6-8-2020

Psychometric Properties of Segmental Assessment of Trunk Control in Infants and Toddlers With Down Syndrome.

Megan Flores
University of St. Augustine for Health Sciences, mflores@usa.edu

Katy Mitchell
Texas Woman's University, kmitchell@twu.edu

Christina Bickley
Texas Woman's University, cbickley@twu.com

Carolyn P. Da Silva
Texas Woman's University, cdasilva@usa.edu

Recommended Citation

Flores, M., Mitchell, K., Bickley, C., & Da Silva, C. P. (2020). Psychometric Properties of Segmental Assessment of Trunk Control in Infants and Toddlers With Down Syndrome. Pediatric physical therapy. Advance online publication. https://doi.org/10.1097/PEP.0000000000000708

Pediatric Physical Therapy

Psychometric properties of Segmental Assessment of Trunk Control in infants and toddlers with Down syndrome

--Manuscript Draft--

Manuscript Number:	PED-PT-D-19-00152R2
Full Title:	Psychometric properties of Segmental Assessment of Trunk Control in infants and toddlers with Down syndrome
Article Type:	Research Report
Corresponding Author:	Megan Flores, PhD University of St. Augustine for Health Sciences Austin, TX UNITED STATES
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	University of St. Augustine for Health Sciences
Corresponding Author's Secondary Institution:	
First Author:	Megan Flores, PhD
First Author Secondary Information:	
Order of Authors:	Megan Flores, PhD
	Katy Mitchell, PhD
	Carolyn P Da Silva, DSc
	Christina Bickley, PhD
Order of Authors Secondary Information:	
Abstract:	Purpose : To investigate infants and toddlers with Down Syndrome (DS) to determine: 1) reliability of the Segmental Assessment of Trunk Control (SATCo), 2) concurrent validity of the SATCo with Gross Motor Function Measure (GMFM), and 3) whether age and SATCo predict GMFM. Methods : Eighteen children with DS were tested on the SATCo by two physical therapist (PT) raters. One PT rater administered GMFM. After 2 weeks, PT raters re-scored their recorded SATCo sessions. A third PT rater also scored the SATCo videos. Results : Interrater reliability of the SATCo was moderate to good and intrarater reliability was good to excellent. The SATCo and GMFM had good to excellent significant correlations. Age and SATCo score were significant predictors of GMFM. Conclusions : Trunk control appears to play a central role in gross motor function of infants and toddlers with DS. The SATCo can be used in this population.

Psychometric properties of Segmental Assessment of Trunk Control in infants and toddlers with Down syndrome.

Authors: Megan Flores, PT, PhD; Katy Mitchell, PT, PhD; Christina Bickley, PT, PhD, BOCO, c/NDT; Carolyn P Da Silva, PT, DSc

Author affiliations: University of St. Augustine for Health Sciences (Dr. Flores), Austin, Texas, United States; Texas Woman's University (Dr, Mitchell, Dr. Bickley, Dr. Da Silva), Houston, Texas, United States

Conflict of Interest Statement: The authors declare no conflict of interest

Correspondence: Megan Flores, University of St. Augustine for Health Sciences, 5401 La Crosse Ave, Austin, TX 78739. Email: mflores@usa.edu

Grant support: This study was supported by a grant from the Academy of Pediatric Physical Therapy (Mentored Research Grant April 2018)

At the time this research was conducted, Megan Flores was a PhD student at Texas Woman's University, Houston, Texas, United States.

ACKNOWLEDGEMENTS: This study would not have been possible without the dedication of Christie Fryatt, PT, DPT, Kelli Croll, PT, DPT, and Simran Gutierrez, PT, DPT. The authors would like to thank the children and families who participated in this study, as well as Jessica Crosby, Abey Oommen, and Adedolapo Adegboyega for their assistance in data collection.

ABSTRACT

Purpose: To investigate infants and toddlers with Down Syndrome (DS) to determine: 1) reliability of the Segmental Assessment of Trunk Control (SATCo), 2) concurrent validity of the SATCo with Gross Motor Function Measure (GMFM), and 3) whether age and SATCo score predict GMFM score.

Methods: Eighteen infants and toddlers with DS were tested on the SATCo by two physical therapist (PT) raters. One PT rater administered GMFM. After 2 weeks, PT raters re-scored their recorded SATCo sessions. A third PT rater also scored the SATCo videos.

Results: Interrater reliability of the SATCo was moderate to good and intrarater reliability was good to excellent. The SATCo and GMFM had good to excellent significant correlations. Age and SATCo score were significant predictors of GMFM.

Conclusions: Trunk control appears to play a central role in gross motor function of infants and toddlers with DS. The SATCo has good psychometric properties in this population.

