ABSTRACT

Purpose: To explore the relationship between physical literacy measures of balance and a clinical balance tool.

Methods: A cross-sectional design was used to evaluate the relationship between the PLAYfun physical literacy balance tasks and the Balance Error Scoring System. Normal bivariate correlations were conducted between each of the outcome measures.

Results: There were moderate negative correlations between the Balance Error Scoring System total and forward walk competence ($r^2 = -.131, n = 240, P < .001$) and backward walk competence ($r^2 = -.126, n = 240, P < .001$), and there were low correlations between the Balance Error Scoring System total and drop-get up competence ($r^2 = -.028, n = 240, P = .09$) and lift lower competence ($r^2 = -.019, n = 242, P = .32$), where fewer Balance Error Scoring System total errors were associated with increased competency.

Conclusions: Physical literacy competence is essential for movement and sport participation. Sports medicine clinicians frequently measure balance for injury risk profiling and throughout rehabilitation. The authors found low to moderate correlations between physical literacy balance and the Balance Error Scoring System, suggesting the need to choose a test that best suits the specific goals and patient population.

From the Department of Interdisciplinary Studies (HJR) and Athletic Training Programs and School of Osteopathic Medicine in Arizona (TCVM), A.T. Still University, Mesa, Arizona; the Department of Athletic Training, Emory & Henry College, Emory, Virginia (EB); the Department of Kinesiology (JB, LJD), University of Connecticut, Storrs, Connecticut, and UCONN Health, Department of Orthopaedic Surgery, Farmington, Connecticut (LJD). Submitted: May 8, 2018; Accepted: August 20, 2018

The authors have no financial or proprietary interest in the materials presented herein.

The authors thank Steve Boyle and the National Association of Physical Literacy for their support, Husky Sport at the University of Connecticut for their ongoing collaboration with the research group, and their community partners in Storrs and Hartford, Connecticut, who participated in the data collection for this study.

Correspondence: Hayley J. Root, PhD, MPH, ATC, A.T. Still University, 5850 E. Still Circle, Mesa, AZ 85206. E-mail: hayleyroot@atsu.edu
doi:10.3928/19425864-20180918-02

The Relationship Between Physical Literacy Measures of Balance and the Balance Error Scoring System in Youth Sports Participants

Hayley J. Root, PhD, MPH, ATC; Tamara C. Valovich McLeod, PhD, ATC, FNATA; Eleanor Beltz, PhD, ATC; Julie Burland, MS, ATC; Lindsay J. DiStefano, PhD, ATC

PHYSICAL ACTIVITY

Physical activity is associated with a variety of physical, mental, and psychosocial benefits. However, nearly half of middle-school aged children do not meet the Centers for Disease Control and Prevention guidelines of engaging in 60 minutes of physical activity per day. A lack of activity likely has lifelong consequences because skills and behaviors developed during childhood (eg, motor coordination and level of physical activity engagement) are predictive of physical activity participation throughout adulthood. Low physical activity engagement in youth may be predicated by a deficit in one or more areas of physical literacy. Physical literacy is a broad term that includes the constructs of motivation, confidence, competence, and the knowledge and understanding to value the engagement of physical activity for life (Figure 1). An example of the interactions between these constructs is if a child is not confident in his or her own physical abilities or is not motivated to be active, he or she will not choose to engage in physical activity. Further, there is a direct relationship between participating in physical activity and developing competence, or the critical fundamental movement skills and coordination needed to continue to engage in physical activity throughout adulthood. Consequently, it is critical that children participate in physical activity and develop physical literacy early in life to increase the likelihood of developing good physical activity habits for lifelong health.
Children must develop general, refined, and activity-specific movements to develop physical literacy competence. In the Canadian Sport for Life PLAYfun assessment of physical literacy measures, general skills are divided into five categories: (1) running, (2) locomotor, (3) upper body object control, (4) lower body object control, and (5) balance, stability, and body control (Figure 2). To optimize sport performance specifically, individuals must be able to apply general skills, such as balance and lower body object control, to activity-specific tasks, such as playing offense in soccer. A high aptitude for and competence in areas of physical literacy is a necessary foundation for improved sport-related performance.

