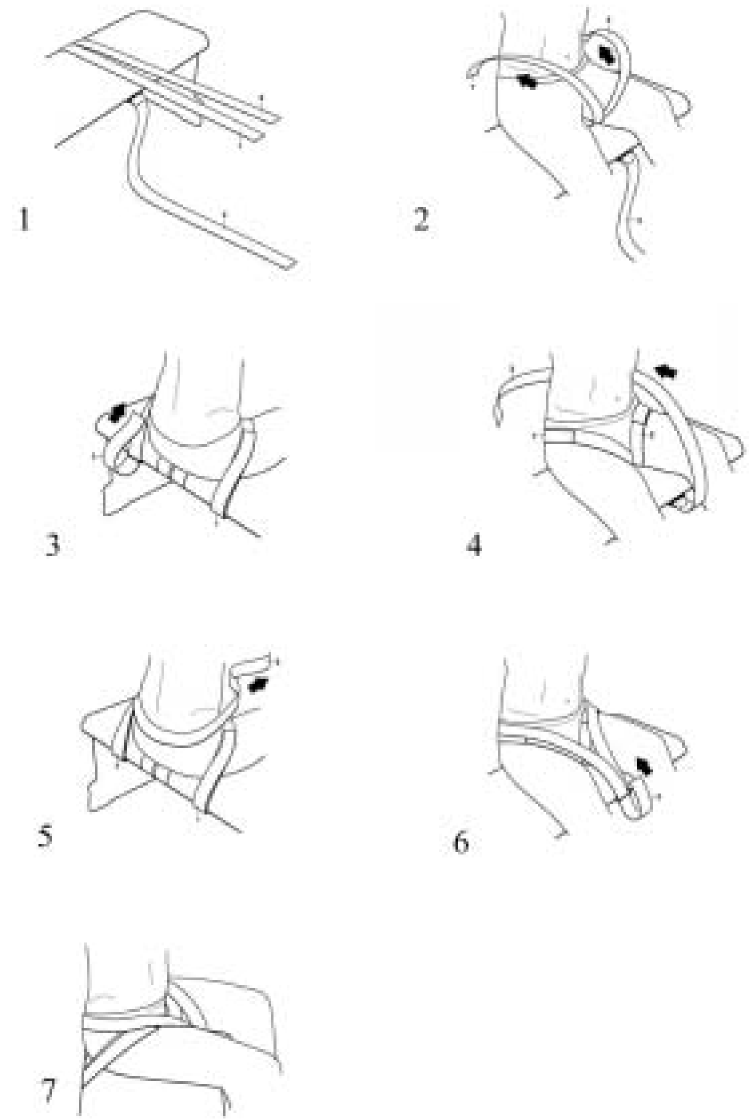
Static: maintains a neutral vertical trunk posture in the sagittal and frontal planes for five seconds. If the subject's attention is briefly lost, accompanied by a head turn, but a vertical position is maintained, this is still scored as presence of control.

Active: may be slight displacement from neutral (<20°) but realigns immediately by most direct route e.g. trunk flexion is corrected by extending to a neutral trunk posture rather than by circling through trunk side flexion.

Reactive: subject will move away from neutral vertical but quickly returns to upright by most direct route.

Optional Video Instructions: If video is available it is recommended that the assessment be videotaped. This secures visual documentation for future reference and also allows review of the test in case of ambiguity in scoring. If video tape is used, a camera set up at a 45 degree angle to the subject will usually allow movement to be judged from the front and side views sufficient to detect movement strategies.

Strapping Instructions: Three straps and three D rings should be firmly attached to the underside of a bench to allow the subject to be strapped to the bench as follows. Pull the thigh straps forward across the top of the bench. Subject should sit on the bench with the thigh straps underneath them. Pull each strap up from between the subject's legs, over the top of the thigh through each D ring loop at the back of the bench and secure snugly. Next, pull the pelvic strap up from the front of the bench, wrap it behind the subject's pelvis and back down through the D ring loop at the front of the bench. Keep the strap low enough to pull against the sacrum and do not allow it to slide up to the lumbar area. Adjust the tightness of this strap until the pelvis is aligned vertically. The purpose of the strap is only as 'another pair of hands' to ensure the pelvis is vertical.



Appendix 2
Scoring Guidelines

Definition of Control: Stable neutral vertical alignment (brief deviation no more than 20°) in both frontal and sagittal planes (eyes level). Allow for normal cervical, thoracic, and lumbar curves.

You score only what you see: If control is not demonstrated, score as absence of control (−) or not tested (NT). If you believe the child has control but performance demonstrating control cannot be elicited and a compensatory strategy persists during testing, then it must be scored NT. Likewise, if the tester made an error of alignment that prevents assessment of true vertical control, it must be scored NT. NT should always contain a comment regarding the nature of the error for future reference.

Watch for compensatory strategies, which may indicate a lack of normal control

- **Hand support**
  - On bench
  - In mouth
  - On body (own or tester's)
  - Together (on toy/object or clasped)
  - On toy/object held by the tester
- **Trunk alignment**
  - Leaning forward
  - Arching backward over manual support
  - Collapse beyond normal curves

- **Movement strategies**
  - Stiffening (rigidity with lack of movement of the trunk above the level of support)
  - Rapid movement rather than a slower controlled movement, for example, of the head

Critical tester errors:

- **Hand support**
  - Not horizontal
  - Not stable
- **Trunk alignment**
  - Trunk below support not held vertical and/or trunk collapse not eliminated
- **Movement**
  - Poor placement and/or magnitude of nudge
  - Nudge during nonvertical alignment

Critical scorer errors leading to incorrect determination of control level:

- Immaturity of the skeletal structure (ribs not yet elongated)
- Obscuration by adipose tissue
- Discriminating loss of head control from habitual posture
- Discriminating loss of control from head movement/posture related to cortical visual impairment

Level of Control Specification:

- The focus is to determine the highest level at which subject demonstrates loss of control and this is scored as absent control (−)
- Not tested (NT) at a level above a check mark (✓ control present) is counted as having control at that level
- Not tested (NT) at a level below check mark is counted as loss of control at that level
- If static balance is NT but subject held the alignment during reactive or active, then static is given credit as having control (✓)