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Establishing Normative Values for the Barnett Balance Assessment Tool: A Preliminary Study

Abstract

The purpose of this study was to establish normative data for the Barnett Balance Assessment (BBA) for individuals ages 18-70+ years. The BBA is a newly developed assessment tool that may address limitations present in other assessments currently used to detect balance deficits. The BBA was administered to 141 participants who had no history of medical issues that could impact balance. A review of the normative data collected indicated little variation in total assessment scores in the age categories of 18-29, 30-39, and 40-49, due to the presence of a ceiling effect. Variations existed in scores among participants in the remaining age categories (50-59, 60-69, and 70+). These findings may imply that the BBA has its greatest discriminative power in assessing individuals with impaired balance, and/or that the BBA is not sensitive enough to detect differences in individuals with mild balance impairments. The researchers suggest future studies be conducted with the BBA to establish norms with populations with known orthopedic or neurological conditions that may impair balance. Results of these studies could then be compared with the baseline data gathered in this study to determine the BBA's usefulness in detecting balance impairments with clinical populations.

Keywords

Assessment, Balance, Barnett Balance Assessment, Normative Data

Cover Page Footnote

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Credentials Display

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According to the Centers for Disease Control and Prevention, in 2010, "falls among older adults cost the United States over 30 billion dollars in direct medical costs" after inflation (CDC, 2013a). Falls can lead to declines in quality of life, due to the diminished levels of mobility, physical fitness, activity, and independence that may occur following a fall (CDC, 2013b). Researchers predict that the costs related to fatal and nonfatal falls, as well as the number of individuals experiencing falls, will increase as the baby boomer generation approaches older adulthood (Trader, Newton, & Cromwell, 2003). For these reasons, falls have been considered a major health concern in the US (Trader et al., 2003).

Prior research has identified declines in balance as a leading factor contributing to falls (Oddsson, Boissy, & Melzer, 2007; Talbot, Musiol, Witham, & Metter, 2005). Not only is balance essential for fall prevention, but a deficit in balance can also impact an individual's ability to perform activities of daily living (ADLs; Blum & Korner-Bitensky, 2008). Thus, accurate identification of individuals with balance deficits should be of importance to professionals working with populations at risk for falls.

There are many balance assessment tools currently utilized in clinical practice that are designed to detect the presence of balance deficits and evaluate the effectiveness of balance-focused treatment interventions. These include the Berg Balance Scale (BBS), the Falls Efficacy Scale International (FES-I), the Tinetti Balance Assessment Tool, and the Multi-Directional Reach Test (MDRT) (Blum & Korner-Bitensky, 2008; Delbaere et al., 2010; Sterke, Huisman, van Beeck, Looman, & van der Cammen, 2010; Winser & Kannan, 2011). Specifically, the BBS measures a subject's ability to sustain equilibrium during the performance of dynamic movement patterns or while maintaining static postural balance for a predetermined period of time (Blum & Korner-Bitensky, 2008). Administration of the BBS requires minimal equipment consisting of common household objects, takes approximately 15 to 20 min to complete, demands relatively little space, and provides a numerical score that can be recorded and reproduced (Berg, Wood-Dauphinee, Williams, & Gayton, 1989; Blum & Korner-Bitensky, 2008; Smith, Hembree, & Thompson, 2004). The FES is reported to be the most widely used tool for its purpose (Delbaere et al., 2010; Yardley et al., 2005). The FES and FES-I subjectively assess the subject's concerns for falling. The POMA-T is used to measure balance and gait abilities and requires minimal equipment, training, and timing for administration (Miller, Magel, & Hayes, 2010; Sterke et al., 2010; Tinetti, 1986). The MDRT measures the limits of stability and balance while reaching forward, backward, to the left, and to the right (Holbein-Jenny, Billek-Sawhney, Beckman, & Smith, 2005; Newton, 2001). These measurements can be used to compare an individual's ability to maintain balance before and after intervention and/or to measure the efficacy of intervention focused on improving balance.