Similarly, the general skill of “balance” has been linked to sport-related performance. Balance can be static (maintaining postural equilibrium within a base of support) or dynamic (maintaining equilibrium while performing a specific task or movement). Balance is a fundamental component for all physical movement. To maintain balance, the body must combine visual, vestibular, and somatosensory inputs. In sports medicine settings, the Balance Error Scoring System (BESS) is a tool commonly used to evaluate static balance, and it is a valid assessment of deficits following concussion injury, chronic ankle instability, and postural control after anterior cruciate ligament injury. The BESS has also been used in the pediatric population, particularly with regard to concussion assessment. In the PLAYfun assessment, the four balance-specific tasks are balance walk forward, balance walk backward, drop to the ground and get back up, and lift and lower (Figure 2). Although the BESS is commonly used in sports medicine, it is a static measurement. A more dynamic and functional assessment, such as the PLAYfun balance tasks, may have a greater applicability to youth athletes and also provide insight into physical literacy during this influential stage of life.

Although both the BESS and the PLAYfun balance tasks assess important aspects of balance and sport performance, it is unknown how these clinical screening tools may be related. Determining whether the measures are complementary or redundant may assist clinicians in identifying the most appropriate measure for their athlete population and goals. Therefore, the purpose of this study was to explore the relationship between physical literacy measures of balance and a clinical balance tool commonly used in youth athlete populations.

METHODS
Design, Setting, and Participants
A cross-sectional study design was used to evaluate the relationship between physical literacy measures of balance and the BESS in recreationally active youth. Participants were recruited from six elementary and middle schools in both suburban and urban areas of Hartford, Connecticut. Prior to the test session, all participants and a parent or legal guardian completed assent and consent forms, respectively, which were approved by the University of Connecticut’s institutional review board. Participants also completed a baseline demographic questionnaire. Participants with existing concussion, musculoskeletal injury, or illness prohibiting them from participating on the day of testing were excluded.

INSTRUMENTATION
Physical Literacy Measures
This study focused on competence performance of the PLAYfun balance, stability, and body control subsection. This subsection includes four tasks with standardized instructions and rating systems. Because the instrumentation was developed in Canada, the instructions were modified slightly by changing the term “pylon” to “cone” to better reflect the common language used in American sport and physical education. Research assistants assessing physical literacy skills were trained to evaluate movement tasks using the standardized definitions and parameters described in the PLAYfun work.
Studies evaluating the PLAYfun constructs in children have found good inter-rater agreement (intra-class correlation coefficient [ICC] = 0.87).

Each task was assessed on a modified visual analog scale of 0 to 100, with a high score indicating increased competence. The rating system is divided into four general categories: initial (0 to 25), competent (26 to 50), emerging (51 to 75), and proficient (76 to 100). Initial is characterized by the presence of numerous gaps during execution, competent is defined as a basic level of execution and minor sequencing errors, emerging means the participant is able to execute the basic sequences of the task with a limited number of major gaps, and proficient is an overall proficiency depicted by a fluid, continuous motion and minor adjustments may be evident. Further descriptions of the four discrete tasks are described below.

In the balance walk forward task (Forward Walk), participants were instructed to walk heel-to-toe from one cone to the next, approximately 2 meters apart, while keeping their balance. For the balance walk backward task (Backward Walk), participants were instructed to walk backward toe-to-heel from one cone to the next. Raters paid particular attention to foot placement, use of arms, and general fluidity of movement.

The next two tasks were related to the participant’s body control. For drop to the ground and get back up (Drop Get Up), the participant was instructed to drop to the ground and come right back up. For lift and lower (Lift Lower), participants were instructed to lift a ball above their head and then lower it back down to the ground. Raters assessed how much control and fluidity of motion was exhibited.

