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The Seated Postural & Reaching Control Test (SP&R-co) in Cerebral Palsy: A Validation Study

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Abstract

Aim: Children with moderate-severe cerebral palsy (CP) show postural control deficits that affect their daily activities, like reaching. The Seated Postural and Reaching Control test (SP&R-co) was developed to address the need for clinical measures that objectively identify dimensions of postural imbalance and corresponding reaching limitations in children with CP.

Methods: SP&R-co documentation was designed for test validity and rater training. Rater and internal consistency were examined using Cronbach's α. Reference SP&R-co score sheets of children and rater's scores were used for absolute item-by-item, average inter-rater, and intra-rater reliability. Motor classification systems and performance tests were used for construct and concurrent validity.

Results: The SP&R-co scoring showed acceptable-good consistency (α = 0.76 – 0.84). Interrelatedness of SP&R-co items was good-excellent (α = 0.82 – 0.97). The raters demonstrated fair, good, and excellent item-by-item reliability (ICC = 0.41–0.92). Inter-rater and intra-rater reliability of SP&R-co dimensions were good-excellent (ICC = 0.68 – 0.86 and ICC = 0.64 – 0.95, respectively). Construct and concurrent validity showed moderate-excellent correlations (r = 0.49 – 0.88).

Conclusions: Results provide evidence that the SP&R-co is a reliable and valid test for therapists to objectively examine and quantify seated postural and reaching control in children with CP.

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Keywords

Cerebral Palsy; Assessment; Posture; Reaching; Sitting

Cerebral palsy (CP) is the most common motor disability in childhood, with a prevalence of 2.0–3.5 per 1000 live births (Colver, Fairhurst, & Pharoah, 2014). The sub-population of children with Gross Motor Function Classification System (GMFCS) level III-V have severe sensory and motor impairments associated with other health-related issues (e.g. epilepsy, feeding, speech, vision, cognition, learning, and intellectual disabilities). Consequently, children with CP GMFCS III-V have reduced motor function and participation, level of engagement in physical activities, and involvement in educational settings (Bjornson, Belza, Kartin, Logsdon, & McLaughlin, 2008; Colver et al., 2014; Dalvand, Dehghan, Hadian, Feizy, & Hosseini, 2012; Majnemer, et al., 2008; Varni et al., 2005).

Postural control is a key problem in children with CP (Krägeloh-Mann & Bax , 2009). In children with GMFCS III-V, seated postural control is a major impairment because it subsequently reduces their level of function during activities of daily living (ADLs). This population of children use wheeled mobility and adapted seating to interact with outdoor environments (Palisano, Rosenbaum, Bartlett, & Livingston, 2008). They demonstrate eye-hand dyscoordination, impaired reaching, and problems during eating, swallowing, and speaking that are primarily caused by head-trunk control deficits (Saavedra, Joshi, Woollacott, & Donkelaar, 2009; Santamaria, Rachwani, Saavedra, & Woollacott, 2016; van der Heide, Fock, Otten, Stremmelaar, & Hadders-Algra, 2005; Larnert & Ekberg, 1995). Thus, sitting postural control is a key rate-limiting factor for a broad range of activities in children with moderate-severe CP.

Postural control is a complex sensorimotor task that involves maintaining the body's position for the dual purpose of orientation (static component) and stability (dynamic component). Postural orientation refers to the ability to maintain an appropriate relationship between body segments and between the body and environment, whereas postural stability is defined as the ability to control the center of mass in relation to the base of support. The orientation and stability components of posture can be divided across four different postural dimensions: static, active, proactive, and reactive (Shumway-Cook, & Woollacott, 2017). The static and active postural dimensions are defined as the ability to control the orientation and stability components of posture under predictable and invariable conditions, like when sitting on a stable chair, or sitting and looking around to visually explore the environment. Proactive balance is the ability to control posture in advance of potentially destabilizing voluntary movements, like when lifting an arm to reach for a target. And reactive balance is the ability to recover a stable position following an unexpected perturbation, like when being bumped in a crowd. Therefore, all these dimensions are critical to acquiring and mastering functional postural control.

While there is a common agreement amongst therapists that seated postural control is critical to functional independence and participation in ADLs, a systematic review identified only four measures of sitting control with evidence of reliability, validity, and clinical applicability (Bañas & Gorgon, 2014): Pediatric Reach Test (PRT; Bartlett & Birmingham, 2003), Sitting Assessment for Children with Neuromotor Dysfunction (SACND; Reid, Schuller, & Billson, 1996), Trunk Control Measurement Scale (TCMS; Heyrman et al., 2011), and Segmental Assessment of Trunk Control (SATCo; Butler, Saavedra, Sofranac, Jarvis, & Woollacott, 2010). The PRT, SACND, and TCMS assess the static and proactive dimensions (by asking the child to reach). However, many items within these tests are beyond the functional capability of children with moderate-severe CP. One of the sections of the PRT is performed in standing position, and many items on the TCMS are based on selective movement instructions of lower limb joints and trunk (e.g. lateral flexion and rotation of pelvis) that might be hard to understand or achieve by children with moderate-severe CP. Moreover, the minimum requirement for performing these tests is to be able to sit without support. If the child fails to sit independently (which is the most common situation in children with moderate-severe CP), the PRT, TCMS, and SACND tests cannot be performed. Thus, with current assessments, how would clinicians know which postural dimensions are impaired and lead the child to experience major functional deficits? And if the child with CP cannot achieve independent sitting, how would clinicians target the trunk region so that they can offer specific support to assist or train such postural control deficits?