While each of these assessments can provide useful information to the rehabilitation team, a review of the literature reveals several limitations. A significant concern with many of these assessments is that they do not examine balance while reaching and performing trunk rotation, which is a crucial element of everyday functional task performance (Holbein-Jenny et al., 2005; Holbein-Jenny, McDermott, Shaw, & Demchak, 2007; Smith et al., 2004; Sterke et al., 2010; Winser & Kannan, 2011). In addition, these tests do not identify the specific point at which the participant experiences a balance deficit during the completion of task-specific movement patterns (Smith et al., 2004; Sterke et al., 2010). A lack of knowledge regarding the specific point of balance loss could prevent clinicians from designing interventions that appropriately address the individual's true deficits in balance (Miller et al., 2010).

Several other elements critical for accurate identification of balance impairments are not evaluated by the more commonly used balance assessments. For example, although most functional tasks that pose a challenge to balance require the integration of fine motor abilities with gross motor reaching, the most commonly used balance assessments do not include tasks that necessitate the use of fine motor abilities while moving or reaching (Holbein-Jenny et al., 2005; Holbein-Jenny et al., 2007; Winser & Kannan, 2011). One specific assessment, the FES-I, relies on the subjective interpretation of data by the administrator and the participant. This may reduce the reliability of assessment scores, as interpretations of the survey questions and the participants' perceived abilities may differ among individuals (Hotchkiss et al., 2004; Trader et al., 2003). Another common balance assessment, the BBS, requires use of common household objects that may differ in regard to key physical characteristics relevant to testing outcomes (such as the presence of arms on a chair). This may reduce reliability, due to inconsistencies in instrumentation (Smith et al., 2004). Therefore, the limitations of the current balance assessments support the need for a tool that more comprehensively assesses balance issues and relates them to functional outcomes.

The Barnett Balance Assessment (BBA) is a newly developed assessment tool that may address the previously discussed limitations. The BBA requires the client to perform specified movements using a standardized testing tool (see Figure 1). The device includes the moveable balance arc and arm, placement hoops, and four markers used to complete the assessment. The BBA is designed to quantitatively measure a client's ability to maintain balance when performing reaching tasks involving various weight shifts in a specified pattern. The assessment consists of three subtests (Ascending Reach, Outward Reach, and a Balance Arc), which can be given consecutively or separately, depending upon the client's needs. Within each of these subtests, balance is evaluated in specific testing categories as follows: Left Side, Left Side at Trunk Rotation, Right Side, Right Side at Trunk Rotation, Shift from Right to Left, and Shift from Left to Right.

A numerical score is given for each subtest, allowing researchers to track a client's progress over time. An individual's subtest score is based on every task within that specific subtest. An overall testing category score can also be calculated by combining scores for that specific testing category across the three subtests of the BBA. For example, researchers can total the scores from specific tasks completed in each of the subtests of the testing category that require the individual to perform trunk rotation.

Figure 1. The Barnett Balance Assessment (BBA).

During the assessment, the client remains flat-footed on the ground and initiates movement within the frontal plane, simulating functional use of the upper extremity. The fine motor component of the BBA includes placing markers (weighted metal hooks) and rings in specified locations on the testing device. This may potentially allow the administrator to discern if the client is having difficulties with balance when completing tasks requiring the integration of fine motor coordination into gross motor movements. The BBA provides information regarding the specific point at which balance dysfunction occurs—a detail not provided in the results of other assessments (Smith et al., 2004; Sterke et al., 2010). In addition, the BBA utilizes standardized testing equipment that requires the integration of fine motor coordination into gross motor reaching tasks, thus more effectively simulating the performance of many daily activities. These characteristics of the BBA differentiate it from many other balance assessments commonly used in clinical practice (Holbein-Jenny et al., 2005; Holbein-Jenny et al., 2007; Smith et al., 2004; Winser & Kannan, 2011).

