Physical fitness and performance of daily activities in persons with intellectual disabilities and visual impairment
Dijkhuizen, Annemarie

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2019

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Download date: 27-08-2019
Chapter 3

Validity of the modified Berg Balance Scale in adults with intellectual and visual disabilities

A. Dijkhuizen
W.P. Krijnen
C.P. van der Schans
A. Waninge

Chapter 3

Abstract

Background A modified version of the Berg Balance Scale (mBBS) was developed for individuals with intellectual and visual disabilities (IVD). However, the concurrent and predictive validity has not yet been determined.

Aim The purpose of the current study was to evaluate the concurrent and predictive validity of the mBBS for individuals with IVD.

Methods Fifty-four individuals with IVD and Gross Motor Functioning Classification System (GMFCS) Levels I and II participated in this study. The mBBS, the Centre of Gravity (COG), the Comfortable Walking Speed (CWS), and the Barthel Index (BI) were assessed during one session in order to determine the concurrent validity. The percentage of explained variance was determined by analyzing the squared multiple correlation between the mBBS and the BI, COG, CWS, GMFCS, and age, gender, level of intellectual disability, presence of epilepsy, level of visual impairment, and presence of hearing impairment. Furthermore, an overview of the degree of dependence between the mBBS, BI, CWS, and COG was obtained by graphic modelling. Predictive validity of mBBS was determined with respect to the number of falling incidents during 26 weeks and evaluated with Zero-inflated regression models using the explanatory variables of mBBS, BI, COG, CWS, and GMFCS.

Results The results demonstrated that two significant explanatory variables, the GMFCS Level and the BI, and one non-significant variable, the CWS, explained approximately 60% of the mBBS variance. Graphical modelling revealed that BI was the most important explanatory variable for mBBS moreso than COG and CWS. Zero-inflated regression on the frequency of falling incidents demonstrated that the mBBS was not predictive, however, COG and CWS were.

Conclusion The results indicated that the concurrent validity as well as the predictive validity of mBBS were low for persons with IVD.
Introduction

Persons with a visual disability exhibit decreased balance. Consequently, for persons with an intellectual disability (ID), these visual deficits are identified as a potential factor for falling. In all of the subgroups with ID, the prevalence of visual impairment (VI) and blindness are significantly higher compared to the overall Dutch population. In persons with severe or profound intellectual disabilities (ID), an additional visual disability moderately affects activities of daily living (ADL); this may be due to balance problems that are more severe.

When compared with their non-disabled counterparts, individuals with ID demonstrate a greater number of instances of instability during both quiet standing and walking. Moreover, individuals with ID, especially those who are ambulatory, also have an increased risk of falling. The rate of hospitalization due to injuries caused by falls is twice as high in persons with ID compared to the general population.

Individuals with visual impairment display inferior performance with locomotor skills as well, and individuals with more severe ID combined with visual disabilities are particularly at risk of developing difficulties with performing these skills and daily activities. It has been determined that mobility is an important predictor for the ability of persons with ID to perform ADL and that persons with severe or profound ID are less able to do so. Moreover, persons with intellectual and visual disabilities (IVD) may be more at risk than persons with ID for decreased balance or even falling.

The Berg Balance Scale (BBS) has been proposed as the most applicable instrument to assess balance capacities and falling risk in older adults with ID. Berg and colleagues found that the original balance score does not predict falling incidents among community-dwelling older people, however, in a previous study, Berg and colleagues showed that the BBS at baseline as well as visual deficits and a recent fall were significant predictors of the occurrence of multiple falls over the next year for this population. A higher score corresponds to better balance capacities with a maximum score of 56. It has been determined that a score of 45 on the BBS is the designated point for a greater risk of falling (<45) for older adults in general. No relationship between BBS and falling was found in older adults with mild to moderate intellectual disabilities and normal eyesight.
Chapter 3

As independent and safe mobility is important for participation in the community and activities of daily life,\(^6\) it is also crucial to determine balance, mobility, prevalence of falls, and activities in daily living in persons with IVD. An initial step to investigate balance in this population was made by adapting the original Berg Balance Scale protocol\(^{19,18}\) into the modified Berg Balance Scale (mBBS).\(^{23}\) This modified scale demonstrates sufficient feasibility and test-retest reliability\(^{23}\) and appears to be an executable and reliable test for evaluating the functional balance of individuals with IVD classified as Gross Motor Function Classification System (GMFCS) Levels I and II.\(^{23}\) However, the validity of the mBBS to predict falls by individuals with IVD has not been previously established. Furthermore, the degree of association of the mBBS with indices of functional performance provides an indication of the concurrent validity of the mBBS and may provide additional insight into the relationship between balance, mobility, ADL performance, and prevalence of falls in persons with IVD. In addition, an indication of the predictive validity of the mBBS could be determined by comparing the scores on the mBBS with the prevalence of falling incidents.

