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

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Chapter 5

Measuring Quadriceps strength in adults with severe or moderate intellectual and visual disabilities: feasibility and reliability

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K.W. Douma
W.P. Krijnen
C.P. van der Schans
A. Waninge

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Abstract

Background A feasible and reliable instrument to measure strength in persons with severe intellectual and visual disabilities (SIVD) is lacking. The aim of our study was to determine feasibility, learning period and reliability of three strength tests.

Methods Twenty-nine participants with SIVD performed the Minimum Sit-to-Stand Height test (MSST), the Leg Extension test (LE) and the 30 seconds Chair-Stand Test (30sCS), once per week for 5 weeks. Feasibility was determined by the percentage of successful measurements; learning effect by using paired t test between two consecutive measurements; test–retest reliability by intraclass correlation coefficient and Limits of Agreement and, correlations by Pearson correlations.

Results A sufficient feasibility and learning period of the tests was shown. The methods had sufficient test–retest reliability and moderate-to-sufficient correlations.

Conclusion The MSST, the LE, and the 30sCS are feasible tests for measuring muscle strength in persons with SIVD, having sufficient test re-test reliability.
Introduction

Muscle strength contributes to mobility which impacts quality of life. The muscle strength of lower limbs is important for ambulatory activities such as rising from a chair, walking at an appropriate speed, and walking on stairs. Loss of muscle strength may lead to a decrease of activities in daily living (ADL) and worse health-related quality of life. A weakness of m. Quadriceps is a predictor of mortality as it is one of the first muscles that degenerates due to inactivity.

Muscle strength can be quantified by several reliable and valid tests that are attuned for specific target populations. In various settings with adolescents to older adults, with or without physical disabilities, it has been demonstrated that, e.g., hand held dynamometry and the 1-repetition maximum (1RM) are reliable and valid methods quantifying muscle strength. The 1RM is considered to be an effective method for assessing leg muscle strength and its changes. The 30 seconds Chair-Stand test (30sCS) is a valid and reliable instrument in the general population as well as in that of older adults for measuring muscular endurance. In addition, the 30sCS demonstrated a high validity for measuring Quadriceps strength. Related to the 30sCS, the Minimum-Sit-to-Stand Height Test (MSST) is used as a reliable functional instrument to measure strength in the lower limbs of older adults and is an effective predictor for functional capacity.

For measuring muscle strength in persons with an intellectual disability (ID), hand held dynamometry, measuring grip strength (Jamar), 30sCS, and the 1RM are used as feasible and reliable instruments measuring muscle strength of m. Quadriceps. However, in persons with severe or profound ID, feasibility for measuring grip strength (Jamar) is moderate to low. Therefore, this measurement does not seem to be feasible for people with SIVD. Also, the hand-held dynamometry may not be applicable in persons with a more severe intellectual disability. In addition, individuals experiencing severe intellectual and visual disability (SIVD) are physically weaker compared to persons with ID. Persons with both (severe) intellectual and visual disabilities (SIVD) often suffer from impaired health and physical fitness. Therefore, we expect persons with SIVD to have low muscle strength like those individuals with ID, in particular m. Quadriceps. However, until recently, a feasible and reliable instrument to measure strength in persons with SIVD has been lacking.
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Difficulties in performing strength tests can be expected due to severe ID and visual impairments. Also, the time frame in which persons with SIVD learn to adequately perform a strength test is currently unknown. The 1RM leg extension (LE) does seem to be an appropriate instrument to measure Quadriceps strength in persons with SIVD due to the availability of the equipment and because this test requires a movement in one fixed direction for the execution of the test. The 30sCS and the MSST seem to be suitable instruments to measure strength and muscular endurance in persons with SIVD due to their required functional movement which also occurs frequently during daily life.