Purpose of the Study

Currently, normative data have not been established for the BBA. In order to consider the BBA a complete and rigorous assessment tool that can be used in clinical practice, researchers must collect normative data from typical adult populations. Normative data will allow for the use of the BBA as a screening tool to assess impairments in static and dynamic balance. Establishing normative data will also allow practitioners to evaluate the effectiveness of treatment by comparing functional performance pre and post treatment (Mitrushina, Boone, Razani, & D'Elia, 2005).

Thus, the purpose of this descriptive, normative study was to collect quantitative, normative data for the BBA. The development of norms is necessary before an assessment can be used in the clinical setting, as these norms allow therapists to evaluate an individual's performance by comparing scores to what is typical of the individual's population (Mitrushina et al., 2005).

Method

Participants

The target population for the study included healthy individuals 18 years and older with the accessible population located within the state of Michigan. In order for a participant to qualify for the study, he or she must have been: (a) free from any neurologic or orthopedic conditions that may have impaired balance, per self-report; (b) independently ambulatory without assistive devices; and (c) able to follow simple verbal instructions.

Participants were not included in the study if they: (a) had experienced a fall resulting in hospitalization or serious injury within the past year; (b) experienced a seizure within the past year; (c) had a prior history of balance impairment or a current balance impairment due to present medication usage that may affect balance performance in any way, per self-report; (d) failed to successfully complete the researcher-designed screening tool and balance questionnaire; (e) were experiencing any health issues at the time of the study that affected their balance performance in any way, per self-report; and (f) were under the age of 18 years. The researchers selected the inclusion and exclusion criteria to reduce the risk of injury to the participants, as well as to ensure that the sample accurately represented a normative population.

The researchers established a target sample size of approximately 270 participants based on a thorough review of various reliability, validity, and normative studies of common balance assessments (Alzayer, Beninato, & Portney, 2009; Berg et al., 1989; Berg, Wood-Dauphinee, Williams, & Maki, 1992; Delbaere et al., 2010; Delbaere, Smith, & Lord, 2011; Hauer et al., 2009; Hotchkiss et al., 2004; Muir, Berg, Chesworth, & Speechley, 2008; Newton, 2001; Panella, Tinelli, Buizza, Lombardi, & Gandolfi, 2008; Peters et al., 2011; Smith et al., 2004; Sterke et al., 2010; Yardley et al., 2005). The researchers aimed to recruit 50 participants within each age category (18-29, 30-39, 40-49, 50-59, 60-69, 70-79, and 80+) for a projected total sample size of 350 participants.

Instrumentation

Materials used in the data collection process included a researcher-designed screening tool and balance questionnaire to determine participant eligibility for the study and the BBA score sheet. The BBA score sheet is divided into three subtests (Ascending Reach and Outward Reach tests [which are scored on a 4-point scale], and the Balance Arc test [which is scored on a 3-point scale]). Within each subtest, the score sheet further breaks down performance into the following testing categories: Left Side, Left Side at Trunk Rotation, Right Side, Right Side at Trunk Rotation, Shift from Right to Left, and Shift from Left to Right. An individual's score in each of these testing categories is based on his/her performance on certain category-specific tasks contained within the three subtests of the BBA. For example, a score in the testing category Right Side at Trunk Rotation is calculated based on the individual's score on specific tasks in each of the subtests (Ascending Reach test, Outward Reach test, and Balance Arc test) that require balance on the right side of the body while performing trunk rotation. All scores were recorded on the BBA data sheet (available in electronic and paper versions). Scores collected from the study sample were used to establish normative data.

Apparatus

The BBA device has two distinct sections (an "arm" and an "arc") that allow the tool to be moved in various testing positions. The "arm" is fitted with four eyelets and can be moved within the frontal and transverse planes. The "arc" can be positioned at 90° vertically or moved 30° away from or toward the client. The device is manufactured with medical-grade metals and plastics (N. Barnett, personal communication, November 27, 2012).

Procedures

Study site. The researchers recruited participants for this research study from various locations within the state of Michigan. Analysis of the data took place on the campus of a medium-sized public university in the Midwestern United States.

Data collection. The researchers' university granted IRB approval prior to initiation of the project. All of the participants gave informed consent. The developer of the BBA trained all of the investigators in the study prior to initiation of data collection. A pair of administrators assessed each participant. Verbal instructions were used to guide the participants through each subtest and testing component.

