

THE VALIDITY OF BTRACKS (BALANCE TRACKING SYSTEM) IN CHILDREN WITH
DOWN SYNDROME

by

Clare Hanrahan

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DOWN SYNDROME

Project Approved:

Supervising Professor: Phil Esposito, Ph.D.

Department of Kinesiology

Amanda Young, Ph.D.

Starpoint School

Adam King, Ph.D.

Department of Kinesiology

ABSTRACT

The purpose of this study was to determine the level of predictive validity and concurrent validity of BTrackS (Balance Tracking System) in children with Down syndrome (DS). Eleven children with DS, ages 4-6 were recruited from Kinderfrogs School on TCU campus. Participants included 5 females and 6 males. Postural sway measures were obtained using BTracks Balance Tracking system to determine fall risk. Subjects were then assessed using the PBS to determine fall risk. It was found that performance on BTrackS explained 46.4% of variance of PBS performance, indicating poor concurrent validity. It was also found that variables measured by BTrackS correctly predicted fall risk 81.8% of the time, indicating some predictive validity. Based on these findings, the PBS may be a more valid measure of fall risk than BTrackS in this population. The attentional demands and time requirements of BTrackS may cause this system to be a less valid measure of balance ability in young children with DS. Additionally, the PBS includes functional activities that require both static and dynamic balance, and is more cost effective than BTrackS and similar force plate systems. Further studies in this area may attempt to improve the validity of both the PBS and BTrackS in this population by decreasing time requirements, improving clarity of instructions, or including the use of visual aids.

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INTRODUCTION

Down syndrome (DS) is a genetic disorder that occurs due to the presence of an extra 21st chromosome. Children with DS exhibit impairments in almost all areas of development including orthopedic, neuromuscular, cognitive and perceptual impairments. DS is characterized by muscle hypotonicity, ligamentous laxity, and joint hypermobility, which affect muscle control and spatial awareness, essential requirements for balance (Tsimaras & Fotiadou, 2004). Other motor deficits include poor coordination, slow reaction time, reduced visual-motor control, overall greater movement variability, and slower onset latencies in muscle responses during postural control (Shumway-Cook & Woollacott, 1985; Wang & Ju, 2002; Gupta, Rao, & Sd., 2010). While it was once thought that neuromuscular deficits were the main contributor to balance deficits in children with DS, it has been shown that both static and dynamic balance are controlled by higher order cognitive processes, including attention and perception (Shumway-Cook & Woollacott, 1985). Therefore, neuromuscular, as well as cognitive and perceptual impairments contribute to balance deficits in children with DS (Gupta, Rao, & Sd., 2010). Because almost all motor tasks require postural control, balance ability is essential for activities of daily living as well as independent mobility (Vuillerme, Marin & Debû, 2001). Reduced balance ability can limit independence and functional ability in children with DS (Mondal, Yadav, & Varghese, 2013).

Due to balance deficits, individuals with DS are a greater risk of falls, which can discourage participation in physical activity (Giagazoglou, Kokaridas, Sidiropoulou, Patsiaouras, Karra, & Neofotistou, 2013). Avoidance of physical activity can cause

further strength and balance deficits and greater mobility impairments in this population, which further discourages physical activity (Dehghani & Gunay, 2015). Eventually, this cycle of avoidance has been shown to lead to a sedentary lifestyle in individuals with DS, and can put them at risk for obesity and related diseases, such as cardiovascular disease and type II diabetes, and reduced overall quality of life (Dehghani & Gunay, 2015). For these reasons, it is important to have valid and reliable measures to determine fall risk in young children with DS. This information is critical to design and implement interventions to improve strength and balance and to determine effectiveness of these interventions (Reis, Michaelsen, Soares, Monteiro, & Allegretti, 2012).

There are several methods to determining balance ability and fall risk, including both pencil and paper methods and force plate data collection methods. One of the most widely used balance assessments in both research and clinical practice is the Pediatric Balance Scale (PBS). The PBS is a modified version of the Berg Balance Scale, designed to assess functional balance ability in children with mild to moderate motor impairments (Franjoine, Gunther & Taylor, 2003). The PBS is one of few balance assessments that measures function and focuses on performance, rather than underlying balance impairments (Kembhavi, Darrah, Magill-Evans & Loomis, 2002). This test has been shown to be both a reliable and valid measure of balance and fall risk and simplicity of application (Jin-Gang, Ji-Hea & Jooyeon, 2012). For these reasons it is widely used in both research and practice (Jin-Gang et al, 2012; Ries et al, 2012; Chen, Shen, Chen, Wu, Liu, & Chung, 2013). The PBS consists of 14 different balance tasks, ranging from simple, such as standing unsupported, to more complex tasks, such as turning 360 degrees. All tasks contained in the PBS assessment are those that children are expected to

be able to perform independently in daily life, and therefore this test provides a good measure of functional ability (Franjoine et al, 2003).