What This Adds to the Evidence: This study contributes to the literature on the psychometric properties of the SATCo and supports its use to measure trunk control in infants and toddlers with DS between the ages of six to 24 months.

INTRODUCTION AND PURPOSE

Down syndrome (DS) is a genetic condition that occurs in approximately 1.26 per 1,000 live births in the United States.[1] Infants and toddlers with DS display deficits in gross motor skills and postural control.[2-4] Although children with DS follow the same predictable sequence of motor development as their typically developing peers, they require twice as much time to acquire basic motor skills.[3] Many infants with DS display trunk hypotonicity with decreased trunk strength and postural control.[5] Postural control at the trunk is a precursor to the development of upright gross motor skills;[6] however, the association between trunk control and gross motor function in children with DS is not clearly understood. To date, few articles have investigated this association in children with DS.

Standardized tools specifically for infants and toddlers with DS are limited. Physical therapists should employ effective, reliable tools to measure the incremental changes that occur in infants and toddlers with DS at various levels of the World Health Organization's *International Classification of Functioning, Disability and Health* (ICF).[7,8] The Gross Motor Function Measure-88 (GMFM) has been shown to be a reliable and valid measure of motor skills at the activity level of the ICF for children with DS.[9-11] However, there is a paucity of research on outcome measures of trunk control at the body structure and function level of the ICF for infants and toddlers with DS. The Segmental Assessment of Trunk Control (SATCo) shows promise as a quick and easy tool that can be employed by pediatric physical therapists in any setting to measure changes in trunk control in infants and toddlers with DS.[12]

Initial psychometrics indicate the SATCo is a good measure of discrete levels of trunk control in different populations.[12] Reliability and validity of the SATCo was originally

determined by rating eight typically developing children and 24 children with neuromotor disability; however none of the children in the sample had a diagnosis of DS.[12]

Hansen et al[13] examined the reliability of the SATCo in children with cerebral palsy (ICC ≥ 0.9); and Cardoso de Sa et al[14] studied the interrater reliability of the SATCo for children with Duchenne muscular dystrophy using the kappa statistic ($\kappa = 0.90$, 95% CI = 0.83, 1.00). Both articles found the SATCo to be a reliable outcome measure for these populations.[13,14] To our knowledge, reliability of the SATCo has not been analyzed in children with DS.

Most of the research exploring the relationship of trunk control and gross motor function has been performed in children with cerebral palsy. Mendoza et al[15] found a significant correlation between sitting ability (as measured by the Level of Sitting Scale) and the capacity to walk (as measured by the Gross Motor Function Classification Scale) in children with cerebral palsy.[15,16] Although the results are interesting, walking ability does not capture the full range of gross motor function in children.

Curtis et al[17] explored the relationship between the SATCo and GMFM in children with cerebral palsy. They determined that both SATCo level and age were significant predictors of gross motor function as measured by the GMFM. Additionally, Butler et al[12] found a significant correlation between the SATCo and the sitting dimension of the GMFM in children with neuromotor disabilities. These studies both demonstrate an apparent relationship between gross motor function and trunk control, but none of the research included children with DS. For infants and toddlers with DS, the relationship between trunk control and gross motor function has not yet been investigated.

The purpose of this study was to investigate infants and toddlers with DS to determine: 1) interrater, intrarater, and live versus video reliability of the SATCo, 2) concurrent validity of the

SATCo with the GMFM, and 3) whether a model of staggered entry with age and SATCo score predicts GMFM score.

METHODS

Study Design

A methodological study on a single group of children with DS was conducted. Dual Institutional Review Board approval was received [redacted]. Written informed consent was obtained from the parents of all the participants prior to testing.

Participants

To obtain an ICC of 0.7 at 80% power, a sample size of 10 participants is required to detect statistical significance at $p = 0.05$ for reliability studies.[18] For an effect size of 0.7, power of 0.8, and $p = 0.05$, a sample of 11 participants is required for a Pearson correlation test and a sample of 18 participants is required for linear regression.[*] Therefore, 18 participants (6 female, 12 male) with DS were recruited from parent support groups, early intervention programs, and outpatient clinics. The average age of the participants was 13.67 months old (SD = 5.31). To participate in the study, participants had to be between the ages of six to 24 months, have a diagnosis of DS, and speak and understand English (as determined by the initial conversation about the study). Participants were excluded from the study if they had a diagnosis unrelated to DS that limited gross motor movement, or medical restrictions that contraindicated movement or handling. The participants represented a wide range of gross motor function abilities. Eleven participants were able to maintain sitting without external support for at least a short amount of

[*] G*Power Version 3.1.9.2, Franz Faul, Universitat Kiel, Germany

time, with seven participants unable to maintain static sitting without support. Four participants were able to take few steps with assistance.