Testing was completed with each participant standing up on a flat, even surface. The participant extended both arms straight out in front and parallel to the floor (90° angle of glenohumeral joint) with shoulders aligned with hips (see Figure 2). The distance from the tip of the participant's middle digit to the front of the device was measured using a measurement marker (measuring 3 inches in length) to ensure a standardized administration of the assessment (see Figure 3).

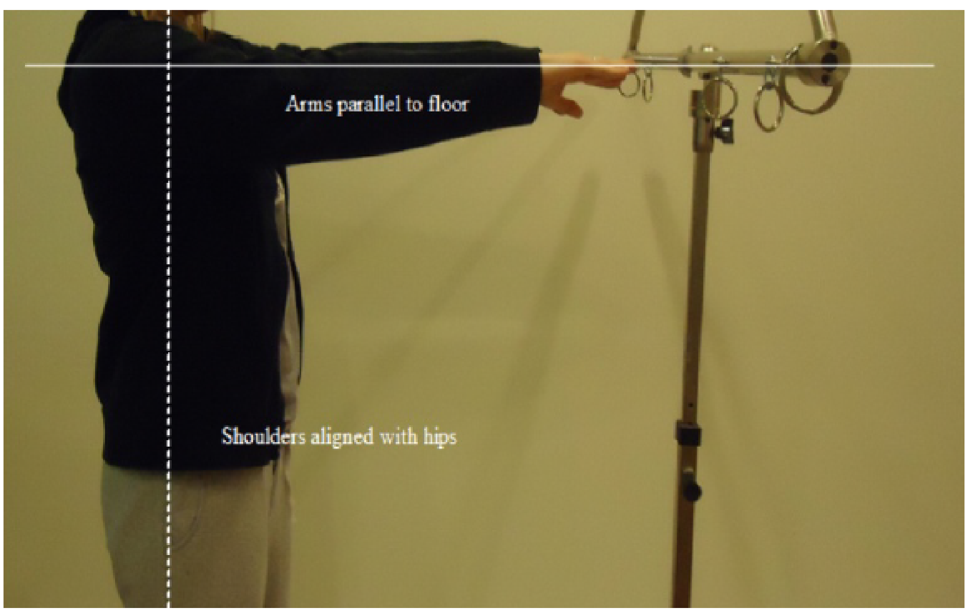

Figure 2. The standardized position of the participant during administration of the BBA.

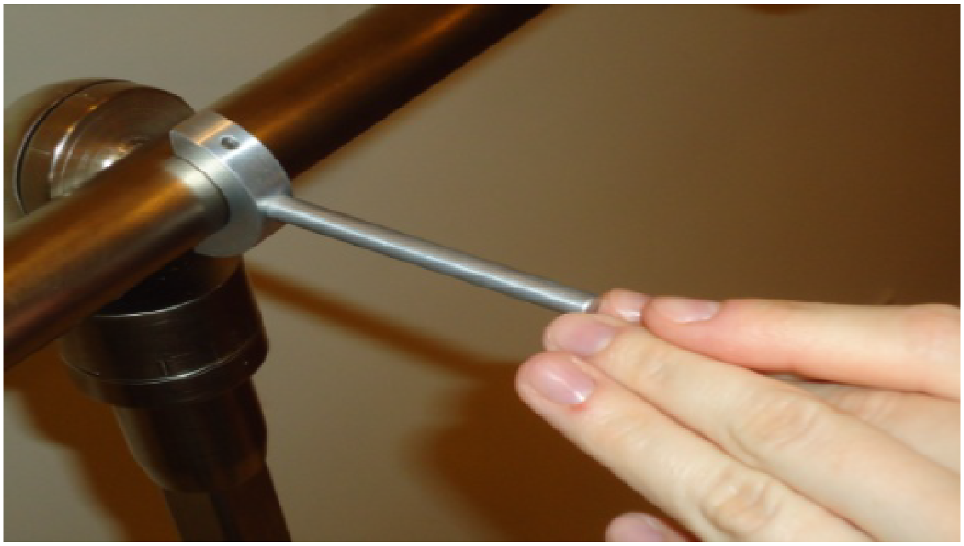

Figure 3. The metal measurement marker, requiring a distance of 3 inches between the participant's fingertips and the device, ensures standardization in the administration of the assessment tool.