The aim of this study, therefore, was to evaluate the concurrent and predictive validity of the mBBS in persons with IVD.

**Methods**

**Participants**

Participants were recruited from residential care facilities within the Netherlands. Inclusion criteria consisted of having a moderate, severe, or profound intellectual disability (ID) according to the ICD-10,\(^{24}\) visual impairment (a visual acuity of less than 0.3 points, which indicates ‘severely partially sighted to blind’),\(^{24}\) and Levels I and II on the Gross Motor Function Classification System (GMFCS).\(^{25,26}\) Additional criteria included both written informed consent of representatives and support for participation from a physician specialized in intellectual disabilities in collaboration with a health care psychologist.

As the mBBS is intended for individuals with moderate, severe, or profound ID, visual impairment, and GMFCS Levels I and II,\(^{23}\) only individuals with these disabilities were included. The GMFCS is a five-level system utilized to classify the severity of motor disabilities in persons with intellectual and physical disabilities. Participants assigned a
Level I classification are generally capable of walking without restrictions but tend to exhibit limitations in motor skills that are more advanced. Those categorized as a Level II classification are capable of walking with minimal restrictions but do not spontaneously increase their speed while walking. Individuals assigned a Level III are capable of walking with walking devices, and the locomotor skills of those assigned with GMFCS Levels IV to V are very limited. The latter three levels were not considered as being viable participants for performing the balance test. As not all of the participants were able to give consent, their legal representatives did so.

Exclusion criteria consisted of mental or physical health issues that prevented the residential care facility clients from participating including psychoses, depression, or other severe psychological problems such as prolonged stress; somatic diseases defined as chronic diseases and/or diseases that are not remedied in a short period of time such as osteoarthritis, osteoporosis, pneumonia, and general illness or fever; taking antibiotics; worsening of asthma or epilepsy as signified with recent insult or epileptic fits; fresh wound(s)/bruise(s); other factors causing pain during movement; and, finally, stress as evidenced by the participant’s behavior shortly prior to the date of assessment.

Design

This quantitative cross-sectional/prospective study examined the concurrent validity of the mBBS in accordance with the strategy of Berg and colleagues,18 i.e., validating the original BBS. Berg18 assessed the validity of the Balance Scale for patients with a stroke by examining the manner in which the BBS scores related to: clinical judgments and self-perceptions of balance; laboratory measures of postural sway; external criteria reflecting balancing ability; and motor and functional performance.

The response variable in this study was the balance score as assessed by the mBBS.23 The availability of feasible and reliable tests for individuals with IVD was limited, therefore, in order to assess concurrent validity, the following indices of functional performances as explanatory variables were employed. To assess balance, the Centre of Gravity (COG)27 and the Comfortable Walking Speed (CWS)28 were used, and the Barthel Index (BI) was utilized to assess functional performance.15 Participant characteristics such as age, GMFCS, level of intellectual disability, level of visual impairment and presence of hearing impairment, and presence of epilepsy as additional explanatory
variables were described. As presence of epilepsy was identified as an independent risk factor for falls by adults with intellectual disabilities, it was expected to influence the mBBS. For the participants in this study with multiple sensory impairments, auditory impairments were added as an explanatory variable.

Fifty-four participants performed the mBBS, the COG, and the CWS during a single session. After completion of the procedure, the BI questionnaire and a monthly registration calendar of falling incidents were sent to the residential caretakers with a request to return the BI questionnaires as soon as possible and to send the calendar back after 26 weeks. Prior to taking the measurements, the test administrator completed a checklist indicating all exclusion criteria. If participants exhibited any of the exclusion criteria at the time of assessment, a new test date was scheduled. During the assessments, a test administrator and a gymnastics instructor were present. The gymnastics instructor organized and coached the participants in sports and exercise activities in daily life and was, therefore, well informed regarding the mental and physical limitations of each participant. The test administrator was a physical therapy bachelor student who was familiar with the protocols of the balance tests. The tests were performed over the duration of one day and in an established order whereby the mBBS was administered first; the participant then performed the COG; and, finally, the CWS. Prior to this study, a small group of persons with severe intellectual and visual disabilities (SIVD; n = 7) was examined in order to determine the optimal order of the tests.

**Ethical statement**

The study was performed in accordance with the guidelines of the Helsinki Declaration. An institutional ethics committee granted permission to conduct the study. Dispensation was obtained from the legal Medical Ethics Committee (2001/386, METcUMCG, Groningen, the Netherlands). The assessments were performed in accordance with the behavioral code section entitled ‘Resistance among people with an intellectual disability in the framework of the Act Governing Medical-Scientific Research Involving Humans’. Consistent distress or unhappiness were interpreted as indicators of a lack of assent, and further participation in the study was reconsidered.
Measures and protocols

Characteristics including intellectual disability, visual impairment, level of GMFCS, age, gender, presence of a hearing impairment, and presence of epilepsy were retrieved from the clients’ medical records. These characteristics were determined and categorized by a physician specialized in intellectual disabilities in collaboration with a health care psychologist. Data regarding visual impairment were categorized as no visual impairment, visual impairment, or being blind. The aetiology was classified as ‘Intellectual Disability (ID)’ in pre-, peri- or postnatal causes, Down Syndrome, and ‘unknown’.