Of the four measures, the Segmental Assessment of Trunk Control (SATCo) may be the only one suitable to examine sitting postural control in children with moderate-severe CP (Butler et al., 2010). With the SATCo, the evaluator progressively reduces the level of trunk support to assess discrete levels of trunk control. For each trunk segmental level, the SATCo examines control in the static, active, and reactive dimensions. However, in addition to its many benefits, the SATCo has certain limitations. (1) The SATCo lacks an objective, quantitative scoring system. During the SATCo administration, the evaluator examines the static, active, and reactive dimensions at each trunk level, but scoring is classified as present, absent, or not tested, rather than measuring *performance* within the specific dimension. (2) The SATCo evaluates the static dimension at a bare-minimum time period (5s) which is unlikely to detect control deficits. (3) The SATCo does not examine the proactive dimension —the ability to control posture during destabilizing voluntary movements (i.e. reaching actions) that demand anticipatory postural adjustments (APAs). Consequently, the SATCo does not examine the bidirectional level of control between posture and reaching. (4) Lastly, the SATCo examines the reactive dimension by applying nudges; but in most situations, the child is aware of the direction and timing of the nudges, compromising the result of the assessment.

In response to the shortage of tests that quantitatively measure postural sitting control across all dimensions while systematizing the level of support provided, we developed the Seated Postural and Reaching Control (SP&R-co) test. The SP&R-co framework is built upon the principles of postural control (Horak, 2006; Shumway-Cook, & Woollacott, 2017) and fits within the body function and structure category of the International Classification of Functioning, Disability and Health: children and youth version (World Health Organization, 2007).

Like the SATCo, the SP&R-co follows a segment-by-segment approach to assess trunk control. However, the SP&R-co refines the validated conceptual and operational features of the SATCo. The SP&R-co provides evaluators with a quantitative score for the orientation and stability components of posture (Appendix A). The SP&R-co evaluates the static dimension during a time period of 20s to detect control deficits. The SP&R-co also includes proactive balance testing with an appropriate functional framework for children with moderate-severe CP. Rather than instructing the child to perform selective postural or upper extremity movements, the SP&R-co examines the child while reaching for a ball or pointing at a stimulating toy that emits a light and sound when pressed. Thus, therapists can assess children's ability to control posture in advance of destabilizing voluntary actions (reaching and pointing) *and* children's reaching performance (ability to hold a ball or point at targets) during the same item test. Lastly, the SP&R-co examines the reactive dimension via the *hold-and-release* technique, where the child is aware of the direction of the perturbation but is oblivious to *"when"* it will occur (Shumway-Cook & Woollacott, 2017).

In the current study, we investigated the use of the SP&R-co in clinical settings by evaluating its theoretical framework, reliability, internal consistency, and construct validity. We further discuss the differences in conceptualizing posture as well as the instructional and operational modifications in the SP&R-co relative to the SATCo.

METHODS

Study Design

This study used a fully-crossed experimental design (i.e. all raters scored all children). The data were generated from a sample of convenience recruited from the CP rehabilitation camps conducted at Teachers College, Columbia University, and the Institute of Neuroscience, Université Catholique de Louvain, Brussels. Both testing locations had a similar environment—a quiet, child-friendly room with no more than two people inside to avoid any possible distractions that could bias the scoring procedure. Prior to the testing, we obtained informed consent from children's caregivers and informed assent from children. This study was approved by the institutional review boards of Teachers College, Columbia University (number 13–220) and Université Catholique de Louvain (number 2013/069; Belgian register B403201316810).

Participants

The sample consisted of 19 children (mean age: 12yrs, SD: 3.0yrs) diagnosed with different CP subtypes and levels of motor function (Table 1). Even though the SP&R-co is more appropriate for children with CP and sitting control problems (GMFCS III-V), four children with GMFCS I-II were included in the study to offer the raters the opportunity to apply the entire range of SP&R-co scores and to prevent statistical negative bias due to scoring restrictions (Hallgren, 2012). Children with severe lack of attention or who were unable to follow simple instructions, such as "hold the ball" or "do not let me push you," would not have qualified for the study because they would not have been able to complete many of the items on the test.

Raters

Five pediatric physical therapists participated. Two experienced raters had seven years of practice using the SATCo in clinical settings and have expertise in postural and reaching control. The experienced raters developed the standardized score sheets. The other three raters had never used the SATCo before and were trained in using the SP&R-co by the experienced raters.

Manual and Training Methods in the SP&R-co Test

The definition and development of the SP&R-co construct, postural dimensions and its norms to describe all postural/reaching control domains was a progressive step-by-step refinement process (Figure 1). The SP&R-co documentation includes a manual (Appendix A), a score sheet (Appendix B), and a document that summarizes the rationale for scoring the postural/reaching domains that comprise each of the four postural dimensions (Appendix C).

As an inclusion criterion, the three trained raters had to attend two in-person training sessions of 2 hours administered by the two experienced raters. In the first session, experienced raters offered a basic clinical description about CP. They provided a more detailed definition of sitting posture (orientation and stability), reaching control, test administration, and standard procedures for video examination with the SP&R-co. Then, trained raters were encouraged to read the manual before the second meeting in which they all examined a representative child with GMFCS-IV across 3 levels of support: over-shoulder, axillae, and below-lower ribs. During testing of the representative child, trained raters used the summarized scoring-procedure rationale document to experience a real-time video-examination. Ratings were then discussed as a group.