Once the participant assumed the standardized position, the BBA was administered. The participant was asked to reach upward/downward, outward/inward, and to rotate the trunk, while in the frontal plane, reaching to the left and right as required for completion of each subtest and testing component. All of the movements were performed using the right and left hands unilaterally while shifting weight to both sides of the body (right-left, left-right) to place the markers on specified rings labeled A, B, C, and D. The participants were required to maintain foot placement shoulder width apart without taking a step. A step included removing a foot completely from the ground and/or sliding a foot from its original placement to another. The participants were able, however, to lift the heel and pivot on the ball of a foot during weight shifts. All of the participants followed a specified sequence as outlined on the data collection score sheet.

Data analysis. Initially, the age categories of 18-29, 30-39, 40-49, 50-59, 60-69, 70-79, and 80+ years of age were identified for data analysis, based on a review of the literature. The limited number of participants in the 80+ age category, however, resulted in the combining of the two age categories 70-79 and 80+ to create one age category of 70+ years of age. Descriptive statistics were utilized to determine the mean and standard deviation of participant data, as well as the median and interquartile range (IQR) of testing scores for the total population and for each age category. Box plots were also constructed to summarize and display data for each age category and the overall tested population, based on the median score and the IQRs of the data. Microsoft Excel 2010 was used to organize normative data according to age group, subtest, and testing categories. Data obtained in each age category were then used to calculate descriptive statistics for the total assessment score, each subtest, and the testing categories established in the BBA testing protocol (Left Side score, Left Side at Trunk Rotation score, Right Side score, Right Side at Trunk Rotation score, Shift from Right to Left score, and Shift from Left to Right score).

Results

Table 1 presents demographic data for all 141 participants. A disproportionately large number of the participants were represented in the age category of 18-29. Males accounted for 32% of all participants. The female participants outnumbered the male participants in every age category except 30-39, in which participation was equal among the sexes. The average age of all of the participants involved in the study was 43.16 years. The researchers noted little variation in the average age of male vs. female participants.

Table 1

Participant Data

	Male			Female			Total		
Age Group	*n*	*M* (*SD*)	Range	*n*	*M* (*SD*)	Range	*n*	*M* (*SD*)	Range
18-29	14	22.29 (2.05)	6	39	22.16 (3.00)	11	53	22.19 (2.76)	11
30-39	7	32.86 (2.04)	6	7	35.57 (3.60)	9	14	34.21 (3.14)	9
40-49	3	44.00 (3.46)	6	15	46.53 (3.34)	9	18	46.11 (3.39)	9
50-59	10	54.20 (2.97)	9	11	53.91 (3.08)	9	21	54.05 (2.96)	9
60-69	4	65.50 (3.11)	7	13	64.46 (3.36)	9	17	64.71 (3.24)	9
70+	7	73.43 (2.70)	8	11	75.55 (4.84)	15	18	74.72 (4.18)	15
Total	45	44.27 (19.47)	59	96	42.64 (19.85)	67	141	43.16 (19.67)	67

Note. Mean scores represent average age in years of the participants in the designated age group.

Distribution of Scores for BBA

The purpose of this study was to determine the normative BBA values for persons in the following age categories: 18-29, 30-39, 40-49, 50-59, 60-69, and 70+. A review of the normative data collected showed little variation in the total assessment scores in the age categories of 18-29, 30-39, and 40-49 (see Figure 4). This distribution of scores was the result of a ceiling effect, in which the majority of the individuals scored at or near the upper limit of the possible scores (Hessling, Traxel, & Schmidt, 2004). Increased variations in scores were present in the remaining age categories.