Modified Berg Balance Scale (mBBS)

The mBBS is an adapted balance scale that has been substantiated as a feasible and reliable test for individuals with IVD.23 The original BBS consists of fourteen items,18 however, a number of these tasks were determined as being too difficult for individuals with IVD to perform, e.g., tandem standing, reaching forward while standing, turning one’s trunk while feet are fixed, and standing with eyes closed.23 Therefore, the protocol was slightly adapted by excluding these four components while adding two new items including walking on a thin line and walking on a gymnastics beam (width 30 cm, 40 cm above the floor). These two items were added since the participants practiced these tasks during gymnastics and, as a consequence, were familiar with them.23 After determining the feasibility and test-retest reliability, the items ‘stool stepping’ and ‘walking on a thin line’ were excluded because these items were not feasible or reliable.23 As a consequence, the final mBBS consists of ten test items which are shown in Table 1.
Chapter 3

**Table 1. Ten test items of the modified Berg Balance Scale.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Test item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sitting unsupported</td>
</tr>
<tr>
<td>2</td>
<td>Change of position: sitting to standing</td>
</tr>
<tr>
<td>3</td>
<td>Change of position: standing to sitting</td>
</tr>
<tr>
<td>4</td>
<td>Transfers</td>
</tr>
<tr>
<td>5</td>
<td>Standing unsupported</td>
</tr>
<tr>
<td>6</td>
<td>Standing with feet together</td>
</tr>
<tr>
<td>7</td>
<td>Turning 360 degrees</td>
</tr>
<tr>
<td>8</td>
<td>Retrieving objects from floor</td>
</tr>
<tr>
<td>9</td>
<td>Standing on one leg</td>
</tr>
<tr>
<td>10</td>
<td>Walking on a gymnastic beam</td>
</tr>
</tbody>
</table>

The performance for each of these items was scored on a 5-point ordinal scale (0-4 points) whereby a score of 0 denotes the inability of the participant to perform the task. A score of 4 is assigned when the participant is capable of completing the task in accordance with the criterion that has been assigned to it. The maximum score of the mBBS is 40 points. If a participant did not comprehend a task, ‘missing’ was noted.

**Center of Gravity (COG)**

The Center of Gravity (COG) during quiet standing balance was assessed with a Wii Balance Board and in accordance with Clark and colleagues. This test demonstrated validity when compared to the test results of a Force Platform and has been determined to be a genuine reflection of laboratory assessments of postural sway.

In order to reduce stress and testing time for participants, the test administrators calibrated the balance board in advance of testing. The participant was required to stand with two feet on the balance-board which could be reached from a specially developed ramp. Several seconds were required to calculate the deviation of the COG during quiet
standing balance. The COG deviation from the center was calculated as a percentage related to the center (0) either to the left or the right side (50%). A lower score indicated less deviation from the center. This value was displayed for the test administrators as a percentage left and right on a quadrant. Verbal support/tactile support was offered in order to maintain the lowest stress level as possible for the participant and to facilitate standing stationary for a few seconds. In some cases, it was necessary for the gymnastics instructor to manually correct the individual’s foot position on the balance board. The participants received the following instructions: ‘stand still, do not move, it’s going well, just stay a moment’. Following completion of this test, the participants received a compliment, ‘Well done.’ Testing the COG occurred over a two-minute time frame.

Comfortable Walking Speed (CWS)

The Comfortable Walking Speed (CWS) is a valid and reliable test for measuring functional stability and performance and is generally considered to be a valid reflection of motor and functional performance.28 The reliability and validity of the CWS were high for the general population,33-35 and the test-retest reliability in older adults with ID was also good (ICCs 0.96 for same-day interval and 0.93 for a two-week interval).36 Using markers on the floor (tape) at zero meters, three meters, and eight meters, the participant walked (with guidance) a distance of five meters with a start-up of three meters. The average of three assessments was recorded. The time was tracked from the moment that the front foot passed the first marker (three meters) to the moment that the front foot passed the last line (eight meters).37 Prior to the assessments, the participants practiced the CWS in order to become familiar with the test and the environment.