Force plate balance systems operate by measuring vertical forces produced by foot contact at 3 or more points on the platform to determine changes in center of pressure (COP) (Riemann, Guskiewicz, & Shields, 1999). Different information about COP, such as velocity or area of change can be used to quantify postural sway and determine balance, as large and rapid changes in COP can indicate poor ability to control the center of mass within the base of support and a higher likelihood of falling (O'Connor, Baweja, & Goble, 2016). The Balance Tracking System (BTrackS) used in this study calculates changes in COP to quantify postural sway in the same manner as a force plate. Force plates have been used in many studies of older populations with DS, including one by Vuillerme et al (2001), in which researchers investigated postural control in teenagers with DS. Additionally, Tsimaris & Fotiadou (2004) examined the effect of balance training on balance ability in adults with DS, using a force plate to measure balance ability. Other balance studies have investigated the effects of balance training on postural control in adolescents with DS, using force plate measures to determine postural control ability (Tae-Jin, 2014; Lee, Lee, & Song, 2016). Despite the widespread use of force plates in adults and young adults with DS, the validity of force plate measures in younger populations with DS has not been determined. Therefore the validity of BTrackS is also undetermined in this population. Valid and reliable measures can help to establish evidence for interventions as well as assess the effectiveness of these interventions in clinical populations. In young children with DS, effective early interventions are especially important to reduce deficits and improve functional ability

(Giagazoglou et al, 2013). Therefore, the goal of this study was to determine both the predictive and concurrent validity of BTrackS in young children with DS.

METHODS

Participants

Eleven children diagnosed with DS were recruited from KinderFrogs School on Texas Christian University Campus. Participants included 6 males and 5 females aged 4-6 years old (mean 5.36 years \pm 0.67). Exclusion factors included children with cardiovascular conditions, dual diagnoses, and functional vision or hearing loss. No attempts were made to differentiate between distinction of DS by translocation, trisomy 21, or mosaicism. Children who used ankle foot orthotics were not allowed to wear these devices during testing. Children were allowed to continue use of any hearing or visual aids during testing. Approval from the institutional review board was attained prior to the study. The children's parents were informed of the study and they signed a university approved consent form before beginning the study. Following parental consent the children were give verbal assent of their comprehension and willingness to participate in the study.

Apparatus

Pediatric Balance Scale

The PBS is composed of 14 different subtests of balance ability, ranging from simple to complex tasks. The items tested in the PBS are carried out in the following order: sitting to standing, standing to sitting, transfers, standing unsupported, sitting unsupported, standing with eyes close, standing with feet together, standing with one foot in front, standing on one foot, turning 360 degrees, turning to look behind, retrieving

object from floor, placing alternate foot on stool, and reaching forward with outstretched arm. Each item is scored on standard criterion-based 0 to 4 point scale. The lowest score 0, is given when the child is unable to perform the task. Scores of 1, 2, and 3 signifying increasing proficiency in the task, and a score of 4 is chosen when the child is able perform the task accurately and safely. The scores on all subtests are added together to determine overall score, with a maximum possible score of 56.

BTrackS

BTrackS (Balance Tracking System) was used to determine postural sway. The BTrackS force plate consists of a rectangular platform with four enclosed strain gauge sensors located on the underside of each corner to determine vertical force. A USB connection allows exchange of the force-related sensor data with an attached computer. BTrackS software determines center of pressure (COP) location as the spatially weighted averages of the four forces (O'Connor et al, 2016).

Procedures

Each participant first was assessed using the PBS. Children were given instructions for each task prior to beginning and were given 3 attempts at each task. The highest performance of the three attempts was then used to score the child for each task. If a child obtained a score of 4 on their first attempt at a task, they did not repeat the task. BTrackS testing consisted of having participants stand in quiet stance with feet shoulder width apart and hands on their hips for 4 trials of 20 seconds each. The first trial served as a familiarization trial, and the scores on the following three trials were averaged to determine fall risk. Children were able to watch a short video while standing on the force plate in order to complete all 4 trials.