Administration of the SP&R-co

Administering the SP&R-co requires a stopwatch, standard basketball (24cm in diameter and 0.6kg) and a toy (height: 5.5cm, width: 4cm, and button: 1cm) that emits sounds or lights to encourage the child to elicit purposeful reaches. The SP&R-co is performed with the child sitting and pelvis firmly strapped to an adjustable bench with two lateral handles located within reaching distance and at the height of the child's lower ribs (Figure 2). Child's feet are in contact with the ground with hips, knees and ankles flexed 90°. Any foot/hand orthoses are allowed. Two examiners are required for performing the SP&R-co test. One examiner administers the items of the test while the other provides manual support on the trunk sub-regions assessed (see Butler et al., 2010 for details about strapping and segmental trunk support). Time to complete the entire assessment is approximately 30 minutes.

A video camera is not required, but it is highly recommended for scoring and testing review. The SP&R-co score may be 0 ("*absent motor behavior*"), 1 (*"impaired motor behavior"*) or 2 (*"normal motor behavior*"). Because *"normal movement*" cannot be practically conceptualized, the category "normal" just refers to the child's ability to accomplish the postural and reaching behavioral criteria established in the SP&R-co manual. Any postural/reaching behavior between a postural failure and "normal" is scored as 1. A domain might also be *Not Tested* (NT) for any reason other than lack or absence of postural/reaching control, such as inadequate instruction compliance, attention-to-task deficits, or cognitive impairments that prevent full understanding of the instructions. The examiner registers the number of items categorized as NT for clinical reference and SP&R-co scoring corrections.

Rating Procedure

One of the experienced raters performed simultaneously the SP&R-co and SATCo assessments for concurrent validity analysis. Other clinicians provided data from additional tests and raters were blinded to their scores. All raters used video-assessments for SP&R-co scoring to ensure systematization, repeatability, and reduce the variability owed to multiple *in-situ* subject assessments (Wagner, Davids, & Hardin, 2016). Two video cameras were used to capture lateral and frontal views and were synched onto a single video. Experienced raters used video-assessments to create the standardized score sheets. Trained raters then used the summarized rationale-scoring procedure document and a hard copy of the score sheet during video-assessments. Trained raters were instructed to play the videos at regular speed and complete the SP&R-co assessment of a child within the same day.

Construct and Concurrent Validity

Motor classification systems and measurement scales commonly applied in CP rehabilitation were used to address construct validity: the Gross Motor Function Measure-66 (GMFM-66), Gross Motor Functional Classification System (GMFCS), the Manual Assessment Classification System (MACS), the Jebsen-Taylor Test of Hand Function (JTTHF), and the Box & Blocks (B&B). The GMFM-66 evaluates gross motor function across 5 dimensions: A, Lying and Rolling; B, Sitting; C, Crawling and Kneeling; D, Standing; and E, Walking, Running and Jumping (Russell, Rosenbaum, Wright, & Avery, 2013). The GFMCS comprises 5 levels that describe the functional abilities of the child, emphasizing sitting, walking and wheeled mobility (Palisano et al., 1997). The MACS categorizes how children manipulate objects during ADL depending on their functional independence (Eliasson et al., 2006). The JTTHF assesses arm function while practicing diverse functional reaching tasks and the B&B provides a summary score for the number of blocks transferred over a partitioned box in one minute (Taylor, Sand, & Jebsen, 1973; Mathiowetz, Volland, Kashman, & Weber, 1985). In these two tests, both the more-affected (MA) and less-affected (LA) upper extremities were tested. Currently, there is no clinical *"gold standard"* to examine sitting control in children with CP. Thus, the SATCo was used to analyze concurrent validity (Butler et al., 2010).

Data Analysis

In three children, we could not examine the SP&R-co items for all levels of support because of technical limitations ($n = 2$) and because of the child's lack of compliance ($n = 1$). These three children were excluded from construct and concurrent validity analyses (because the total SP&R-co score was unavailable) but considered for reliability and internal consistency analyses. We recruited three additional children to increase our sample size to 16 for performing construct and concurrent validity analyses (see last three cases in Tables 1 and 2).

Statistical package SPSS 25 (*IBM, 2016*) was used. Reference values for interpretation of statistical outcomes have been published elsewhere (Cohen, 1960; Hallgren, 2012). The α rate was set at 0.05 to test statistical significance. Score consistency among the three trained raters was examined with Cronbach's α. Following a paired-rater design (reference and trained rater's SP&R-co scores), an intraclass correlation coefficient (ICC), two-way mixed effects, absolute agreement, single measurement model, was used to test item-by-item reliability. Similarly, an ICC two-mixed, absolute agreement, average measures analysis was applied to define the mean error magnitude of trained raters in SP&R-co dimensions compared to the reference SP&R-co summed scores. The latter ICC model was also used to examine intra-rater reliability at two different time points, with one month between assessments. Trained raters re-assessed 30% of the data (10 dimensions) in 10/16 children. Ten children was based on a priori sample size calculation to obtain a Pearson's correlation coefficient of 0.80, with a power of 0.85 at a two-tailed alpha level of 0.05. Note that the sample size calculation was likely conservative because the ICC is considered to be more powerful than the Pearson correlation coefficient (Kraemer & Korner, 1976). The 10 selected children were pseudorandomized to ensure that raters were re-scoring children from different GMFCS categories. ICC coefficients were interpreted as fair (ICC = 0.40 to 0.59), good (ICC = 0.60 to 0.74), or excellent (ICC = 0.75 to 1) (Hallgren, 2012).