Only a small number of measuring instruments to measure Quadriceps strength, described in literature, seems feasible for persons with SIVD, specifically, the MSST, the LE, and the 30sCS due to their functionality and participants’ required cognitive ability. Hence, we have formulated the following research questions: What is the feasibility, learning period, and reliability of the Minimum Sit-to-Stand Height test, the Leg Extension test, and the 30 seconds Chair-Stand test for persons with severe intellectual and visual disabilities? What is the association between scores of these tests?

Methods

Participants

Participants were recruited from a residential facility in the Netherlands. Inclusion criteria consisted of having a moderate to severe intellectual disability (ID) according to the ICD-10, visual disabilities (‘severely partially sighted to blind’), and Levels I and II on the Gross Motor Function Classification System (GMFCS). After obtaining written consent from the representatives of the participants, participants were screened regarding support for participation from a physician specialized in intellectual disabilities in collaboration with a health care psychologist. Individuals classified within Gross Motor Function Classification System (GMFCS) Levels I or II were included as a sufficient balance and mobility is required to perform the tests. The GMFCS is a five-level system utilized to classify the severity of motor disabilities in persons with intellectual and physical disabilities. Individuals classified at Level I are generally capable of walking without restrictions but tend to have limitations in advanced motor skills. Persons classified in Level II are capable of walking with minimal restrictions but do not spontaneously increase their speed while walking. Persons classified in Level III are
capable of walking only with the help of walking devices. The locomotor skills of persons classified in GMFCS Levels IV or V are very limited; therefore, they had to be excluded from the current study. Characteristics including gender, age, level of ID, level of GMFCS, visual impairment, presence of a hearing impairment, weight, and height were retrieved from the clients’ medical records. Data regarding visual impairment were categorized as no visual impairment, visual impairment, or being blind. These characteristics were determined and categorized by a physician specialized in intellectual disabilities in collaboration with a health care psychologist.

Exclusion criteria consisted of mental or physical health issues that prevented the client from participating such as psychoses, depression, or other severe psychological problems such as behavioural and prolonged stress; somatic diseases defined as chronic diseases and/or diseases that are not resolved 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); or other factors causing pain during movement; and, finally, stress as evidenced by a participant’s behavior shortly prior to the date of measurement.

Design

This is a repeated measurements study to examine measurement properties of three muscle strength measurements: The Minimum Sit-to-Stand Height Test (MSST), the Leg Extension (LE), and the 30 seconds Chair-Stand (30sCS).

Participants performed the MSST, LE and 30sCS within one session once a week for a period of five weeks. Prior to measuring, the test administrator completed a checklist on all exclusion criteria. A test administrator and a gymnastics instructor were present during the measurements. The latter was well informed on the mental and physical limitations of each of the participants and was familiar to the participants which facilitated the accuracy of the performance during testing. The test administrator was a physical therapist or a physical therapy bachelor student familiar with the protocols of the strength tests. The tests were performed in the established order whereby the 30sCS was measures first; the participant then performed the LE; and, finally, the MSST. At least a one-minute pause was taken between each performance of a test.
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Ethical statement
This study was performed in accordance with the guidelines of the Helsinki Declaration. Dispensation was obtained from the legal Medical Ethics Committee (2014/137, Medical Ethics Committee, University Medical Center Groningen, the Netherlands, METcUMCG). Because the participants were not able to, their legal representatives gave informed consent. The measurements 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 was interpreted as a sign of a lack of assent, and further participation in the study was reconsidered.

Measurements
Extra verbal instructions and encouragement were given to the participant during the test. Participants were also shown the expected movement and modelling in order to ensure an accurate performance. This form of adapted guidance was offered to maintain a minimal stress level for the participant because a presence of SIVD and a possible additional hearing impairment make it difficult or impossible for the participants to undergo measurements. If participants were able to complete the tests according to the protocol, the test result was recorded as ‘successfully performed’. When participants could not be present at time of the measurements due to extenuating circumstances, ‘not present’ was noted. Measurements were defined as ‘not feasible’ if participants could not perform the tests properly according to the protocol at the time of the measurements; e.g., when participants were unable to perform the test for cognitive reasons because they did not understand the test; when participants wanted to get up/raise by using their hands or arms while performing the MSST and the 30sCS; and when participants showed an incomplete lifting of the lower leg in the performance of LE.