Frequency Distribution of Total Assessment Scores for the Barnett Balance Assessment

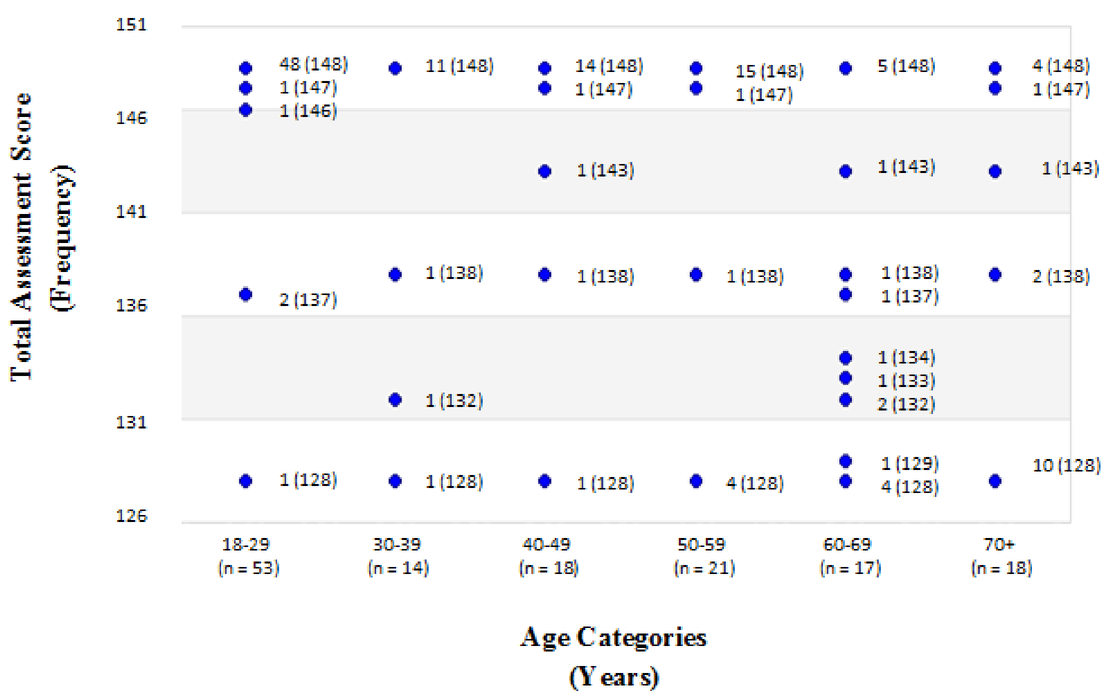

Figure 4. The maximum total assessment score on the BBA is 148.

Descriptive Statistics for BBA Total Assessment Score

Descriptive statistics were used to formulate a box plot representation of total assessment scores (see Figure 5). No outliers were observed above the third quartile because the third quartile represented the maximum possible score on the BBA. The median and the third quartile were observed as the same value (148), which also represented the maximum possible score on the BBA.

Descriptive Statistics for BBA Subtests

Descriptive statistics (including sample size, median, minimum, maximum, first quartile, third quartile, and IQR) were calculated for each subtest of the BBA as follows.

Ascending Reach. In the Ascending Reach subtest, no variation in the total scores was observed among the age categories. All participants, regardless of age or sex, scored the same. Each participant received the highest possible score for the subtest, resulting in first quartile, median, and third quartile scores of 48. This also led to an IQR of 0.