Instruments

The SATCo is an outcome measure used to assess discrete levels of trunk control in children with motor disabilities.[12] To complete this assessment, the child is seated on a bench with the pelvis held in a neutral position, either with a strapping system or with assistance from a second person. The tester gives manual support at specific landmarks, starting at the shoulder girdle and moving segmentally down the trunk through seven segmental levels of control. Static trunk control (seven items), active trunk control (seven items), and reactive trunk control (six items) at each level are recorded, for a total of 20 items. The tester gives the child a score of present (✓), absent (-), or not tested (NT) for each item.[12] Control is demonstrated by the child's ability to maintain a neutral posture for static control, maintain neutral posture during head turns for active control, and maintain or quickly regain neutral posture during perturbations for reactive control. Segmental levels increase as the examiner's hands move down the trunk. The highest segmental level at which a child maintains control in all categories is recorded as the level of trunk control. Higher levels indicate better trunk control with less support needed from the tester. The highest score, Level 7, is given when no support is needed, and pelvis support is removed.[12] For this study, children were given one point for each item in which trunk control was marked "present," resulting in a score range of zero to 20 for the items, and zero to seven for the highest level of control.[27] See Figure 1 for the SATCo score sheet and levels.

The GMFM was developed to measure gross motor function in children with cerebral palsy and can be used for children with DS under six years old.[9,19,20] The examiner scores a child's capabilities across five dimensions of functional movement: A) Lying and Rolling, B)

Sitting, C) Crawling and Kneeling, D) Standing, and E) Walking, Running, and Jumping. Each dimension is made up of several items (88 total items) with a total possible score of 264. For each item, the child receives a score of 0 (does not initiate), 1 (initiates), 2 (partially completes), or 3 (completes). The GMFM can be administered uniquely to children with DS by direct observation of the child supplemented with parent report.[10,11] For children with DS, the GMFM has strong interrater reliability (ICC = 0.96 to 0.98) and test-retest reliability (ICC = 0.95 to 0.96), with evidence of responsiveness and validity with the Motor Scale of the Bayley Scales of Infant Development.[11,21]

Procedure

Three experienced physical therapist raters (PT raters) with at least five years working in pediatric physical therapy participated in data collection. Prior to recruiting child participants, the PT raters were given the SATCo protocol, score sheet, and supporting literature to review. The PT raters attended a training session with the principal investigator (PI) to ensure consistency of scoring. At the training session, the PI explained the outcome measure and the PT raters watched a video demonstration of the SATCo. The PI and the PT raters discussed common testing errors and possible compensatory strategies that children with DS might employ. The PT raters demonstrated their competence with the SATCo by performing and scoring the outcome measure on a live volunteer child with DS.

Each child participant was tested on the SATCo by two different PT raters (PT Rater 1 and PT Rater 2). Testing occurred on one day with at least 30-minutes of separation between SATCo testing sessions. Each PT rater was randomly assigned to testing during the first or second session. To ensure consistency of testing, the participants were tested in the same environment, using the same research assistants, equipment, and toys. Each PT rater tested the

child on the SATCo through all seven levels (as long as the child was safe), which lasted about five to 10 minutes. Children were video recorded from the front and the side during each testing session. After a period of at least two weeks, PT Raters 1 and 2 re-scored their own SATCo testing sessions by watching themselves test each participant in the video recordings. This method was chosen rather than completing a second administration to account for maturation effects and to decrease the possibility of the children becoming familiar with the test. PT Rater 3 did not perform live testing but watched and scored the videos for PT Rater 2. Figure 2 shows the reliability comparisons for this study.

Additionally, the GMFM was administered to all participants by PT Rater 2 at the same session as the SATCo administration. The GMFM was performed with the modifications recommended by Russell et al[9] and Gemus et al[11] for children with DS. These included the use of parent report if the child refused to perform an item and the use of verbal cues or demonstration.[11]

Data Analysis

Each item in the SATCo was given one point if control was considered "present." The columns were summed to reveal a score for static control (maximum score = 7), active control (maximum score = 7), and reactive control (maximum score = 6). The total SATCo item score was obtained, from zero to 20, and the level of trunk control was identified, from zero to seven.

Five comparisons were made among the three PT raters. Interrater reliability was assessed by comparing the live independent ratings of PT Raters 1 and 2, live rating of PT Rater 2 versus video rating of PT Rater 3, and video ratings of PT Raters 2 and 3. To assess intrarater reliability, video recordings were re-scored by Raters 1 and 2 at least two weeks after the testing session to minimize recall bias.