Minimum Sit-to-Stand Height Test (MSST)
The participant was asked to stand up from the lowest possible position to fully upright without using his / her hands (without pushing off with arms/hands) or widening their foot position outside the legs of the seat. This position was recorded in unit centimeters. In order to rise from this deepest position, a special stepless in-depth-adjustable seat was developed. Below 18 cm, judo mats with a thickness of 4 cm were used. This allowed the
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Minimum Sit-to-Stand Height Test (MSST)
The participant was asked to stand up from the lowest possible position to fully upright without using his/her hands (without pushing off with arms/hands) or widening their foot position outside the legs of the seat. This position was recorded in unit centimeters. In order to rise from this deepest position, a special stepless in-depth-adjustable seat was developed. Below 18 cm, judo mats with a thickness of 4 cm were used. This allowed the seat depth to be reduced to 16 cm, 12 cm, 8 cm, 4 cm to eventually be phased to 0 cm when standing up from the floor. The minimum sit-to-stand height test has an excellent reliability of ICC 0.91 (95% confidence interval) CI 0.81-0.96 and moderate responsiveness for an inpatient rehabilitation setting. Leg Extension test (LE)
The participant sat on appropriate fitness equipment to perform maximum leg extension. Before performing the test, the maximum achievable extension (range of motion) was recorded. We then asked the participant to fully extend the leg against the maximum achievable resistance. The 1RM leg extension is a feasible and reliable instrument for measuring muscle strength of m. Quadriceps in adults with ID.

30 seconds Chair-Stand test (30sCS)
The participant sat in a firm chair that had no arms. We asked the participant to correctly stand up (full stance) and sit down as often as possible within a 30 second time frame without using his/her hands (without pushing off with hands) and, when possible, with arms crossed over chest/over each other. Testing time (30 seconds) was recorded using a handheld stopwatch. The number of completed standing incidents (up–down) was recorded. The 30sCS is developed in a population of older adults and is highly correlated with strength of the lower limbs. The 30sCS is a valid and reliable instrument in the general population to measure muscular endurance. Feasibility and test-retest reliability was moderate to good in adults with ID (ICC of 0.72 for same-day interval and 0.65 for a two-week interval). Reliability and validity of the 30sCS in the general elderly population is good with high test-retest reliability (r = 0.89). Test–retest reliability of the 30sCS in older adults with ID is moderate ICC 0.72 (same-day interval) and 0.65 (two-week interval).

Data analyses

Data analyses were performed using the Statistical Package for the Social Sciences (SPSS 22).
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Feasibility

The number of unsuccessful measurements (not feasible) was compared with the total number of measurements to derive the percentage of all successful measurements in order to determine feasibility. Feasibility was considered to be sufficient if the percentage of successful assessments exceeded 85%.\textsuperscript{34-36}

Learning period

The difference scores between consecutive time points of MSST, LE and 30sCS measurements was subjected to the Shapiro-Wilk and the Anderson-Darling normality tests. To gain insight into the learning period for the MSST, LE, and 30sCS, we used the paired t-test and the Wilcoxon signed rank test to investigate whether there was a difference in mean between two consecutive measurements over a period of five weeks. A non-significant difference was considered as the end of the learning period for a particular instrument.

Test re-test reliability

Between Weeks 4 and 5, test-retest reliability was analyzed by an intra-class correlation coefficient (ICC, one way random) for the MSST, LE, and 30sCS where an ICC ≥ 0.75 was considered to be acceptable.\textsuperscript{37,38} An ICC <0.75 indicated poor or moderate, 0.75 - 0.90 good, and > 0.90 very good reliability.\textsuperscript{39} For the reference range of the differences between the two measurements of the MSST, LE, and 30sCS, the limits of agreement (LOA) were calculated as ±1.96 timed the SD of the difference. The LOA is considered to be an indicator of test-retest reliability expressed in units of the measurement instrument as well as in a percentage of the mean of the first test.\textsuperscript{37} To assess test-retest reliability, the Standard Error of Measurement (SEM) was calculated for the MSST, LE, and 30sCS. The Standard Error of Measurement (SEM) represents the standard deviation of measurement error.\textsuperscript{39} The SEM reflects the reliability of the response.\textsuperscript{39}
Association between MSST, LE and 30sCS