**BESS**

The BESS is a clinical balance assessment with good concurrent validity compared to the computerized dynamic posturography. It includes six conditions that progressively challenge the sensory systems by altering the stance position and surface: double-leg, single-leg, and tandem stances were performed on firm and foam surfaces. To perform the BESS, participants assume the stance for each condition with their hands on their hips and are instructed to close their eyes. During the 20-second trial, errors are recorded with one error point awarded for each compensatory movement (error) during each of the six conditions and summed for a total error score. A standard score of 10 errors is given for each condition if the participant is unable to remain in the starting stance for at least 5 seconds of the trial. Lower scores on the BESS indicate better balance. Studies evaluating the BESS in children have reported excellent inter-rater (0.57 to 0.96) and intra-rater (0.87 to 0.98) reliability and good to excellent test–retest reliability (0.70 to 0.90) with reference data for children and adolescents available.

**Procedures**

All participants completed a single test session lasting approximately 15 to 25 minutes that included many physical literacy measures and the BESS test. Testing took place during the academic school day at the respec-
tive elementary or middle schools that the participants attended.

Data Reduction and Statistical Analysis

All analyses were performed using SPSS software (version 24.0; SPSS, Inc., Chicago, IL). Descriptive data (means and standard deviations) were reported for all variables (BESS firm score, foam score, and total score, and the Forward Walk, Backward Walk, Drop Get Up, and Lift Lower scores). Normal bivariate correlations were conducted between each of the balance outcome measures. Statistical significance was set a priori at a $P$ value of less than .05 for all analyses.

RESULTS

A total of 287 children (male: n = 92; age [mean ± SD] = 10.1 ± 1.8 years, height = 130.89 ± 44.12 cm, mass = 42.16 ± 13.92 kg; female: n = 101, age = 9.6 ± 2.1 years, height = 123.64 ± 50.67 cm, mass = 42.49 ± 14.18 kg; missing: n = 94) volunteered to participate. As part of the study, participants completed a baseline questionnaire at home with the assistance of a parent or guardian as needed. The questionnaire included background demographic information, including sex. The 94 missing participants did not provide the background demographic information but did consent to participate in the study and completed the physical tasks.

Descriptive data for the balance measures are listed in Table 1. Per the PLAYfun scale, participants’ mean competency scores during the Forward Walk (70.98 ± 18.18), Backward Walk (66.60 ± 19.44), and Drop Get Up (64.79 ± 23.95) were categorized as emerging (between 51 and 75). Lift Lower (78.31 ± 16.63) competence was classified as proficient (between 76 and 100).

There were moderate negative correlations between the BESS total score and Forward Walk competence ($r^2 = -.131, n = 240, P < .001$) and Backward Walk competence ($r^2 = -.126, n = 240, P < .001$) and low correlations between BESS total score and Drop Get Up competence ($r^2 = -.028, n = 240, P = .09$) and Lift Lower competence ($r^2 = -.019, n = 242, P = .32$), where fewer BESS total score errors were associated with increased competency in each task. Table 2 presents the correlation matrix between dependent variables.

DISCUSSION

Although physical literacy is a fundamental component of movement and sports performance, athletic trainers or other sports medicine providers rarely use these measures. To our knowledge, no study has considered the relationship between commonly used sports medicine balance assessments and physical literacy measures. Our primary findings indicate that there is a low to moderate relationship between the BESS total score and physical literacy balance and stability tasks. The BESS is commonly used to evaluate postural stability,14,18 and the physical literacy tasks are used as assessments of functional balance and skill development.24 These findings suggest that the different measures may have unique contributions that collectively describe an individual’s balance ability, so the selected measure(s) used by a clinician should be based on the patient population and the objectives of the balance assessment.

Although statistically significant, the correlations were low to moderate across tasks. The BESS and physical literacy tasks measure balance in general, but the BESS is a static, eyes-closed task that relies heavily on

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>BESS firm</td>
<td>4.59</td>
<td>3.93</td>
<td>287</td>
</tr>
<tr>
<td>BESS foam</td>
<td>7.76</td>
<td>5.23</td>
<td>287</td>
</tr>
<tr>
<td>BESS total</td>
<td>12.35</td>
<td>8.56</td>
<td>287</td>
</tr>
<tr>
<td>Forward Walk competence</td>
<td>70.98</td>
<td>18.18</td>
<td>244</td>
</tr>
<tr>
<td>Backward Walk competence</td>
<td>66.60</td>
<td>19.44</td>
<td>244</td>
</tr>
<tr>
<td>Drop Get Up competence</td>
<td>64.79</td>
<td>23.95</td>
<td>244</td>
</tr>
<tr>
<td>Lift Lower competence</td>
<td>78.31</td>
<td>16.63</td>
<td>246</td>
</tr>
</tbody>
</table>