Data was analyzed using IBM SPSS Statistics 25 software.[†] To be consistent with previous studies of the SATCo[12,13,22,23], reliability was calculated using Intraclass Correlation Coefficient (ICC) (2,1) estimates with 95% CI based on a single measure, absolute consistency, two-way random effects model. Reliability was assessed for each category (static, active, and reactive), overall total score, and SATCo level of trunk control. Results were interpreted as: poor (< 0.5), moderate (0.5 to 0.75), good (>0.75 to 0.9), and excellent (> 0.9).[24]

To examine the concurrent validity of the SATCo with the GMFM, Spearman's rho was calculated for each category of the SATCo, total SATCo score, SATCo level, dimension B (sitting) of the GMFM, and total GMFM score. A p-value < 0.05 was used to indicate significance. Spearman's rho correlation results were interpreted as: little or no relationship (0 to 0.25), fair relationship (> 0.25 to 0.50), moderate to good relationship (> 0.50 to 0.75), and good to excellent relationship (> 0.75).[25]

To explore whether age and SATCo scores have a predictive effect on GMFM in infants and toddlers with DS, a linear model was used:

$$\text{GMFM}_i = b_0 + b_1\text{SATCo}_i + b_2\text{Age}_i$$

Age was included in the model because gross motor growth curves from the GMFM have been shown to be related to age in children with DS.[10] To fully explore the relationships, several models of linear regression were analyzed using blocked or hierarchical entry.[26]

RESULTS

Eighteen children with DS (six female and 12 male) between the ages of six to 23 months, with a mean age of 13.67 (SD = 5.31) months participated in the study. Trunk control was assessed using the SATCo by three PT raters in live and/or video recorded sessions. The PT

[†] IBM Corporation, Armonk, New York

raters were all female with an average age of 41 years (SD = 7.94), and pediatric physical therapy clinical practice experience for an average of 11.33 years (SD = 7.09).

ICC (2,1) results are presented in Table 1. Interrater reliability was moderate to good with ICC values between 0.5 and 0.9 ($p \leq 0.013$). The highest reliability scores were obtained when PT raters re-scored their own videos taken from live testing sessions, with good to excellent intrarater reliability of the SATCo ($p < 0.001$). The interrater reliability between Rater 1 and Rater 2 reflected the lowest overall scores (ICC (2,1) ≤ 0.686). Highest scores were found in the intrarater reliability of Rater 1 (ICC (2,1) ≥ 0.806). When comparing live rating versus video recording, the interrater reliability of the SATCo remained moderate for most categories but improved to good for static control and overall total score. Across all raters, the category of static trunk control (ICC (2,1) = 0.647 to 0.922) and total SATCo score (ICC (2,1) = 0.661 to 0.941) showed the strongest reliability. The lowest reliability was reactive trunk control (ICC (2,1) = 0.508 to 0.846).

Static (mean = 5.72, SD = 1.53), active (mean = 5.83, SD = 1.30), and reactive (mean = 4.22, SD = 1.59) categories of the SATCo, as well as the composite SATCo total score (mean = 16.06, SD = 4.01) and SATCo Level (mean = 5.22, SD = 1.59) were compared to GMFM Dimension B score (mean = 34.44, SD = 20.75) and GMFM total score (mean = 98.83, SD = 45.88). Dimension B of the GMFM represents the child's ability to maintain static and dynamic sitting. Spearman's rho correlations revealed a good to excellent significant relationship ($r_s > 0.75$, $p < 0.001$) among all comparisons. Correlation values are presented in Table 2.

A hierarchical model was used to determine if SATCo level has a predictive effect on GMFM total score beyond what age predicts. In this model, age accounted for 63% of the variation in GMFM total score and SATCo total score accounted for an additional 17%. To

further explore the data, another hierarchical model was used with SATCo total score as the primary predictor and age as a secondary predictor. This model showed that SATCo total score accounted for 71% of the variation in GMFM total score and age accounted for an additional 9%. Both models revealed a significant regression equation (F[2,15] = 30.45, $p < 0.001$). The raw coefficients for the predictive equation for both models were as follows: $GMFM_i$ = -53.22 + (6.40 x SATCo total score) + (3.61 x Age).

Models using block entry of the single predictors of age or SATCo level were consistent with the hierarchical models, demonstrating 63% and 71% of the variance in GMFM total scores, respectively. When analyzing the opposite model, the single predictor of GMFM total score also predicted 71% of the variance in SATCo total score. Block entry of the single predictors of age (R = 0.82, R^2 = 0.67, F[1,16] = 31.89, $p < 0.001$) and SATCo total score (R = 0.86, R^2 = 0.74, F[1,16] = 46.599, $p < 0.001$) had a significant predictive effect on Dimension B (Sitting) of the GMFM. Results of the linear regression models are shown in Table 3.