To investigate the degree in which the MSST, LE, and 30sCS measure the same construct, the Pearson correlations (two-tailed) were calculated for Week 5. Correlations of 1.0-0.9 are indicated as nearly perfect, 0.9-0.7 very large, 0.7-0.5 large, 0.5-0.3 moderate, 0.3-0.1 small, and anything smaller than 0.1 trivial /very small.40 We applied a principal components analysis (PCA) to the MSST, LE, and 30sCS, to analyze the percentage of common variance between the three measurements on the basis of their inter-correlations.

Results

Written consent was requested from the representatives of 75 candidates whereby 44 agreed. Fifteen individuals were excluded for medical/behavioral reasons. None of the participants were excluded from the study due to consistent distress or unhappiness that was interpreted as a sign of a lack of consent. The 29 participants in this study comprise 16 males and 13 females. The mean (SD) age of all of the participants was 38.7 (14.5) with a minimum age of 20 and a maximum age of 63. The characteristics of the participants are depicted in Table 1.
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**Table 1.** Characteristics of the participants (N=29).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender, N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16 (55.2%)</td>
</tr>
<tr>
<td>Female</td>
<td>13 (44.8%)</td>
</tr>
<tr>
<td><strong>Age, Mean, ± SD</strong></td>
<td>38.7 ±14.5</td>
</tr>
<tr>
<td><strong>Intellectual disability, N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>7 (24.1%)</td>
</tr>
<tr>
<td>Severe</td>
<td>22 (75.9%)</td>
</tr>
<tr>
<td><strong>GMFCS level, N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Level I</td>
<td>25 (86.2%)</td>
</tr>
<tr>
<td>Level II</td>
<td>4 (13.8%)</td>
</tr>
<tr>
<td><strong>Visual Impairment, N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>(Severely) partially sighted</td>
<td>16 (55.2%)</td>
</tr>
<tr>
<td>Blind</td>
<td>13 (44.8%)</td>
</tr>
<tr>
<td><strong>Auditory Impairments, N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Normal hearing</td>
<td>16 (55.2%)</td>
</tr>
<tr>
<td>(Severely) hearing loss</td>
<td>11 (37.9%)</td>
</tr>
<tr>
<td>Deaf</td>
<td>2 (6.9 %)</td>
</tr>
<tr>
<td><strong>Weight in kg, Mean, ± SD</strong></td>
<td>69.4 ±12.2</td>
</tr>
<tr>
<td><strong>Height in cm, Mean, ± SD</strong></td>
<td>167.4 ±12.8</td>
</tr>
<tr>
<td><strong>BMI, Mean, ± SD</strong></td>
<td>24.8 ±3.5</td>
</tr>
</tbody>
</table>

**Feasibility**

The percentage of successfully performed MSST measures was over a period of five consecutive measurements between 86% and 100%, for LE between 86% and 97%, and between 93% and 100% for 30sCS. This indicates sufficient feasibility for the three different measurements.

**Learning period**

The normality of the difference scores between consecutive time points of the MSST, LE and, the 30sCS test, revealed in rejection of normality in all three tests. The parametric t-test and the non-parametric Wilcoxon signed rank test gave comparable p-values.

Table 2 shows the mean (SEM) differences of the consecutive weeks, the T-values, and the P-values corresponding to the paired differences in the mean. The size of the differences decreased for the sequential measurements. For the MSST, a non-significant difference was determined between the measures of Weeks 3 and 4. Regarding the
30sCS test, there was no significant difference between the first and the second measurements and, for the LE, a non-significant difference was found between the measures of Weeks 4 and 5.