They walked the expanse of the course back and forth because of the issues presented by their visual impairment. Furthermore, the gymnastics instructor accompanied several of them in finding their way and assisted them in understanding what was expected during the trials without influencing their comfortable speed by making sounds, clapping, or by providing individually adapted information. In some cases, the gymnastics instructor accompanied participants in finding their way by giving tactile stimuli, e.g., a light tap on the shoulder. This adaptation was necessary due to intellectual disability combined with visual impairment.
Chapter 3

Barthel Index (BI)

The ability to perform ADL was assessed with the Barthel Index (BI)\textsuperscript{15,38,39}, which is generally accepted as an instrument for measuring the performance of daily activities within the clinical setting.\textsuperscript{40-42} Research of Mahoney and Barthel\textsuperscript{38} and de Haan\textsuperscript{43} substantiated the applicability and simplicity of the questionnaire. There were ten questions to be answered regarding the daily activities of the participants, namely: bowel control, bladder control, grooming, toilet use, feeding, transfer, walking, dressing, stair climbing, and bathing. There were two to four scoring categories with a total score ranging from zero (completely dependent) to 20 (completely independent).\textsuperscript{42,44} The Barthel Index (BI), which has been found to be just as reliable as testing the participant, was filled in by the residential caregivers.\textsuperscript{14,44} It is applicable as a reliable assessment of ADL performance in persons with intellectual disabilities\textsuperscript{15} and is considered to be a reflection of a clinical judgment of Activities of Daily Living (ADL).

Fall Registration Calendar

A registration calendar to record falling activity is a recommended method of data collection by the Prevention of Falls Network Europe.\textsuperscript{45} Accordingly, the following definition of criterion for a fall was employed: ‘an unexpected event in which the participant comes to rest on the ground, floor, or lower level’.\textsuperscript{45} To register fall incidents, a monthly fall registration calendar was used\textsuperscript{30} for a duration of 26 weeks. These fall registration calendars were sent to the residential caregivers, and instructions were included on how to fill in the fall calendar noting the day a participant had fallen with a cross on the specific date and, if necessary and appropriate, how often a participant had fallen on that day. Caregivers were requested to return the calendar after the allotted time frame. Further information and details of the fall were recorded on the form ‘Error, Accident, or Near Accident’.

Data analyses

The data were analyzed by SPSS 20.0 and the programming language R version 2.3.0.\textsuperscript{46} The distribution of the measures was checked for normality with the Shapiro-Wilk Test. Throughout, 0.05 was taken as the significance level. Descriptive statistics were used to summarize participant characteristics.
Concurrent validity

Concurrent validity refers to the degree in which the operationalization of a construct correlates with other assessments of the same construct that are simultaneously assessed. Concurrent validity of the mBBS was examined in two ways:

1) Firstly, the explained percentage of mBBS variance by the explanatory variables BI, COG, CWS, GMFCS, and age, gender, level of ID, presence of epilepsy, level of visual impairment, and presence of hearing impairment was determined by the squared multiple correlation. The COG and CWS were utilized for determining the concurrent validity of the mBBS for measuring balance, and BI was used for measuring functional performance. Since employing too many explanatory variables in a linear regression may cause overfitting, model selection by minimum Akaike Information Criterion (AIC) was used. The R squared as well as its adjusted version was reported in order to evaluate the degree of overfitting by the size of their differences.

2) Secondly, to gain additional insight into the structure of (conditional) interdependencies between mBBS, BI, CWS, and COG, a graphical modelling approach based upon minimum AIC was employed. This afforded an opportunity to explore how predictive each of these measurements are for any of the remaining predictors or to what extent there is a most important predictor for the remaining three.

Predictive validity

The mBBS scores of persons with and those without falling incidents were visualized with a box-and-whisker plot. Subsequently, to evaluate the predictive validity of the mBBS to identify persons at risk for falling, hurdle regression models for count data were applied using the explanatory variables mBBS, BI, COG, CWS, and GMFCS. In order to account for a relatively large number of zeros (no fall incidents) in the data, a two-component mixture approach was taken which combines a negative binomial for positive counts and a binomial for zero counts. The predictive variables were selected according to the Akaike Information Criterion (AIC), which is a practical, flexible, and frequently applied method for model selection. Differences in means were explored by the independent t-test in order to identify variables that distinguish between falling and the absence of falling incidents.
Chapter 3

Results

Written informed consent of the representatives was obtained for 69 participants.

Fifteen participants were excluded for the following reasons; six for medical/behavioral reasons and nine as a result of the exclusion criteria at the time of obtaining the assessments. The 54 participants in this study comprised 33 males and 21 females. The mean (SD) age for males was 43.8 (12.5) years and 39.9 (13.6) years for their female counterparts. Participant characteristics and test results of the participants are exhibited in Table 2.

Table 2. Characteristics and test results of the participants.