Cronbach's α was also used to address internal consistency and determine if the postural/ reaching domains, which are intended to measure the same construct, produced consistent scores across support levels within each dimension (Tang, Cui, & Babenko, 2014). Cronbach's α was interpreted as acceptable ($0.8 > \alpha \geq 0.7$), good ($0.9 > \alpha \geq 0.80$), or excellent ($\alpha \geq 0.9$) (Ponterotto & Ruckdeschel, 2007). Additionally, confidence intervals for postural dimension scores were estimated with the Standard Error of Measurement (SEM).

Construct and concurrent validity were investigated by Pearson product moment (r) and Spearman's rank order (ρ) correlations. Concurrent validity was examined between overall SP&R-co scores and the level of the SATCo. Additional correlations between the postural dimensions of the SP&R-co and SATCo were performed. Because the SATCo indicates the presence/absence of postural deficits across levels of trunk support, the total number of present postural responses within each dimension was used for correlation.

The operational modification in the static dimension of SP&R-co with respect to the SATCo consisted in an increase of the assessment time from 5s to 20s. The proportion of children with static control deficits detected by SP&R-co and SATCo was compared with McNemar's Chi-Square test. Additionally, a sensitivity/specificity analysis was performed to examine the capacity of the SP&R-co test to detect children with and without static control deficits.

RESULTS

A total of 3,034 items were rated across dimensions and levels of trunk support. The average SP&R-co scores across dimensions and levels of trunk support are shown in Figure 3.

Rater Consistency

Trained raters as a group displayed consistent scores across the SP&R-co dimensions—Cronbach's α decreased when one of the raters was eliminated from analysis. They showed good consistency in active (α = 0.80), proactive unimanual (α = 0.84), and reactive (α = 0.84), and acceptable consistency in both static and proactive bimanual (*α*s = 0.76).

Inter-rater Reliability

Figure 4 shows absolute item-by-item reliability between reference SP&R-co scores and trained rater's scores. Reliability was excellent in 19% of the items, good in 40%, and fair in 38%. Poor inter-rater reliability was only observed in 3% of the items. Overall, trained raters showed good (40%) and excellent (60%) reliability in SP&R-co dimensions.

Intra-rater Reliability

Overall, intra-rater reliability was excellent across dimensions (87%). Raters 2 and 3 obtained excellent ICC coefficients for all dimensions, whereas rater 1 obtained excellent ICC for the static and proactive dimensions, and moderate intra-rater ICC in the active (ICC = 0.64, 95% CI = 0.38 to 0.80) and reactive (ICC = 0.69, 95% CI = 0.53 to 0.79) dimensions.

Internal Consistency

Overall internal consistency of the SP&R-co was excellent (*α* = 0.9, SEM = 2.62). The static dimension exhibited good internal consistency (α = 0.82, SEM = 0.50). All other dimensions displayed excellent internal consistency (active α = 0.97, SEM = 0.26; proactive bimanual α = 0.94, SEM = 1.06; proactive unimanual α = 0.97, SEM = 1.32; and reactive α = 0.96, SEM = 0.99).

The postural and reaching domains within each dimension were independent of one another (lack of shared covariance among items). Direct inter-item correlation matrices were observed, indicating that the sitting and reaching domains captured a unidimensional concept. Furthermore, the item-by-item correlation matrix did not demonstrate higher α-values when individual domains were removed from the analysis, indicating that each domain provides significant independent insights about the construct.

Construct and Concurrent Validity

In the construct validity analyses, significant excellent (r > 0.7) or moderate (r > 0.40 – 0.69) correlations were observed. SP&R-co was correlated with the GMFM (r = 0.76, 95% CI = 0.47 to 0.90, $p < 0.001$), GMFCS (ρ = −0.80, 95% CI = −0.54 to −0.92, $p < .001$), MACS (ρ = −0.84, 95% CI = −0.62 to −0.94, $p < 0.001$), JTTHF (LA: r = −0.88, 95% CI = −0.71 to 0.95, $p = 0.03$ and MA: r = −0.54, 95% CI = −0.11 to 0.80, $p = 0.03$), and B&B (LA: r = 0.64, 95% CI = 0.26 to 0.85, $p = 0.008$ and MA: r = 0.64., 95% CI = 0.26 to 0.85, $p = 0.007$).

Concurrent validity between the overall SP&R-co score and SATCo showed a significant excellent correlation (ρ = 0.76, 95% CI = 0.47 to 0.90, $p = 0.01$). A significant excellent association between SP&R-co and SATCo was found in the static dimension (ρ = 0.70, 95% CI = 0.31 to 0.88, $p = 0.002$). Significant moderate correlations were also observed between SP&R-co proactive bimanual and SATCo proactive (ρ = 0.58, 95% CI = 0.12 to 0.84, $p = 0.02$), SP&R-co proactive unimanual and SATCo proactive (ρ = 0.64, 95% CI = 0.21 to

0.86, $p = 0.008$), and SP&R-co and SATCo reactive dimensions ($\rho = 0.49$, 95% CI = 0.008 to 0.79 $p = 0.05$).