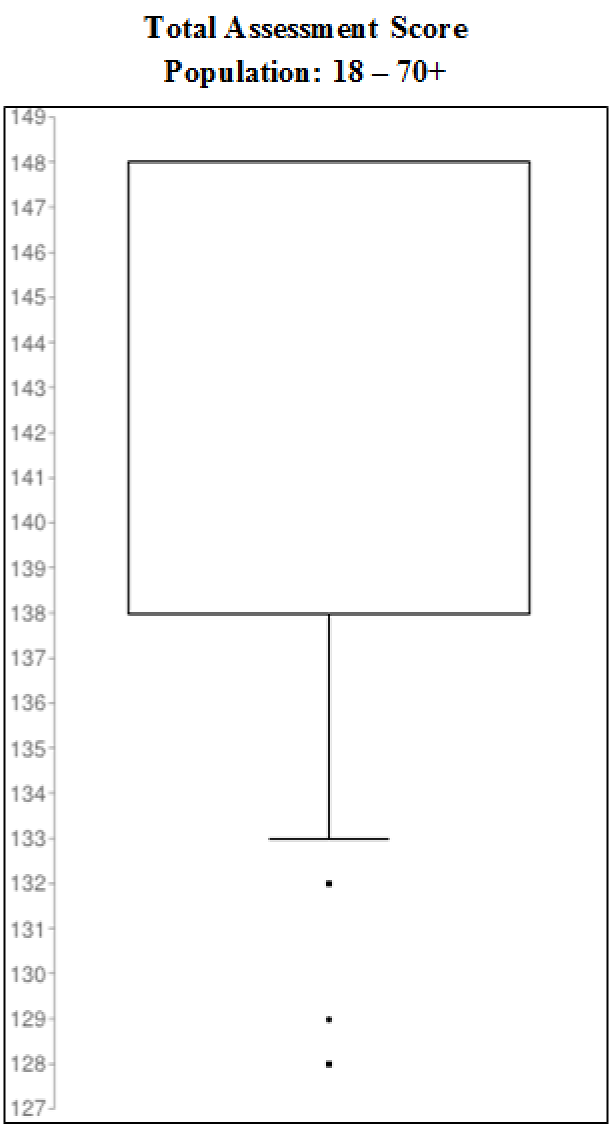

Figure 5. Total assessment score for participants among all age groups revealed the following: median = 148; minimum = 128; maximum = 148; first quartile (Q1) = 138; third quartile (Q3) = 148; interquartile range (IQR) = 10. Population size (*n*) = 141.

Outward Reach. The Outward Reach test was the only subtest in which variations in scores were observed. However, in each age category, the minimum score was 44 and the maximum was 64. There was very little variation in the IQR for the participants in the age categories of 18-29, 30-39, and 40-49. Increases in the amount of variation in the IQR were noted in the participants in the age categories 50-59, 60-69, and 70+.

The number and percentage of subjects in each age category scoring below ceiling on the Outward Reach test was not consistent. The number and percentage of subjects scoring below ceiling in each of the age categories are as follows: ages 18-29, five out of 53 participants (9%) scored below ceiling; ages 30-39, three out of 14 participants (21%) scored below ceiling; ages 40-49, four out of 18 participants (22%) scored below ceiling; ages 50-59, 16 out of 21 participants (76%) scored below ceiling; ages 60-69, 12 out of 17 participants (70%) scored below ceiling; and ages 70+, 14 out of 18 participants (78%) scored below ceiling.

Balance Arc. Variations were not observed in subject scores on the Balance Arc test. Each participant received the maximum possible score of 36, resulting in first quartile, median, and third quartile scores of 36. This also led to an IQR of 0.

Discussion

This study was the first to establish normative data for the BBA, a new tool designed to evaluate balance in individuals age 18-70+ years. The purpose of this descriptive study was to collect quantitative, normative data for the BBA, including the total assessment score; scores for each subtest (Ascending Reach score, Outward Reach score, and Balance Arc score); and scores for each testing category (Left Side score, Left Side at Trunk Rotation score, Right Side score, Right Side at

Trunk Rotation score, Shift from Left to Right score, and Shift from Right to Left score) for each age category.

A major finding in this study was that the data for the total assessment score displayed an asymmetrical (negatively skewed) distribution, which was the result of a ceiling effect for the participants under the age of 49 years. However, a ceiling effect was not observed in the total assessment scores for participants 49 years and older. The greater variation among scores in the older age categories was expected, due to age-related health changes that occur among older adults, which may affect balance (Bohannon, Larkin, Cook, Gear, & Singer, 1984).