Test re-test reliability

Table 2 summarizes the results of the (paired) t-tests and the Wilcoxon signed rank tests, ICC analyses, the LOA, and the LOA as a percentage of the mean between measurements of Weeks 4 and 5. Intra class correlation coefficients (one way random) were very strong and significant. The LOA, expressed as a percentage of the means (LOA %), were less than or equal to 17% for all three methods (MSST 6.7 %; LE 16.4%; 30sCS 17%). The standard error of measurement (SEM) was (0.12) for the MSST, (0.53) for the LE, and (0.21) for the 30sCS.
Table 2. (Paired) t-tests (measurements 1-5), Wilcoxon signed rank test (measurements 1-5), ICC analyses, the LOA and the LOA as a percentage of the mean for MSST, LE and 30sCS (measurements 4-5).

<table>
<thead>
<tr>
<th></th>
<th>Mean Diff (SEM)</th>
<th>T</th>
<th>P value t-test Wilcoxon</th>
<th>ICC</th>
<th>95% CI</th>
<th>LOA</th>
<th>LOA as mean %</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSST (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSST 1-2</td>
<td>1.6 (0.63)</td>
<td>2.5</td>
<td>0.020 / 0.024</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSST 2-3</td>
<td>1.4 (0.47)</td>
<td>3.1</td>
<td>0.004 / 0.004</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSST 3-4</td>
<td>0.69 (0.38)</td>
<td>1.8</td>
<td>0.085 / 0.090</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSST 4-5</td>
<td>0.00 (0.12)</td>
<td>0.0</td>
<td>1.000 / 1.000</td>
<td>0.999*</td>
<td>0.997 – 0.999</td>
<td>1.16</td>
<td>6.7</td>
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<tr>
<td>LE (kg)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>LE 1-2</td>
<td>-2.7 (0.67)</td>
<td>-4.0</td>
<td>0.001 / 0.001</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LE 2-3</td>
<td>-3.1 (0.795)</td>
<td>-3.8</td>
<td>0.001 / 0.001</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LE 3-4</td>
<td>-2.6 (0.94)</td>
<td>-2.8</td>
<td>0.011 / 0.004</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LE 4-5</td>
<td>-0.17 (0.53)</td>
<td>-0.3</td>
<td>0.747 / 0.484</td>
<td>0.973*</td>
<td>0.939 – 0.989</td>
<td>5.09</td>
<td>16.4</td>
</tr>
<tr>
<td>30sCS (no)</td>
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<td>30sCS 1-2</td>
<td>-0.68 (0.53)</td>
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<td>0.208 / 0.199</td>
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<td>-0.6</td>
<td>0.563 / 0.582</td>
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<tr>
<td>30sCS 3-4</td>
<td>-1.1 (0.295)</td>
<td>-3.8</td>
<td>0.001 / 0.001</td>
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<tr>
<td>30sCS 4-5</td>
<td>-0.15 (0.21)</td>
<td>-0.8</td>
<td>0.461 / 0.448</td>
<td>0.967*</td>
<td>0.927 – 0.985</td>
<td>1.96</td>
<td>17.0</td>
</tr>
</tbody>
</table>

MSST: Minimum Sit-to-Stand height test in centimeters (cm); LE: Leg Extension expressed in kilograms (kg); 30sCS: 30 seconds Chair Stand test expressed in number of repetitions (no); SEM: Standard error of measurement; Correlation is significant at the 0.01 level (1-tailed); *P value <0.001.
Table 2. (Paired) t-tests (measurements 1-5), Wilcoxon signed rank test (measurements 1-5), ICC analyses, the LOA and the LOA as a percentage of the mean for MSST, LE and 30sCS (measurements 4-5).