DISCUSSION

The SATCo is a measure of segmental trunk control for children with neuromotor disabilities. This study expands upon previous psychometric studies of the SATCo and informs clinicians about the reliability of this tool for infants and toddlers with DS.[12-14,17,22,27] Clinically, the SATCo appears to be a useful tool for children with DS with good to excellent intrarater reliability and moderate to good interrater reliability among PT raters. The SATCo may prove more useful when used by the same clinician to monitor and document incremental changes in trunk control in infants and toddlers with DS. In previous published research, the relationship of trunk control and gross motor function in infants and toddlers with DS has not been fully explored. This study provides evidence that segmental trunk control, as measured by the SATCo,

shows a strong correlation to gross motor function, as measured by the GMFM. The authors recommend clinicians attend an online or in-person training course prior to implementing the SATCo in clinical practice.

Agreement among raters was highest for the older children who demonstrated full trunk control. Some variability between raters was observed by the PI in the testing sessions. Rater 1 appeared to be more lenient with scoring. Rater 3, who only watched videos and did not participate in any of the live testing sessions appeared to have a stricter, more narrow view of trunk control that was "present." Butler et al[12] found good to excellent reliability among all categories of the SATCo; however, raters had previous experience with development or administration of the SATCo, which may account for the higher reliability results.[12] The PT raters in our study, although experienced clinicians who all attended training on the SATCo, had no previous exposure to the SATCo.

When the participants with DS had difficulty maintaining trunk control, they often used subtle compensations such as clasping their hands together, bringing both hands to the mouth, or hyperextending the cervical spine with increased thoracic flexion. PT raters experienced difficulty in observing these compensations while sitting behind the wiggling participants. Pin et al[22] suggest having a trained assistant vigilantly monitor and report these small compensations during the testing session. Both raters were skilled at handling children with DS, patiently allowing the children to attempt the item to the best of their ability before moving on to the next item.

Additionally, the participants may have performed differently for Rater 1 than for Rater 2. The children may have experienced increased fatigue, or they may have become more familiar with the testing procedure after the first session.

The SATCo and the GMFM are measurements at two different levels of the ICF model.[7,8] The SATCo is a quick and easy assessment to perform, taking a fraction of the time that it takes to perform the full GMFM. The SATCo could be a valuable complementary measure for infants with DS who has a functional goal related to sitting. Clinicians may want to consider that the SATCo requires a second person if a strapping system is not used to secure the child's pelvis.

A predictive effect of trunk control on gross motor function was found for infants and toddlers with DS. All linear regression models showed that the SATCo was a significant predictor of GMFM total score. This evidence indicates trunk control is an important factor for determining gross motor function in infants and toddlers with DS.

This study builds upon similar work done by Curtis et al[17] in children with cerebral palsy. Our results indicate that as a single predictor, age accounted for a large amount of the variance in GMFM total score. Regardless of whether hierarchical or blocked entry was used for the regression models, both SATCo and age remained significant predictors for children with DS who were less than 24 months of age.

All three raters for this study were blinded to each other's scores and their own previous scores. Data was analyzed by the PI, who did not perform any of the scoring for this study. This study had a strong research design with a diverse sample of participants of various ages and abilities.

Study Limitations

A more rigorous training session with several live child demonstrations and more hands-on practice could have decreased the variability in scoring among the PT raters for control that was "present" or "absent" in infants and toddlers with DS. The addition of more than one training session may also have improved testing consistency among the raters. Scores for the live

testing sessions were obtained immediately after administration. The developers of the SATCo suggest using a video recording to review and assist with scoring.[12] Good to excellent reliability was found by several authors when video recordings were used to score the SATCo.[12,13,22] Perhaps allowing the PT raters to view their video and score the SATCo within one day of administration would have improved overall interrater reliability of the tool. Test-retest reliability was not assessed in this study, since a second administration by the same rater was not completed.

Given the narrow age range for inclusion, recruitment of participants was difficult. Therefore, the sample size for regression analysis was relatively small. Caution should be used in generalizing the results for the wider population of infants and toddlers with DS. Although construct validity was found for the SATCo in children with DS, this study did not demonstrate that the SATCo differentiates trunk control in infants with DS compared to their typically developing peers. Future studies should focus on further investigating the psychometric properties of the SATCo in infants and toddlers with DS. For example, clinicians would benefit from information on the responsiveness of the SATCo, including the possibility of performance variability, and the predictive ability of the SATCo for functional mobility in children with DS.

WHAT THIS ADDS TO THE EVIDENCE

This study contributes to the literature on the psychometric properties of the SATCo and supports its use to measure trunk control in infants and toddlers with DS between the ages of six to 24 months.