<table>
<thead>
<tr>
<th></th>
<th>Participants N (%)</th>
<th>mBBS Mean ±SD</th>
<th>COG (points) Mean ±SD</th>
<th>CWS (m/s) Mean ±SD</th>
<th>BI (points) Mean ±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, Mean ±SD</td>
<td>42.3 ±12.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMFCS level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level I</td>
<td>32 (59%)</td>
<td>33.8 ±5.05</td>
<td>7.9 ±5.80</td>
<td>5.1 ±1.25</td>
<td>14.3 ±4.04</td>
</tr>
<tr>
<td>Level II</td>
<td>22 (41%)</td>
<td>26.2 ±3.82</td>
<td>7.1 ±6.82</td>
<td>6.5 ±2.65</td>
<td>10.1 ±3.94</td>
</tr>
<tr>
<td>Intellectual disability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>7 (13%)</td>
<td>36.4 ±5.03</td>
<td>7.8 ±5.23</td>
<td>5.8 ±1.63</td>
<td>15.5 ±5.24</td>
</tr>
<tr>
<td>Severe</td>
<td>33 (61%)</td>
<td>31.3 ±4.68</td>
<td>7.5 ±6.63</td>
<td>5.7 ±2.13</td>
<td>13.8 ±3.39</td>
</tr>
<tr>
<td>Profound</td>
<td>14 (26%)</td>
<td>26.1 ±5.87</td>
<td>7.7 ±5.79</td>
<td>7.5 ±2.63</td>
<td>8.3 ±3.82</td>
</tr>
<tr>
<td>Visual disabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blind / Severely partially sighted</td>
<td>35 (65%)</td>
<td>30.7 ±5.88</td>
<td>7.1 ±4.55</td>
<td>6.2 ±2.26</td>
<td>12.0 ±4.32</td>
</tr>
<tr>
<td>Partially sighted</td>
<td>15 (28%)</td>
<td>29.7 ±4.80</td>
<td>8.4 ±9.12</td>
<td>6.3 ±2.66</td>
<td>13.1 ±3.87</td>
</tr>
<tr>
<td>Slightly limited sight</td>
<td>4 (7%)</td>
<td>33.3 ±9.91</td>
<td>8.5 ±5.49</td>
<td>5.3 ±1.38</td>
<td>16.3 ±6.85</td>
</tr>
<tr>
<td>Epilepsy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>30 (56%)</td>
<td>33.18 ±5.99</td>
<td>6.8 ±5.67</td>
<td>6.4 ±2.30</td>
<td>11.2 ±3.62</td>
</tr>
<tr>
<td>No</td>
<td>24 (44%)</td>
<td>28.72 ±5.13</td>
<td>8.7 ±6.79</td>
<td>5.9 ±2.33</td>
<td>14.6 ±4.81</td>
</tr>
<tr>
<td>Hearing disabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>19 (35%)</td>
<td>32.2 ±6.02</td>
<td>6.8 ±5.44</td>
<td>6.5 ±2.49</td>
<td>11.7 ±4.11</td>
</tr>
<tr>
<td>No</td>
<td>35 (65%)</td>
<td>29.7 ±5.72</td>
<td>9.1 ±7.21</td>
<td>5.6 ±1.84</td>
<td>14.3 ±4.73</td>
</tr>
</tbody>
</table>

GMFCS: Gross Motor Functioning Classification System
Written informed consent of the representatives was obtained for 69 participants. Fifteen participants were excluded for the following reasons; six for medical/behavioral reasons and nine as a result of the exclusion criteria at the time of obtaining the assessments. The 54 participants in this study comprised 33 males and 21 females. The mean (SD) age for males was 43.8 (12.5) years and 39.9 (13.6) years for their female counterparts. Participant characteristics and test results of the participants are exhibited in Table 2.

Table 2. Characteristics and test results of the participants.

<table>
<thead>
<tr>
<th>Participants</th>
<th>N (% )</th>
<th>mBBS Mean, ±SD</th>
<th>COG (points) Mean, ±SD</th>
<th>CWS (m/s) Mean, ±SD</th>
<th>BI (points) Mean, ±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, Mean, ±SD</td>
<td>42.3 ±12.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMFCS level</td>
<td>Level I</td>
<td>32 (59%)</td>
<td>33.8 ±5.05</td>
<td>7.9 ±5.80</td>
<td>5.1 ±1.25</td>
</tr>
<tr>
<td></td>
<td>Level II</td>
<td>22 (41%)</td>
<td>26.2 ±3.82</td>
<td>7.1 ±6.82</td>
<td>6.5 ±2.65</td>
</tr>
<tr>
<td>Intellectual disability</td>
<td>Moderate</td>
<td>7 (13%)</td>
<td>36.4 ±5.03</td>
<td>7.8 ±5.23</td>
<td>5.8 ±1.63</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>33 (61%)</td>
<td>31.3 ±4.68</td>
<td>7.5 ±6.63</td>
<td>5.7 ±2.13</td>
</tr>
<tr>
<td></td>
<td>Profound</td>
<td>14 (26%)</td>
<td>26.1 ±5.87</td>
<td>7.7 ±5.79</td>
<td>7.5 ±2.63</td>
</tr>
<tr>
<td>Visual disabilities</td>
<td>Blind / Severely partially sighted</td>
<td>35 (65%)</td>
<td>30.7 ±5.88</td>
<td>7.1 ±4.55</td>
<td>6.2 ±2.26</td>
</tr>
<tr>
<td></td>
<td>Partially sighted</td>
<td>15 (28%)</td>
<td>29.7 ±4.80</td>
<td>8.4 ±9.12</td>
<td>6.3 ±2.66</td>
</tr>
<tr>
<td></td>
<td>Slightly limited sight</td>
<td>4 (7%)</td>
<td>33.3 ±9.91</td>
<td>8.5 ±5.49</td>
<td>5.3 ±1.38</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>Yes</td>
<td>30 (56%)</td>
<td>33.18 ±5.99</td>
<td>6.8 ±5.67</td>
<td>6.4 ±2.30</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>24 (44%)</td>
<td>28.72 ±5.13</td>
<td>8.7 ±6.79</td>
<td>5.9 ±2.33</td>
</tr>
<tr>
<td>Hearing disabilities</td>
<td>Yes</td>
<td>19 (35%)</td>
<td>32.2 ±6.02</td>
<td>6.8 ±5.44</td>
<td>6.5 ±2.49</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>35 (65%)</td>
<td>29.7 ±5.72</td>
<td>9.1 ±7.21</td>
<td>5.6 ±1.84</td>
</tr>
</tbody>
</table>