Operational Modification in the time domain: Seated Static Postural Control

Increasing the evaluation time from 5s (as assessed in the SATCo) to 20s (as assessed in the SP&R-co) to examine static postural control was justified (Tables 2 and 3). In our sample, 14/19 children (74%) demonstrated static postural problems at one or more trunk sub-regions after the first 5s. McNemar test indicated a significant difference, χ^2 (1, 111) = 38.03, $p < 0.001$, in the proportion of segments with and without static control deficits during 5s- or 20s-examination. A 5s-window only had 31% sensitivity (95%CI = 10 to 52) but 100% specificity.

DISCUSSION

Results indicate that the SP&R-co test is a valid and reliable tool. Test documentation and training methods based on two in-person sessions seem to be appropriate for training clinicians without previous expertise in assessing postural control with the SATCo. Moreover, we show that the SP&R-co test would be appropriate for children age 7 years or older. All but one child was engaged in the task, completed the assessment, and complied with test instructions. The SP&R-co test could possibly be used in children younger than 7 years; however, further studies would be required to examine its generalizability to younger children.

Applicability of the SP&R-co Test

Children with moderate-severe forms of CP (GMFCS IV-V) require external assistance to maintain upright sitting posture, to engage in upper extremity activities (i.e. ball games, writing, painting), and to interact with the environment, family, and peers (Palisano, Rosenbaum, Bartlett, & Livingston, 2008; Rigby, Ryan, & Campbell, 2009; Stavness, 2006). Several studies and reviews have found that it is difficult to determine the best support among diverse types of seating devices (i.e. inserts, external supports, and modular seating systems), to maximize the sitting workspace of children with CP, and improve both postural control and sitting-related activities (Chung et al., 2008; Ryan, 2012). In this new era of precision or personalized medicine (Redekop & Mladsi, 2013), the reason for the inconclusive evidence in deciding the best kind of postural support may be that each child should receive individualized seating support. Thus, there is an urgent need for tests that can measure how the use of external supports impact seated postural control and upper limb functions (i.e. reaching).

The SP&R-co test provides clinicians with an individualized quantitative profile of seated postural and reaching control. The test can guide clinicians to pinpoint the most impaired trunk sub-region and objectively target the postural dimension/s that requires further therapeutic training. With the scoring system, clinicians can document changes across children and therapy sessions, and aid in the clinical decision-making process for the use and location of an external trunk support.

Reliability and Validity of the SP&R-co Test

Trained raters were capable of perceiving and accurately discriminating impairments in seated postural and reaching control in different subtypes of CP. Moreover, raters mostly displayed excellent intra-rater reliability in detecting postural and reaching behaviors one month after the initial evaluation. The lowest item-by-item agreement across raters was for item 1 (the SP&R-co static dimension A1: postural strategy). As a result, we believe that it is necessary to use a more effective training strategy for raters to conceptualize and score item 1.

The overall SP&R-co score was well correlated with other performance tests that measure gross motor function (GMFM), reaching and hand dexterity (JTTHF and B&B), and functional classification systems widely applied in CP, such as the GMFCS and MACS. The strong validity correlations between the SP&R-co and both performance and functional measures show that the SP&R-co reflects the child's body function impairments *and* activity limitations.

The SP&R-co overall score and dimension scores demonstrated high-moderate correlations with the level of SATCo and its dimensions. Nonetheless, the SP&R-co test compensates for the existing limitations of the SATCo at the scoring, operational, conceptualization, and instruction levels. Results provide evidence that the time increment from 5s (item of the SATCo) to 20s in the SP&R-co test to examine static sitting is substantially more sensitive. A time interval longer than 20s may cause CP-related muscle fatigue and secondarily obscure the examination of static sitting control (Damiano, Dodd, & Taylor, 2002). In the SP&R-co, the bidirectional level of control between posture and reaching is examined in the proactive dimension. Proactive balance is examined by instructing the child to execute fast accurate bimanual and unimanual reaches to right, left and forward directions. Based on prior work, we believe that the use of movement directionality to elicit selective APA strategies; movement-based instructions: *"fast and accurate"* and; bimanual/unimanual tasks, all offer a complete assessment of proactive postural and reaching control (Cordo & Nashner, 1982; Folio & Fewell, 2000; Girolami et al., 2010).

Future Research on the SP&R-co Test

We plan to standardize the SP&R-co test and address its clinimetrics (i.e. responsiveness) in a larger sample size. Furthermore, we will perform a Rasch analysis to define the level of difficulty of the postural/reaching tasks included in the SP&R-co test and the plausible redundancy added by each of the current 7 trunk sub-regions under examination.

CONCLUSIONS

Physical therapists—as experts in movement behavior—need the appropriate movement-based tools to evaluate and work to improve the underlying impairments that affect a patient's function, performance, and quality of life. The SP&R-co is a valid and reliable functional test that provides a complete assessment of the impaired postural dimension/s and objectively indicates the optimal level of trunk support to maximize, or train, seated postural and reaching abilities in children with CP aged 7 years or older.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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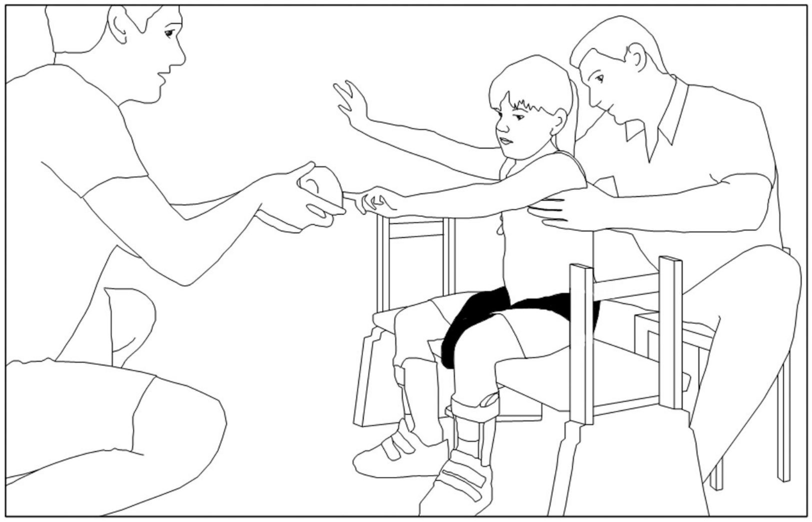

Figure 1.