Design and Analysis

This cross sectional descriptive study examined the concurrent validity of the Pediatric Balance Scale with the BTrackS balance tracking system in a sample of children with Down syndrome. Descriptive statistics were calculated for all data and are presented as means \pm standard deviations. Explained percentage of variance was determined by the squared multiple correlation. The R squared as well as its adjusted version was evaluated in order to evaluate the degree of overfitting. Data was analyzed using SPSS version 20.0.

RESULTS

Selected participant characteristics are shown in Table 1. The sample had a mean height 42.36 ± 2.501 inches and a mean weight of 46.73 ± 8.643 pounds. Mean BMI percentile was $88.682 \pm 9.746\%$.

Table 1. Selected Participant Demographics.

	Minimum	Maximum	Mean \pm Std. Deviation
Age (years)	4	6	5.36 ± 0.67
Height (in)	40.0	49.0	42.36 ± 2.50
Weight (lbs.)	40.0	65.0	46.73 ± 8.64
BMI %	71.0	99.0	88.68 ± 9.74

PBS

Scores on the PBS items are shown in table 2. Nine participants were classified as low fall risk, and two participants were classified as medium fall risk.

Table 2. Pediatric Balance Scale Score

	Mean \pm Std. Deviation
Sit to Stand	4.0 \pm 0.0
Stand to Sit	3.2 \pm 1.0
Transfers	3.3 \pm 0.6
Stand Unsupported	3.9 \pm 0.3
Sit Unsupported	3.8 \pm .60
Stand- Eyes closed	3.6 \pm .92
Stand- Feet together	3.2 \pm 1.4
Stand- one foot in front	1.7 \pm 1.2
Single leg stand	1.1 \pm .40
Turn 360°	2.5 \pm 1.3
Turn to look over shoulder	3.0 \pm .77
Pick up object from floor	3.9 \pm .30
Place alternating feet on stool	3.2 \pm 1.0
Forward reach	2.9 \pm .94

BTrackS

The mean ellipse area was 13.45 ± 12.36 cm² and the mean velocity was 5.445 ± 12.63 cm/s. Additional BTrackS data is shown in Table 3. All participants were classified as high fall risks.

Table 3 BTrackS Scores

	Minimum	Maximum	Mean \pm Std. Deviation
95% Ellipse Area (cm ²)	3.17	46.10	13.45 \pm 12.63
Mean Velocity (cm/s)	2.59	9.11	5.44 \pm 2.15
Mean Distance (cm)	0.62	2.28	1.33 \pm 0.53
Mean Frequency (Hz)	0.50	0.80	0.66 \pm 0.09
RMS Distance ML (cm)	0.35	2.33	1.24 \pm 0.67
RMS Distance AP (cm)	0.65	1.55	1.01 \pm 0.29
Range ML (cm)	2.23	14.03	7.62 \pm 4.08
Range AP (cm)	1.27	8.32	5.00 \pm 1.95
Approx. Entropy ML	0.36	0.57	0.48 \pm 0.07
Approx. Entropy AP	0.40	0.53	0.49 \pm 0.40
Percentile	0	17	4.2 \pm 6.62

Validity

It was found that performance on BTrackS explained 46.4% of variance of performance on the PBS. Additionally, postural sway measures measured by BTrackS correctly predicted fall risk 81.8% of the time.

DISCUSSION

The goal of this study was to determine the concurrent and predictive validity of BTrackS in children with DS. BTrackS was compared against the PBS, a valid and

reliable measure of functional balance ability in children with motor impairments.

Concurrent validity is a measure of the extent to which the results of a test or measurement correspond to those of a previously established test for the same construct.

Predictive validity is a measure of the extent to which scores on an assessment predict future performance on another measure of the same construct.

The scores on the PBS indicated that children performed well on simple functional tasks such as standing to sitting (mean score 4.0 ± 0.0) and standing unsupported (mean score $3.9 \pm .30$). However, when tasks required participants to minimize their base of support, such as standing with one foot in front (mean score 1.7 ± 1.2) or standing on one leg (mean score $1.1 \pm .40$), participants performed poorly. This may be due to the fact that those with DS show longer muscle onset latencies and less anticipatory postural control, making it more difficult to control the center of mass within a narrow base of support (Gupta et al, 2011).