The Shapiro-Wilk Test did not reject normality of the mBBS and BI assessments (p=0.07 and p=0.09) but did reject normality for the CWS and COG assessments (p values < 0.001). However, Quantile-Quantile normality plots indicated that all observations fell within 95% confidence intervals with the exception of two out of 51 for CWS and five out of 48 for COG. The mean (SD) score for mBBS was 30.7 (5.9), for BI score 12.6 (4.5), for COG score 7.6 (6.2) and for CWS score 6.2 (2.3).

Concurrent validity

First, Model 1 was estimated by employing all explanatory variables. This model (Table 3) depicts the three significant predictors of the GMFCS level, BI score, and level of intellectual disability with R squared 0.6737, adjusted R squared 0.5831 (p<0.001), and residual standard error 3.534 on 36 degrees of freedom. Neither the COG nor the CWS demonstrated a significant influence on the mBBS. Furthermore, no statistical evidence was found for the influence of age, gender, presence of epilepsy, visual impairment, and hearing impairment on mBBS. Substantial overfitting in this model is indicated by the difference between R squared and adjusted R squared (0.08) due to the presence of several explanatory variables with non-significant beta coefficients.

Second, Model 2 was found by variable selection according to minimum AIC beginning with the same significant explanatory variables as previously found in Model 1 and supplemented with Comfortable Walking Speed (Table 3). The R squared of this model was 0.6664, the adjusted R square was 0.6257, and the residual standard error was 3.349 on 41 degrees of freedom. The smaller difference between R squared and adjusted R squared indicated a reduction in overfitting. In Model 2, the score of CWS exhibited no significant influence on the score of the mBBS.
Chapter 3

Table 3.

Model 1: Linear regression model with mBBS as response variable and potentially relevant explanatory variables.

Model 2: Linear regression model by minimum AIC with mBBS as response variable.

<table>
<thead>
<tr>
<th>Model 1</th>
<th>mBBS score</th>
<th>Estimate (regression coefficient)</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>26.94</td>
<td>5.65</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>GMFCS level II</td>
<td>-7.20</td>
<td>-3.74</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Barthel Index, BI (in points)</td>
<td>0.52</td>
<td>2.81</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Comfortable Walking Speed, CWS (m/s)</td>
<td>0.48</td>
<td>1.46</td>
<td>0.153</td>
<td></td>
</tr>
<tr>
<td>Centre of Gravity, COG</td>
<td>-0.06</td>
<td>-0.63</td>
<td>0.529</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.02</td>
<td>0.29</td>
<td>0.776</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.17</td>
<td>0.15</td>
<td>0.882</td>
<td></td>
</tr>
<tr>
<td>Level of Intellectual Disability severe</td>
<td>-4.34</td>
<td>-2.15</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Level of Intellectual Disability profound</td>
<td>-3.29</td>
<td>-1.48</td>
<td>0.148</td>
<td></td>
</tr>
<tr>
<td>Presence of Epilepsy</td>
<td>0.19</td>
<td>0.13</td>
<td>0.901</td>
<td></td>
</tr>
<tr>
<td>Level of Visual Impairment</td>
<td>1.13</td>
<td>0.67</td>
<td>0.508</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model 2</th>
<th>mBBS score</th>
<th>Estimate (regression coefficient)</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>27.65</td>
<td>7.58</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>GMFCS level II</td>
<td>-6.51</td>
<td>-5.18</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Barthel Index (in points)</td>
<td>0.51</td>
<td>3.28</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Level of Intellectual Disability severe</td>
<td>-3.82</td>
<td>-2.51</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>Level of Intellectual Disability profound</td>
<td>-3.47</td>
<td>-1.78</td>
<td>0.082</td>
<td></td>
</tr>
<tr>
<td>Comfortable Walking Speed (m/s)</td>
<td>0.43</td>
<td>1.51</td>
<td>0.139</td>
<td></td>
</tr>
</tbody>
</table>

Model 1: R squared 0.67; adjusted R squared 0.58 (p<0.001); residual standard error: 3.53 on 36 degrees of freedom.