REFERENCES

1. de Graaf G, Buckley F, Skotko BG. Estimates of the live births, natural losses, and elective terminations with down syndrome in the united states. *Am J Med Genet A*. 2015(4):756-768.

2. Shumway-Cook A, Woollacott MH. Dynamics of postural control in the child with down syndrome. *Phys Ther*. 1985;65(9):1315-1322.

3. Kim HI, Seong WK, Kim J, Jeon HR, Jung DW. Motor and cognitive developmental profiles in children with down syndrome. *Ann Rehabil Med*. 2017;41(1):97-103.

4. das Neves Cardoso AC, de Campos AC, dos Santos MM, Cabrera Santos DC, Ferreira Rocha, NAC. Motor performance of children with down syndrome and typical development at 2 to 4 and 26 months. *Pediatr Phys Ther*. 2015;27(2):135-142.

5. Martin K, Inman J, Kirschner A, Deming K, Gumbel R, Voelker L. Characteristics of hypotonia in children: A consensus opinion of pediatric occupational and physical therapists. *Pediatr Phys Ther*. 2005;17(4):275-282.

6. Westcott SL, Burtner P. Postural control in children: Implications for pediatric practice. *Phys Occup Ther Pediatr*. 2004;24(1):5-55.

7. International classification of functioning, disability and health - children and youth version. ICF-CY. geneva: World health organization; 2007.

8. Fay D, Brock E, Peneton S, et al. Physical therapists' use and alteration of standardized assessments of motor function in children. *Pediatr Phys Ther*. 2018;30(4):318-325.

9. Russell D, Palisano R, Walter S, et al. Evaluating motor function in children with down syndrome: Validity of the GMFM. *Dev Med Child Neurol*. 1998;40(10):693-701.

10. Palisano RJ, Walter SD, Russell DJ, et al. Gross motor function of children with down syndrome: Creation of motor growth curves. *Arch Phys Med Rehabil*. 2001;82(4):494-500.

11. Gemus M, Palisano R, Russell D, et al. Using the gross motor function measure to evaluate motor development in children with down syndrome. *Phys Occup Ther Pediatr*. 2001;21(2):69-79.

12. Butler PB, Saavedra S, Sofranac M, Jarvis SE, Woollacott MH. Refinement, reliability, and validity of the segmental assessment of trunk control. *Pediatr Phys Ther*. 2010;22(3):246-257.

13. Hansen L, Erhardsen KT, Bencke J, Magnusson SP, Curtis DJ. The reliability of the Segmental Assessment of Trunk Control (SATCo) in children with cerebral palsy. *Phys Occup Ther Pediatr*.2018;38(3):291-304.

14. Cardoso de Sa, Cristina dos Santos, Fagundes IK, Araujo TB, Oliveira ASB, Favero FM. The relevance of trunk evaluation in duchenne muscular dystrophy: The segmental assessment of trunk control. *Arq Neuropsiquiatr*. 2016;74(10):791-795.

15. Mendoza SM, Gómez-Conesa A, Montesinos MDH, Montero Mendoza S, Hidalgo Montesinos MD. Association between gross motor function and postural control in sitting in children with cerebral palsy: A correlational study in spain. *BMC Pediatrics*. 2015;15(1):1.

16. Fife SE, Roxborough LA, Armstrong RW, Harris SR, Gregson JL, Field D. Development of a clinical measure of postural control for assessment of adaptive seating in children with neuromotor disabilities. *Phys Ther*. 1991;71(12):981-993.

17. Curtis DJ, Butler P, Saavedra S, et al. The central role of trunk control in the gross motor function of children with cerebral palsy: A retrospective cross-sectional study. *Dev Med Child Neurol*. 2015;57(4):351-357.

18. Bujang MA, Baharum N. A simplified guide to determination of sample size requirements for estimating the value of intraclass correlation coefficient: A review. *Arch Orofac Sci*. 2017;12(1).

19. Russell DJ, Avery LM, Rosenbaum PL, Raina PS, Walter SD, Palisano RJ. Improved scaling of the gross motor function measure for children with cerebral palsy: Evidence of reliability and validity. *Phys Ther*. 2000;80(9):873-885.

20. Russell DJ, Rosenbaum PL, Wright M, Avery LM. *Gross motor function measure (GMFM-66 & GMFM-88) user's manual.* Hamilton, Ont. McMaster University 2013; 2nd ed; 2013.

21. Nourbakhsh MR, Ottenbacher KJ. The statistical analysis of single-subject data: A comparative examination. *Phys Ther*. 1994;74(8):768-776.

22. Pin TW, Butler PB, Cheung H, Shum SL. Segmental assessment of trunk control in infants from 4 to 9 months of age- a psychometric study. *BMC Pediatr*. 2018;18(182).