Example of the SP&R-co setup. The child sits on a bench with two lateral handles located within reaching distance. Pelvis is firmly strapped to the bench. Two examiners are observed. One is kneeling in front of the child to perform the test and the other offers manual support at a specific trunk sub-region (here shown at axillae level). The seated proactive unimanual postural dimension (C2) is being evaluated. The child performs a unimanual reach (i.e. pointing) with the left hand while maintaining balance of head and upper thorax. The right hand is kept in the air.

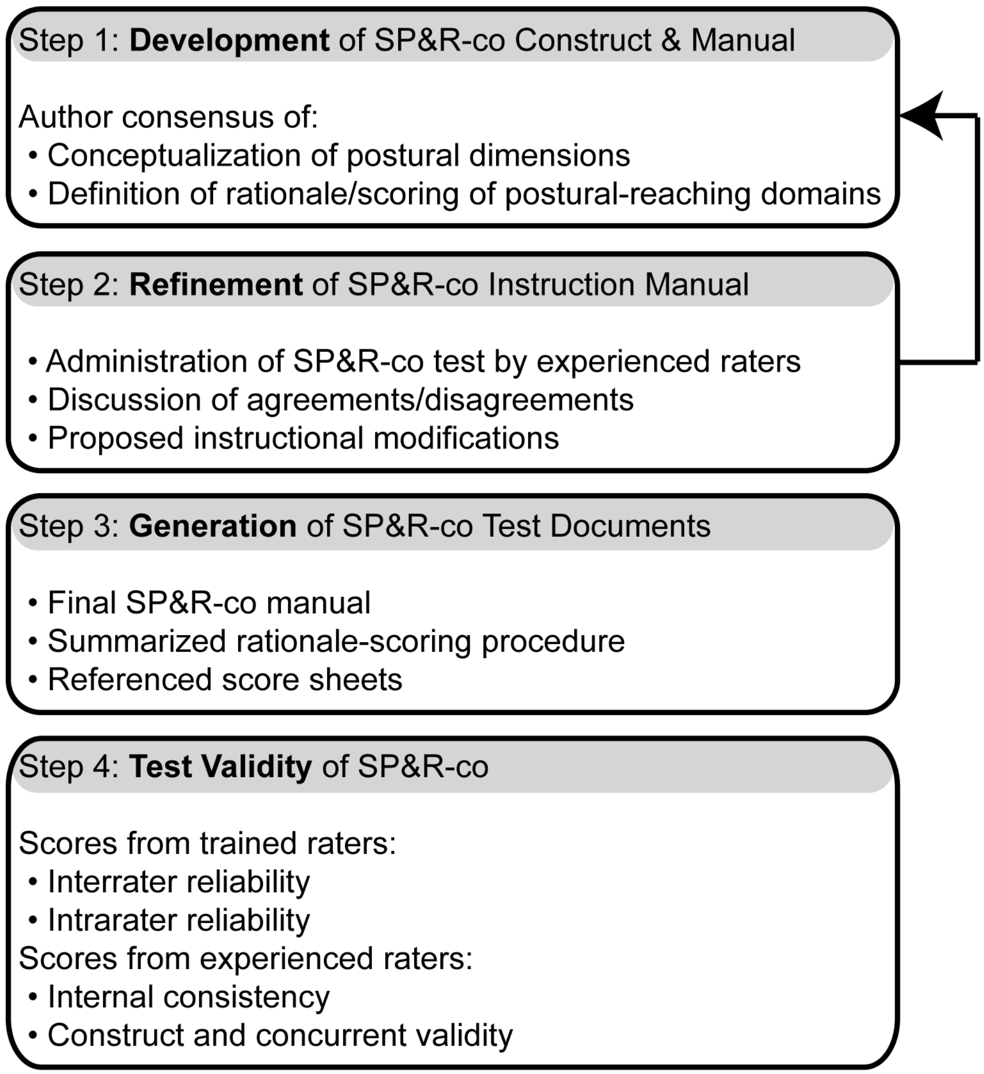

Figure 2.

Step-by-step summary of the SP&R-co test development. All authors conceptualized sitting control across dimensions and designed the SP&R-co manual. After the two experienced raters applied the manual to score all children, the seated postural dimensions and their domains were further discussed to include as many modifications as needed. Once all the authors reached a unanimous consensus, the SP&R-co documentation was prepared to train the three pediatric physical therapists with no previous experience in the concept of segmental trunk support or in using the SATCo. The outcomes from the experienced and trained raters were used to validate the SP&R-co test.