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<tr>
<td>30sCS 4-5</td>
<td>-0.15 (0.21)</td>
<td>-0.8</td>
<td>0.461 / 0.448</td>
<td>0.967*</td>
<td>0.927 – 0.985</td>
<td>1.96</td>
<td>17.0</td>
</tr>
</tbody>
</table>

**Figure 1** Boxplots MSST week 1-5

**Figure 2** Boxplots LE week 1-5

**Figure 3** Boxplots 30sCS week 1-5
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The Box-and-whiskers plots in Figures 1, 2, and 3 visualize the measurements obtained for the MSST, LE, and 30sCS over a period of five weeks.

Association between MSST, LE and 30sCS

A Pearson Correlation was computed for Week 5 in order to assess the association between the MSST, LE, and 30sCS. The correlation between the MSST and 30sCS was large (MSST-30sCS r = -0.56, p= 0.004), moderate between MSST and LE (MSST-LE r = -0.31, p= 0.165) and moderate between LE and 30sCS (LE-30sCS r = 0.45, p= 0.031). The principal components analysis (PCA) of the MSST, LE and, 30sCS, revealed that 62% of the variance is explained by the the first principal component.

Discussion

The results show sufficient feasibility for the MSST, LE, and the 30sCS with an acceptable learning period of a maximum of five practice sessions for individuals with severe intellectual and visual disabilities (SIVD). Test re-test reliability is very good for all three methods in persons with SIVD. The correlation between the MSST, LE, and 30sCS ranges from moderate to large, suggesting that these instruments measure a different construct.

Our results indicate a sufficient feasibility for the MSST (86%-100%), LE (86% and 97%), and 30sCS (93%-100%) for persons with SIVD. The MSST is a feasible instrument for persons experiencing SIVD possibly due to its required functional movement which often occurs during daily life. Feasibility of the LE is sufficient which may be explained by the fact that the required movement was in one fixed direction. Our 30sCS feasibility percentage is considerably better compared to that found by Hilgenkamp and colleagues who found 44% 30sCS feasibility in older adults with intellectual disabilities (ID). In addition, this may be due to Hilgenkamp’s study design where participants performed seven different physical fitness tests including the 30sCS. Furthermore, in our study, extra verbal instructions and encouragement were given to the participants during testing by gymnastic instructors who also demonstrated the movement expected from the participants. This additional guidance could possibly have improved the feasibility of the tests in our study. Lastly, in our study, persons with profound ID were excluded, and the mean age of the participants was younger than in the study of Hilgenkamp. In our results show a non-significant difference between the measures of Weeks 3 and 4 for the MSST that may indicate a learning period of at least four practice sessions, which is
one week (one session) shorter compared to the learning period of the LE. As for the 30sCS, a non-significant difference was noticeable from the first measures which could indicate the absence of a learning period. For persons with SIVD, the MSST, and the 30sCS appear to be easier to perform than the LE possibly because of the required functional movement in both measurements. The LE requires a coordinative difficult movement, and it is not a functional test. Therefore, we already expected that the LE would be the most difficult test to perform for those experiencing SIVD. The learning periods we found were in accordance with those of other performance tests in persons with SIVD, for example, five practice sessions were performed to become familiar with a modified Berg Balance Scale. In another study of Waning and colleagues in which persons with SIVD performed the six minutes walking distance at relatively short intervals, a learning period of two weeks was required. It is possible that the learning period of the present study could be decreased if the training sessions were planned closer to each other. The participants in our study seemed to be capable of performing the 30sCS well with the given instructions and guidance from the first measurement, which could indicate that persons with SIVD can perform the 30sCS well without the need of a learning period. The possible absence of a learning period for 30sCS seems to be in line with the findings of Hilgenkamp who found no statistically significant learning effect in the test results of 30sCS between their practice session and their first measurement. Also, the means in our study are not less than those determined by Hilgenkamp.19