23. Craddock D, Shen E, Monti G. Measurement of reactive and anticipatory balance in children with cerebral palsy: A new tool for community based practice. *Physiotherapy*. 2015;101(2013):e276.

24. Koo TK, Li MY. Cracking the code: Providing insight into the fundamentals of research and evidence-based practice: A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med*. 2016;15:155-163.

25. Watkins MP, Portney LG. *Foundations of clinical research : Applications to practice.* Upper Saddle River, NJ:Prentice-Hall, Inc.; 3rd ed; 2009.

26. Field AP. *Discovering statistics using IBM SPSS statistics : And sex and drugs and rock 'n' roll.* 4th ed. Thousand Oaks, CA:Sage; 2013.

27. Argetsinger LC, Trimble SA, Roberts MT, Thompson JE, Ugiliweneza B, Behrman AL. Sensitivity to change and responsiveness of the segmental assessment of trunk control (SATCo) in children with spinal cord injury. *Dev Neurorehabil*. 2018:1-12.

FIGURE LEGENDS

Figure 1. SATCo Score Sheet with Levels (modified from Butler et al.).[12]

Figure 2. Five Reliability Comparisons (Three Interrater, Two Intrarater)

Figure 1

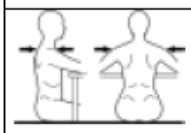
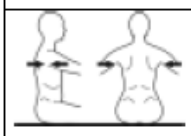
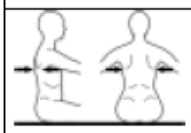
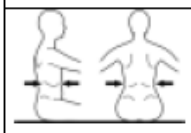
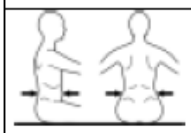
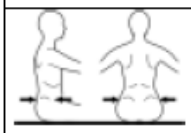
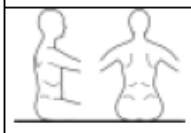
Identification #: Tester Name: Date:	**Level of Manual Support** Pelvic/thigh strap used except as indicated	**Functional Level** Arms and hands in air except as indicated	**Static** Maintain vertical neutral position of head and trunk above manual support level minimum of 5 seconds	**Active** while turning head with arms lifted	**Reactive** Maintain/quickly regain following brisk nudge	**Comments**
	Shoulder girdle Testers hand position may vary from horizontal	**Head control** Arms may be supported throughout			**NOT Tested for Head Control**	Level 1
	Axillae	**Upper Thoracic Control**				Level 2
	Inferior scapula	**Mid Thoracic Control**				Level 3
	Over lower ribs	**Lower thoracic Control**				Level 4
	Below ribs	**Upper lumbar Control**				Level 5
	Pelvis	**Lower lumbar Control**				Level 6
	No support given and pelvic/thigh straps removed	**Full trunk control**				Level 7
Fixed spinal deformity? Yes_____No_____Comments_____ Limitation of Cervical Rotation Left_____Right_____Comments_____						

Figure 2

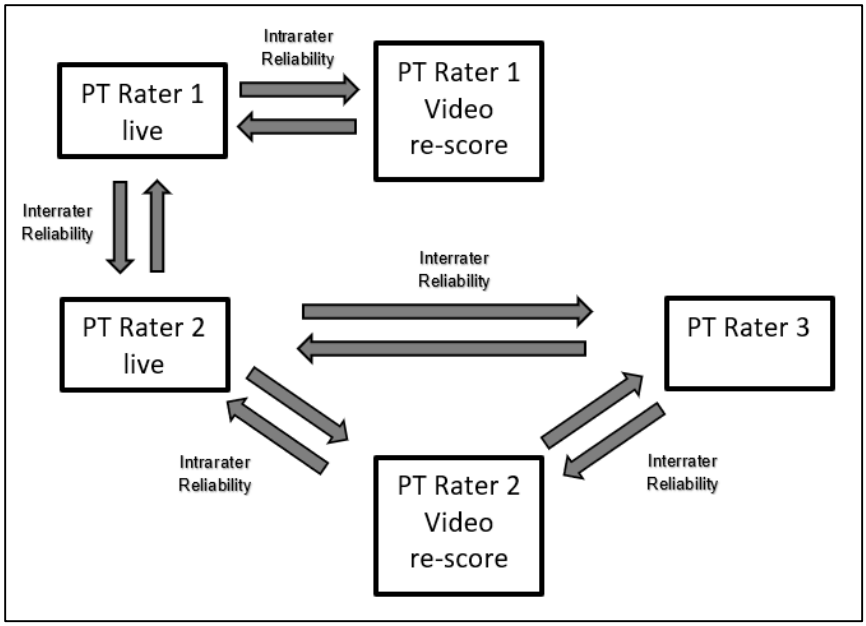

Intrarater Reliability
PT Rater 1 live
PT Rater 1 Video re-score
Interrater Reliability
Interrater Reliability
PT Rater 2 live
PT Rater 3
Intrarater Reliability
Interrater Reliability
PT Rater 2 Video re-score