A systematic review of the BBS revealed a similar ceiling effect when the assessment was used to measure balance in individuals with mild impairments. The investigators in the study concluded that because of the observation of a ceiling effect, the BBS may not detect important changes in individuals with mild impairments and therefore should be used with caution when assessing these individuals (Blum & Korner-Bitensky, 2008).

Implications

The findings from this study may indicate one or more of the following conclusions. The detection of a ceiling effect may suggest that the test has its greatest discriminative power at the lower end of the measurement scale (i.e., the tool is most appropriate for use in detecting individuals with moderate to severe balance impairments) (Mitrushina et al., 2005). The observation of a ceiling effect, however, may also suggest that the BBA is not sensitive enough to detect mild balance impairments (Blum & Korner-Bitensky, 2008). Therefore, while individuals with mild impairments may make notable improvements in balance over time, the BBA may not detect these differences. Now that preliminary normative data have been established for the BBA, the researchers suggest that future studies be conducted to gather data from populations with known orthopedic or neurological conditions that may impair balance. Results of these studies could then be compared with the baseline data that have been established in this study to determine the BBA's usefulness in detecting balance impairments with clinical populations.

Limitations

A review of the literature revealed a mean sample size of 270 participants recruited for various normative studies (Alzayer et al., 2009; Berg et al., 1989; Berg et al., 1992; Delbaere et al., 2010; Delbaere et al., 2011; Hauer et al., 2009; Hotchkiss et al., 2004; Muir et al., 2008; Newton, 2001; Panella et al., 2008; Peters et al., 2011; Smith et al., 2004; Sterke et al., 2010; Yardley et al., 2005); however, the study's projected sample size of 350 participants was not obtained within the data collection time period. This resulted in an overall smaller than anticipated sample size of 141 participants, and a smaller than desired sample size in each age category.

Another limitation of the study was the use of convenience sampling. The accessible population involved individuals who were located in the Midwestern United States, specifically within the state of Michigan. The participants recruited

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may not be representative of the entire population, resulting in limitations in the generalizations and inferences that can be made.

Sampling bias was also observed as another limitation of this study. In the study there was an overrepresentation of females, with 68% of all subjects tested being female. In addition, a healthy participant bias may have existed in the recruitment of older individuals. Most of the participants recruited who were above the age of 65 were individuals from a member-based organization that offers non-credit educational programs and travel opportunities for the over-50 population. These participants may have been more active and healthy compared to the average population of individuals 65 years and older. This may also limit the generalizations and inferences that can be made about the population aged 65 years and older.

In addition, there was a limited sample size of individuals above the age of 80, which resulted in limited normative data to represent the typical performance of these individuals. Obtaining data from participants over the age of 80 is clinically relevant because individuals in this age group are at a higher risk for falls (Talbot et al., 2005).

Finally, inter-tester reliability was not investigated. Although the test developer trained all of the examiners, results could have potentially differed across individual examiners based on individual differences in administration of the assessment.

Conclusion

This was the first normative study to provide data for the BBA, a new tool designed to evaluate balance in individuals ages 18-70+ years. The purpose of this descriptive study was to collect quantitative, normative data for each test of the BBA from individuals among six different age categories. Normative data for the BBA was established based on the assessment of 141 participants who were determined to have no impairments in balance.

A review of the normative data collected showed little variation in total assessment scores in the age categories of 18-29, 30-39, and 40-49, which was the result of a ceiling effect. However, greater variation in scores was present in the remaining age categories. These findings may suggest that the BBA has its greatest discriminative power in assessing individuals with impaired balance, and/or it is not sensitive enough to detect differences in individuals who score near the top of the measurement scale (e.g., individuals who have mild balance impairments). The researchers suggest that future studies should be conducted with populations with known orthopedic or neurological conditions that may impair balance. Results of these studies could then be compared with the baseline data that has been established in this study to determine the BBA's usefulness in detecting balance impairments with clinical populations. With the increasing number of falls occurring in the US today and a shift toward preventative care, this study will provide the field of occupational therapy with a means of detecting functional deficits in balance performance when compared to the typical population.

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