It was found that BTrackS performance explained 46.4% of variance of PBS performance, indicating that this measure has poor concurrent validity. Additionally, variables measured by BTrackS correctly predicted fall risk 81.8% of the time, indicating fair predictive validity. These results indicate that BTrackS may not be a valid measure of fall risk in young children with DS and that the PBS is a more valid and reliable measure of fall risk in this population. There may be several reasons for this. Young children with DS have cognitive deficits, which impact attention, focus and higher order processing (Giagazoglou et al, 2013), therefore this may impair their ability to stand still on the force plate for the entirety of the trial period. Often, it took several attempts for participants to complete a full trial on BTrackS. Additionally, BTrackS assessment requires children to

perform a task that they do not generally perform, and therefore may not accurately assess functional balance. Alternatively, the PBS includes several measures of functional balance ability, which may be more applicable to daily activities. These activities also keep children in this population more engaged, due to the dynamic nature of the activities.

The results of this study contradict the results of a study done by O'Connor et al (2016), which indicated that the validity of BTrackS was similar to that of a laboratory grade force plate. However, this study was done using an inverted pendulum system that simulated the weight and postural sway of an average adult, and did not examine the validity of this measure in clinical populations or children. Another study by Levy, Thralls & Kviatkovsky (2017) found that BTrackS was a valid and reliable measure of balance in older adults. Geurts, Nienhuis, & Mulder (1993) found that force plates were a valid and reliable measure of balance ability in healthy adult populations, and suggested that force plates were a reliable and valid clinical measure. However, none of the previously mentioned studies include research on the validity of force plates in children. Our results support the findings of a study by Karlsson & Frykberg (2000) comparing force plate measures of balance against the Berg Balance Scale (BBS) in stroke patients. They found that the only force plate measure that correlated with scores on the BBS was the measure of vertical force, indicating that the BBS and the vertical force measure of a force plate quantify a similar aspect of postural stability. Additionally, the antero-posterior mean velocity of COP was significantly correlated to the static components of the BBS, although the reasons for this correlation were not determined (Karlsson & Frykberg, 2000).

While force plate measures of balance have been used in teens and adults with DS (Vuillerme et al, 2001; Tsimaris & Fotiadou, 2004; Tae-Jin, 2014; Lee et al, 2016), these measures may be more valid in these populations due to increased cognitive functioning when compared with young children with DS. Literature focused on validity of force plate measures has also determined validity of force plates in several different adults populations including stroke patients and those with Parkinson's disease (Geurts et al, 1993; Levy et al, 2017). Another drawback to force plates measures is that they tend to be cost-prohibitive and for this reason may be less useful in clinical settings compared to pen-and-paper assessments such as the PBS.

Implications

The implication for practitioners is that relying on these more valid means of measurement may produce better outcomes in young children with DS. The PBS may continue to be used in both clinical and research settings. Valid and reliable measures of balance are essential for establishing baselines, demonstrate evidence for interventions, and evaluate the effectiveness of these interventions in terms of patient outcomes. These findings are also important for researchers, due to the prevalent use of force plate measures to evaluate balance ability in those with DS. Force plate measures may not be the most valid measure of balance ability in these populations, and researchers must keep this in mind when evaluating young children with DS.

Limitations

One limitation of this study was the small samples size. A larger sample size of twenty or more participants would have been ideal. A way to address this limitation is to recruit subjects not only at KinderFrogs but from around different schools in the area. A

reason for the reduced sample size was that BTrackS requires a minimum weight of 40 pounds to complete testing, and this requirement eliminated almost half of the available participants for this study. Another limitation of this study is that only one researcher was available to score the PBS. Ideally, several researchers would have been present to score the PBS, to attain an average score from all researchers and prevent bias towards scoring too easily or too harshly. The study was required to be carried out during the participants' regularly scheduled physical activity classes, and therefore placed a time constraint on researchers who were available to assess the participants.

Further Directions

There is limited research on the validity of force plate measurements of balance in individuals with intellectual disability (ID). While these measures have been investigated in several different clinical populations, further research may investigate the validity of force plate measures in these populations. This is an important direction of research, due to the prevalent use of force plates in research studies evaluating balance abilities in this population. Further research in this area may investigate improving the validity of both the PBS and force plate measures such as BTrackS. Several ways to improve validity may be to decrease time requirements and include visual aids for both assessments. Oftentimes, participants did not seem to understand what was required of them or were unwilling to fully cooperate with researchers. Another way to increase validity of the PBS may be to make the assessment more engaging and interesting for young children, and future studies may investigate the effects of adding any of these elements to these assessments. Additionally, the validity of BTrackS and force plates in other young

clinical populations, such as children with cerebral palsy may be an area of focus for further research.

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