Model 2: R squared 0.67, adjusted R squared 0.63 (p<0.001); residual standard error: 3.35 on 41 degrees of freedom.
The degree of linear dependency between mBBS, BI, CWS, COG was investigated by the size of the inter correlations and their significance. Pearson correlation between mBBS and BI was highly significant and moderately strong (mBBS-BI r = 0.63, p = < 0.001), significant and moderate between mBBS and CWS (mBBS-CWS r = -0.36, p = 0.014), and not significant and poor between mBBS and COG (mBBS-COG r = 0.10, p = 0.491). The Pearson correlation between BI and CWS were highly significant and moderately strong in size (BI-CWS r = -0.52, p = < 0.001). COG did not have significant correlations with any of the other assessments (COG-BI r = 0.26, p = 0.073 and COG-CWS r = -0.05, p = 0.738). A significant correlation implies that pairs of variables are dependent whereas, under normality of the data, a zero or non-significant correlation indicates independence.

*Figure 1. Graphical model of measurements mBBS, BI, CWS and COG.*

The conditional dependencies from the graphical model are visualized in Figure 1. The graph indicates that each of the four measurements depends on BI and that, given the BI score of the participant, the measurements of mBBS and CWS are independent and, given the BI score, the measurements of mBBS and COG are independent.

The graphical model clarifies the observation that mBBS is predicted better by BI and, once BI is part of the regression, both COG and CWS are unimportant as explanatory variables.
Chapter 3

Model 2 does not include COG and explains approximately 63% of the mBBS variance by, among others, the BI. The concurrent validity of the mBBS is not sufficient with respect to balance as measured by the COG. This finding is in accordance with the results from the graphical model and the partial correlations.

Predictive validity

The box-and-whisker plots of mBBS scores for persons with and without falling incidents are shown in Figure 2 which illustrates a complete overlap of mBBS scores from persons with and without falling incidents. During the course of six months, thirty-seven participants experienced no falling incidents; five participants experienced one fall; three persons fell two times; two persons fell three times; one person fell six times; two persons, eight times; and one person, 18 times. For three of the participants, data on falling incidents were not available.

![Box-and-whisker plots of mBBS scores for persons with and without falling incidents.](image)

**Figure 2.** Box-and-whisker plots of mBBS scores for persons with and without falling incidents.
To evaluate the predictive validity of the mBBS to identify persons at risk of falling, hurdle regression models for count data\(^5\) were used for fall incidents with explanatory variables mBBS, BI, COG, CWS, and GMFCS. To determine if any of the other variables distinguished fall incidents from no fall incidents, an independent t-test was performed. Age appeared to be the only variable which distinguished fall incidents from no fall incidents (mean age was 47 years for fall incidents; mean age was 40 years for no fall incidents; \(p=0.027\)). Therefore, age was included in the model to account for the overdispersion of zeros. The best model according to minimum AIC, given in Table 4, indicates that COG and CWS were significant predictors of fall incidents and that the mBBS had no additional predictive contribution.

**Table 4.** Count regression model to predict the response variable ‘number of falling incidents’.

<table>
<thead>
<tr>
<th>Incidence of falling</th>
<th>Estimate (regression coefficient)</th>
<th>Z value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.5969</td>
<td>-0.529</td>
<td>0.5971</td>
</tr>
<tr>
<td>Centre of Gravity (points)</td>
<td>-0.1149</td>
<td>-2.550</td>
<td>0.0108*</td>
</tr>
<tr>
<td>Comfortable Walking Speed (sec)</td>
<td>0.4472</td>
<td>2.507</td>
<td>0.0122*</td>
</tr>
<tr>
<td>Age</td>
<td>0.0333</td>
<td>1.225</td>
<td>0.2206</td>
</tr>
</tbody>
</table>

\(*P\) value < 0.05

**Discussion**

The results demonstrate that, for persons with IVD, the concurrent validity of mBBS is not sufficient for measuring balance nor for predicting a risk of falling. The mBBS is strongly related to BI and ADL performance. It was discovered that Model 2 predicts approximately 63% of the variance of the mBBS scores by the explanatory variables GMFCS, BI, CWS, and level of intellectual disability. Age, visual impairment, and presence of epilepsy have no influence on the scores of the mBBS. It was expected to ascertain a relationship between the mBBS and CWS, COG, and BI.