BESS = Balance Error Scoring System
vestibular input to maintain a static posture in different poses and with a surface perturbation. The BESS score is a summation of errors tallied when a person deviates from the standardized posture or compensates to remain balanced. Conversely, the physical literacy tasks are movement-based tasks and measure how competently an individual completes the standardized task on a continuous 0 to 100 scale. Although the two tasks are measuring a component of balance, neither holistically addresses the different types of balance. From a motor development standpoint, youth athletes may not have the strength, coordination, or sensory integration ability to complete the BESS stances. Specifically, studies of normative performance on the BESS and modified BESS (firm stances only) have found increased age is associated with better performance on the BESS and that median scores on the modified BESS are lower among children and adolescents compared to adults. On the other hand, the PLAYfun balance measures are designed for youth ages 7 years and older and take into account that the skill will continue to develop through different stages of maturation and development. Because adult balance ability may not develop until the mid- to late-teenage years, physical literacy assessments may be more appropriate to evaluate balance, particularly in a youth population.

Although measures of physical literacy are not widely used in the United States, Canada has been at the forefront of the physical literacy movement and developed the PLAYfun physical literacy assessment. The PLAYfun physical assessment addresses running, locomotion, upper body object control, lower body object control, and balance skills. In this study, the mean competency performance for the Lift Lower task was in the proficient range (76 to 100). However, in the Forward Walk, Backward Walk, and Drop Get Up tasks, the mean competency performance was in the emerging range (51 to 75). This is not surprising because the Lift Lower task was a two-legged stationary stance and required less functional coordination compared to both walking tasks and the Drop Get Up task. This supports the motor development literature and the idea that the more dynamic movements or additional degrees of freedom needed to complete a given task will be more challenging and require more motor competence.

In youth, immature balance control can impede normal gait development, which is fundamental to engagement in sport and physical activity. Therefore,
it is imperative to ensure fundamental movement skill development or skill rehabilitation following injury, particularly balance development and ability. Balance assessments are used in clinical practice for a variety of reasons ranging from performance and injury prevention\(^{34}\) to injury assessment.\(^{35,36}\) The physical literacy competence domain seeks to assess one’s movement skills because gross motor development is vital for athletic performance and completing activities of daily living,\(^{37}\) whereas motor skill proficiency is a predictor of level of physical activity during adolescence.\(^{38}\) Physical literacy measurements may be most useful in a population where motor control is developing, and the BESS may be more useful in a population where vestibular control is fully developed but may be compromised from injury. In some instances, both measurements may be useful information to include in an evaluation. Clinicians measuring balance ability should consider their patient’s stage of maturation and development when choosing the most appropriate instrument(s).

Physical literacy is an important aspect of movement and lays the foundation for competence in sport participation. Although there are numerous constructs of physical literacy, this study focused on the balance-specific components of competence because balance is often measured by athletic trainers and sports medicine clinicians in movement assessments, post-injury evaluations, and during rehabilitation. We noted only low to moderate correlations between the BESS and competence in the physical literacy balance tasks, which suggests the need for clinicians to critically consider their goals and the age and development stage of their patient population prior to choosing a balance measurement instrument.

**IMPLICATIONS FOR CLINICAL PRACTICE**

Balance ability is a pivotal component of motor development and, in turn, sport and physical activity participation. All tasks used in this study require minimal equipment and can be performed by trained clinicians at a low cost in a relatively short period of time per athlete. Clinicians must consider their purpose for measuring balance when choosing the most appropriate balance tool(s). Physical literacy measurements may be more appropriate to gauge motor development of younger athletes, but the BESS may be more informative when the clinician wants to challenge the patient’s vestibular and somatosensory systems more specifically. Similarly, clinicians may want to use multiple assessments to holistically evaluate the balance development of an athlete.

**REFERENCES**