Due to the limitations of persons with SIVD, it was necessary to adapt the guidance of the participants during testing in the sense of some extra standardized verbal instructions, encouragement, and demonstrating the expected movement and modelling to the participant during the test in order to achieve optimal performance. These additional instructions ensured that participants kept their arms crossed over the chest during the performances of the MSST and the 30sCS. Also, encouragement was provided by counting out loud while participants performed the 30sCS to ensure that they did not stop prior to the end of the 30sCS. This support was also offered to maintain the most minimal stress level as possible for the participant. In some cases, the test instructor indicated that the limit had been reached concerning the mental capacity of the participant to maintain a minimal stress level. To decrease the influence of differences in these limits, the gymnastics instructors were all instructed in the same manner and were well-informed of the test protocols prior to the measurement period.
The test re-test reliability for the MSST, the LE, and the 30sCS is very good in persons experiencing SIVD. This accords with the findings of Schurr regarding the MSST\textsuperscript{17} and Hilgenkamp concerning 30sCS.\textsuperscript{19} Moreover, our results showed that LOA, expressed as a percentage of the means, were less than or equal to 17\% for all three methods. In general, higher LOA’s are found in performance tests when compared to non-performance testing such as, for example, BMI measurements. Our LOA’s are in line with the findings of Waninge who found a sufficient test-retest reliability for the aSRT (LOA\% = 23\%), and for the 6MWD (LOA\% = 30\%) in persons with SIVD.\textsuperscript{24} Taking into account the limited abilities of persons with SIVD to perform measurements, in general, and the required level of intelligence, concentration, and coordination to perform the MSST, the LE, and the 30sCS well, we consider the LOA expressed as a percentage sufficient for these methods. Hence, we consider that the reliability is sufficient for the MSST, LE, and 30sCS in persons with SIVD.

A significant correlation was determined between the MSST and the 30sCS, a moderate correlation between the MSST and the LE, and a moderate correlation between the LE and the 30sCS (p 0.031). It seems that our finding concerning the correlation between LE and MSST is in line with findings of Schurr and colleagues who ascertained that 8-17\% of the variability in the MSST was explained by the strength of the m. Quadriceps.\textsuperscript{17} Apparently, performance of MSST is influenced by factors other than knee extensor muscle strength.\textsuperscript{17} In our study, a number of participants had achieved their maximum depth while performing the MSST; however, they were able to repeat the test several times from this maximum depth. This could indicate that the participant’s mobility or agility was the limiting factor instead of muscle strength. It appears that all three methods actually measure different aspects, e.g., the MSST for agility and strength, the LE for strength, and the 30sCS for muscle endurance with which they could complement one another. However, the principal components analysis (PCA) to the MSST, LE and, 30sCS, revealed that 62\% of the variance is common. Therefore, the first principal component (strength) explains a relatively large amount of variance. Clinically, the tests seem to be partly complementary (a view sustained by our PCA). Therefore, we recommend that when the Quadriceps strength is the primary outcome for a training program, then the LE test as a measuring instrument would be legitimate to use in persons with (S)IVD. If, however, functional aspects such as measuring and mapping the performance or level of ambulatory activities, are deemed important, then the MSST...
(flexibility and strength) and/or 30sCS (muscle endurance and strength) are of added value and therefore the tests might be used as a test-set to gain insight into clients' ambulatory abilities and their need for support.

A limitation of this study is that, due to the exclusion criteria implied by the research question, only a rather small number of participants could be included. The aim of the study was to explore if the tests developed for persons with severe intellectual and visual disabilities (SIVD), would be feasible and reliable. In this study, the measurements were repeated every week over a period of five weeks. This frequency per week was expected to be too intensive for persons with profound intellectual disability. Therefore, they were excluded implying a smaller sample size. Nevertheless, this study provides extensive statistical analyses to firstly explore the feasibility and reliability of the measurements and secondly to investigate the correlation between the measurements, for persons with SIVD. A follow-up study should aim at providing further evidence concerning the feasibility and reliability of the results in a larger more heterogeneous group. Therefore, further research of the feasibility and reliability in persons with less severe and more severe intellectual disabilities, and both with and without additional visual impairment is recommended to be able to better generalize the results for a broader target group.

In conclusion, the MSST, the LE, and the 30sCS are feasible methods with an acceptable learning period and a sufficient test re-test reliability for persons with SIVD.
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