Table 1

Table 1. Reliability of the SATCo Using ICC (2,1)

	Static ICC (2,1) [95%CI]	**Active** ICC (2,1) [95%CI]	**Reactive** ICC (2,1) [95%CI]	**Total Score** ICC (2,1) [95%CI]	**SATCo Level** ICC (2,1) [95%CI]
Interrater Reliability (Rater 1 vs Rater 2)	0.647 [0.272,0.852] $p = 0.001$	0.544 [0.118,0.801] $p = 0.008$	0.686 [0.336,0.870] $p = 0.001$	0.661 [0.294,0.858] $p = 0.001$	0.615 [0.221,0.836] $p = 0.003$
Interrater Reliability (Rater 2 live vs Rater 3 video)	0.852 [0.647,0.942] $p < 0.001$	0.679 [0.324,0.867] $p = 0.001$	0.549 [0.124,0.803] $p = 0.008$	0.784 [0.511,0.913] $p < 0.001$	0.568 [0.152,0.813] $p = 0.006$
Interrater Reliability (Rater 2 video vs Rater 3 video)	0.859 [0.662,0.945] $p < 0.001$	0.678 [0.332,0.866] $p = 0.001$	0.508 [0.068,0.782] $p = 0.013$	0.747 [0.441,0.897] $p < 0.001$	0.524 [0.090,0.791] $p = 0.011$
Intrarater Reliability (Rater 1 live vs Rater 1 video)	0.852 [0.648,0.0.942] $p < 0.001$	0.830 [0.602,0.933] $p < 0.001$	0.806 [0.554,0.923] $p < 0.001$	0.859 [0.662,0.945] $p < 0.001$	0.806 [0.554,0.923] $p < 0.001$
Intrarater Reliability (Rater 2 live vs Rater 2 video)	0.922 [0.803,0.970] $p < 0.001$	0.772 [0.488,0.908] $p < 0.001$	0.846 [0.635,0.939] $p < 0.001$	0.941 [0.850,0.978] $p < 0.001$	0.867 [0.679,0.948] $p < 0.001$

Table 2. Spearman's Rho Correlations (r_s)

	SATCo Static Score	**SATCo Active Score**	**SATCo Reactive Score**	**SATCo Total Score**	**SATCo Level**
GMFM Dimension B Score	0.781	0.803	0.834	0.821	0.834
GMFM Total Score	0.788	0.832	0.821	0.829	0.821

*all values significant at $p < 0.001$

Table 3. GMFM Prediction Models

Variable	*B* (SE)	*p*	*F*	R	R^2	Adjusted R^2
Block Entry Models with One Predictor on GMFM Total Score						
Age	6.87 (1.31)	<0.001	27.53	0.79	0.63	0.61
SATCo Total Score	9.63 (1.55)	<0.001	38.64	0.84	0.71	0.69
Block Entry Model with Two Predictors on GMFM Total Score						
Model 1			30.45	0.90	0.80	0.77
Age	3.61 (1.34)	0.017				
SATCo Total Score	6.40 (1.78)	0.003				
Hierarchical Models with Two Predictors on GMFM Total Score						
Model 1			27.53	0.80	0.63	0.61
Age	6.87 (1.31)	<0.001				
Model 2			30.45	0.90	0.80	0.78
Age	3.61 (1.34)	0.017				
SATCo Total Score	6.34 (1.78)	0.003				
*R^2 Change = 0.17						
Model 1			38.64	0.84	0.71	0.69
SATCo Total Score	9.63 (1.55)	<0.001				
Model 2			30.45	0.90	0.80	0.78
SATCo Total Score	6.34 (1.78)	0.003				
Age	3.61 (1.34)	0.017				
*R^2 Change = 0.09						
Block Entry Models with One Predictor on GMFM Dimension B						
Age	3.19 (0.56)	<0.001	31.89	0.82	0.67	0.65
SATCo Total Score	4.47 (0.66)	<0.001	46.59	0.86	0.74	0.73
Block Entry Models with One Predictor on SATCo Total Score						
GMFM Total Score	0.07 (0.01)	<0.001	38.64	0.84	0.71	0.70
GMFM Dimension B	0.17 (0.02)	<0.001	46.59	0.86	0.74	0.73
Age	0.51 (0.014)	0.002	13.39	0.68	0.46	0.42