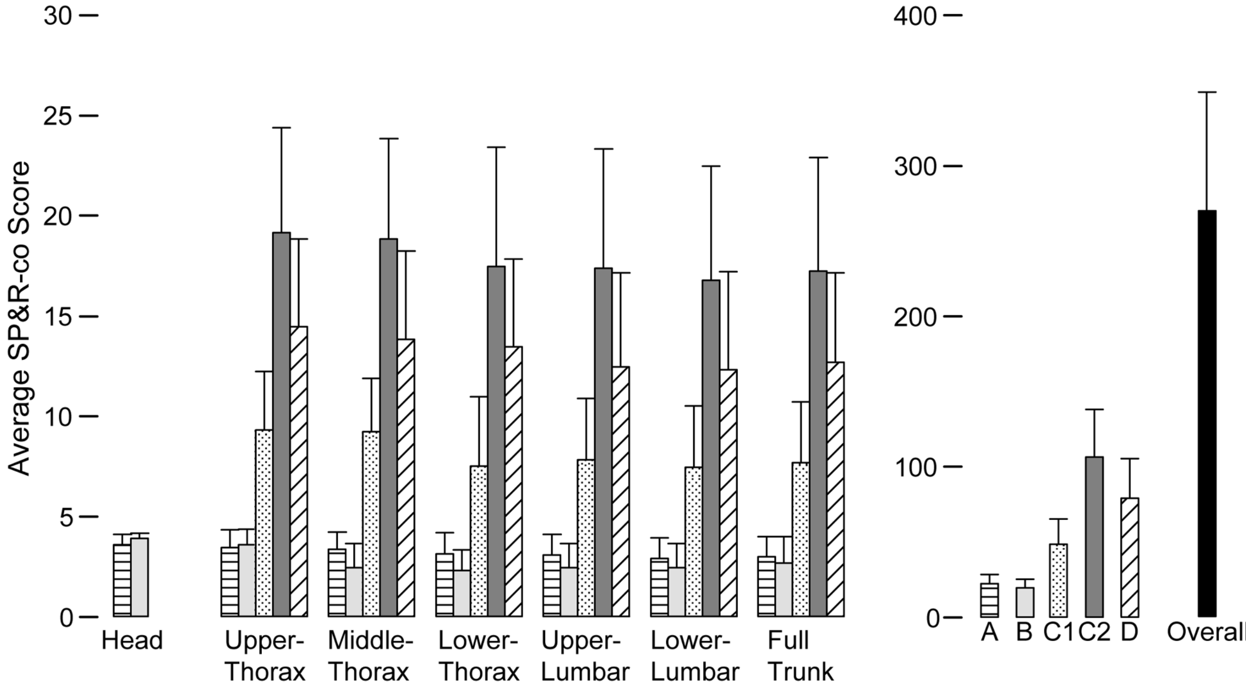

Figure 3.

Left panel shows the group average of reference scores for dimensions A-D per level of trunk support. Bars in the right panel serves as the legend for the bars in the left panel (A = static, B = active, C1 = proactive: bimanual, C2 = proactive: unimanual, D = reactive). Right panel shows averaged reference scores for each SP&R-co dimension across all levels of trunk support. Black bar shows the overall score for the group of children. Error bars represent ± 2 SD.

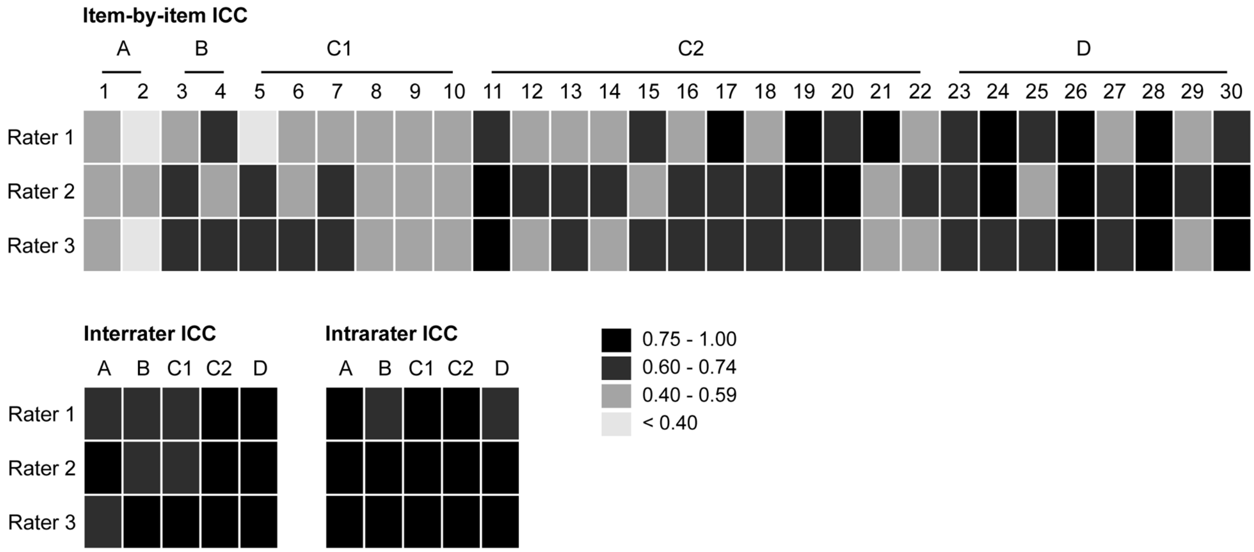

Figure 4.