The graphical model demonstrates that, once BI is a component of the regression equation, CWS and COG have less predictive relevance. The results further show that
Chapter 3

mBBS is significantly and strongly related to the performance of activities in daily living (BI). This finding is in accordance with Oppewal\textsuperscript{14} regarding the BBS.

In Model 1, the score for the CWS had no influence on the score of the mBBS which could be due to the moderate sample size and the feasibility of the CWS. However, the CWS is a major contributor to the model because the regression coefficient is relatively large compared to the range of CWS scores. Furthermore, the finding that BI and COG are dependent from the graphical model explains that BI is the most important in a linear model with the mBBS as a response variable and the others as explanatory. It also explains that, once BI is incorporated into the regression equation, then CWS and COG are of minimal predictive importance.

For the participants, it was inconvenient to attempt to accomplish the CWS in one direction each time as this led to a diminished walking pace and to even stopping at times which may affect feasibility. Therefore, the participants walked back and forth while performing the CWS, and gymnastics instructors were required to accompany several of the participants to assist them in finding their way and helping them to understand what was expected of them. It is noteworthy that the experienced gymnastics instructors only guided the participants without giving them any physical support. For certain participants, the COG was also difficult to perform. The Wii Balance Board is very sensitive, and the participants were not allowed to move during the test which is very difficult for persons with IVD. During testing, each participant required some form of additional explanation that was more extensive than warranted by current protocols. Therefore, it may be a recommendation to re-examine the protocols of the CWS and the COG in the future for possible adaptations. In addition, further research should aim for testing the feasibility and the reliability of the COG and the CWS in individuals with IVD.

The current data did not provide evidence for using the mBBS as a significant predictor of fall incidents. This result is consistent with findings of Enkelaar\textsuperscript{20} in which the BBS could not differentiate between those with a tendency to fall and those who do not fall and with the findings of Oppewal\textsuperscript{21} who ascertained no relationship between the BBS and falls in older adults with either mild or moderate ID. The findings reported in the literature on the predictive validity of the original BBS in older adults are somewhat inconsistent. Berg\textsuperscript{18} found that, for older people, the BBS at baseline as well as visual deficits and a recent
fall were significant predictors of the occurrence of multiple falls over the next year. It has been determined that a score of 45 on the BBS is the designated point for determining a greater risk of falls for older adults in general.\textsuperscript{19} However, according to another study of Berg,\textsuperscript{17} the BSS does not reliably estimate the probability of falling.

Furthermore, it is worth noting that, in the current study, predictive validity is difficult to precisely assess due to the type of data: the majority of the participants showed no incidents of falling, and those participants with incidents of falling exhibited a wide range of fall incidents. Although zero-inflated regression accounts for an extensive number of zero fall incidents, the models may provide a systematic representation which clarifies only part of the data. In the current study, a complete overlap of mBBS scores from persons with and without fall incidents was shown. According to Berg,\textsuperscript{17} the BBS has better discriminatory ability for identifying people sustaining recurrent or multiple falls than identifying those among community-dwelling older people who fall once or sustain an injury.

The limitation of this study is that, due to the exclusion criteria, only a rather minimal number of participants in this study could be included for determining predictive validity. Another limitation might be that data concerning weight and height were not collected, whereby an insight into the homogeneity of this group and the comparison of body weight with the test results were not possible. Over all, it is evident that further research will be necessary with more participants in order to confirm our initial findings. In this future research, the number of predictor variables is an important factor in determining the minimum required sample size.\textsuperscript{53}

In conclusion, the concurrent criterion and predictive validity of mBBS is not sufficient for persons with IVD. Determining protocols of the CWS and the COG, adapting them, and testing feasibility as well as reliability in individuals with IVD are recommended. A follow-up study should aim at aggregating further evidence concerning the predictive validity of COG and CWS in a larger group of participants with IVD and identifying persons who have experienced recurrent or multiple falls.
Chapter 3

Acknowledgements

The research was financed by Hanze University Groningen, Royal Dutch Visio the Brink, and with funding from the Science Board of Physical Therapy in the Netherlands. The authors kindly acknowledge and thank the participants for their participation in this study, their representatives for giving permission, and the gymnastics instructors of Royal Dutch Visio the Brink for assistance with the assessments.
The research was financed by Hanze University Groningen, Royal Dutch Visio the Brink, and with funding from the Science Board of Physical Therapy in the Netherlands. The authors kindly acknowledge and thank the participants for their participation in this study, their representatives for giving permission, and the gymnastics instructors of Royal Dutch Visio the Brink for assistance with the assessments.

References


Chapter 3


Chapter 3

40. Green, J., Forster, A., & Young, J. (2001). A test–retest reliability study of the Barthel Index, the Rivermead Mobility Index, the Nottingham Extended Activities of Daily Living Scale and the Frenchay Activities Index in stroke patients. Disability and Rehabilitation, 23, 670-676.