ICC coefficients were interpreted as poor (ICC< .40), fair (ICC=.40 to .59), good (ICC=.60 to .74) and excellent (ICC= .75–1.00). Top panel shows absolute item-by-item reliability analysis with ICC between reference SP&R-co score sheets and rater's scores. Good, fair and excellent item-by-item absolute reliability was more frequently observed (97%) than poor reliability (13%). Bottom panel shows average inter-rater and intra-rater reliability for postural dimensions (summed SP&R-co scores) with ICC. Only excellent and good reliability was observed. A: Seated static posture; B: Seated active posture; C1: Seated proactive posture: bimanual; C2: Seated proactive posture: unimanual; and D: Seated reactive posture. Numbers 1–30 represent the items that comprise the SP&R-co test.

Table 1.

Clinical features of the sample

ID#[a]	Age (Yrs)	Gender	Topographical Distribution	GMFCS[b]	GMFM[c] 95%CI	SATCo[d]	MACS[e]	JTTHF[f]		B&B[g]	
								MA	LA	MA	LA
01	10	M	Quadriplegia	IV	44.0 (42.0–46.1)	3	IV	391	93	11	30
02	13	M	Quadriplegia	IV	50.1 (47.8–52.4)	3	IV	797	80	23	24
03	13	F	Quadriplegia	IV	45.6 (43.5–47.6)	3	IV	1080	294	10	10
04	17	F	Hemiplegia	II	68.9 (66.0–71.7)	7	III	482	47	7	46
05	16	M	Hemiplegia	II	77.5 (73.2–81.7)	7	II	81	44	11	35
06	9	M	Hemiplegia	II	73.1 (69.7–76.6)	7	III	446	126	0	20
07	11	M	Diplegia	IV	52.6 (50.2–55.0)	5	IV	225	99	1	30
08	7	M	Diplegia	II	79.1 (74.6–83.6)	7	II	443	77	24	30
09	16	M	Quadriplegia	III	48.1 (45.9–50.3)	7	II	139	68	25	30
10	9	M	Quadriplegia	III	61.2 (58.7–63.7)	3	III	431	268	19	24
11	7	F	Quadriplegia	III	63.0 (60.3–65.6)	3	II	234	231	22	28
12	16	F	Quadriplegia	III	50.3 (48.0–52.6)	3	II	301	76	24	42
13	10	F	Quadriplegia	V	23.9 (19.1–28.7)	0	V	890	573	3	13
14	15	M	Diplegia	III	56.6 (54.3–58.9)	7	II	57	38	39	47
15	10	M	Quadriplegia	IV	51.3 (48.9–53.7)	3	III	366	245	16	23
16	12	F	Quadriplegia	V	46.9 (44.9–49.0)	0	V	927	268	6	18
17*	7	M	Diplegia	III	50.6 (48.3–52.9)	3	III	184	108	19	24
18*	16	F	Quadriplegia	III	43.0 (41.0–45.1)	5	III	55	51	39	43
19*	10	F	Hemiplegia	I	72.2 (68.8–75.5)	7	I	35	46	45	52

[a]ID = Participant identification

[b]GMFCS = Gross Motor Function Classification System I-V

[c]GMFM = Gross Motor Function Measure-66 ± 95%CIs

[d]SATCo = Segmental Assessment of Trunk Control

[e]MACS = Manual Ability Classification System

[f]JTTHF = Jebsen-Taylor Test of Hand Function. MA = More-affected and LA = Less-affected

[g] B&B = Box & Blocks. MA = More-affected and LA = Less-affected

[*] Additional children recruited for construct and concurrent validity analyses

Table 2.

Examination of seated static postural dimension during 5 vs. 20 seconds

	Head	Upper-Thorax	Middle-Thorax	Lower-Thorax	Upper-Lumbar	Lower-Lumbar	Full Trunk
CP01	20s	20s	8s	7s	16s	10s	17s
CP02	20s	20s	4s	11s	10s	2s	3s
CP03	20s	6s	2s	7s	4s	4s	17s
CP04	-	-	-	-	-	-	20s
CP05	-	-	-	-	-	-	20s
CP06	-	-	-	-	-	-	16s
CP07	20s	20s	20s	20s	4s	15s	7s
CP08	20s	20s	20s	20s	20s	20s	16s
CP09	20s	20s	20s	20s	20s	5s	20s
CP10	13s	18s	20s	20s	20s	20s	20s
CP11	20s	20s	20s	18s	13s	11s	13s
CP12	20s	20s	20s	10s	6s	1s	1s
CP13	7s	10s	16s	Abs	Abs	Abs	Abs
CP14	18s	20s	20s	20s	20s	20s	20s
CP15	0s	13s	7s	11s	14s	4s	10s
CP16	0s	4s	16s	6s	4s	14s	8s
CP17*	17s	18s	4s	7s	11s	3s	6s
CP18*	20s	20s	20s	20s	20s	1s	20s
CP19*	20s	20s	20s	20s	20s	20s	20s

Levels of trunk support where children showed static postural control deficits beyond 5 seconds of examination (grey cells). The SATCo detected static postural deficits in 18 out of the 58 impaired segments (31%). Abs = Absent static control owed to postural failure. - = data unavailable.

*Additional children recruited for construct and concurrent validity analyses.

Table 3.

Contingency table showing the comparison between the 5 and 20 seconds of static postural examination.

Static Posture (5s)	Static Posture (20s)			
		Present	Absent	Total
	Present	18	0	18
	Absent	40	53	93
	Total	58	53	111

A temporal window of 5 seconds was associated with low sensitivity (31%) and high specificity (100%), false negative rate (69%) and false positive rate (0%). s = seconds.