Reliability and validity of standing balance assessment index using a hand-held dynamometer in stroke patients

KOJI IWAMOTO, PT, PhD1)*, MASAHARU YOSHIO, PT, PhD2), YUICHI TAKATA, PT, PhD3), NAOKI KOZUKA, PT, PhD4)
1) Department of Physical Therapy, Ibaraki Prefectural University of Health Sciences: 2-4669 Ami, Amimach, Inashiki-gun, Ibaraki 300-0394, Japan
2) Senri Rehabilitation Hospital, Japan
3) Department of Physical Therapy, Faculty of Human Science, Hokkaido Bunkyo University, Japan
4) Department of Physical Therapy School of Health Sciences, Sapporo Medical University, Japan

Abstract. [Purpose] This study aimed to determine the reliability and validity of our standing balance assessment index using a hand-held dynamometer (the hand-held dynamometer assessment index) in stroke patients. [Subjects and Methods] The participants were 60 stroke patients with impaired standing balance. Intrarater and interrater reliabilities were evaluated employing the intraclass correlation coefficient. Criterion-related validity was evaluated by Spearman’s rank correlation coefficient between the HHD assessment index and the functional balance scale. [Results] The intraclass correlation coefficient values obtained ranged from 0.91 to 0.98, and the correlation coefficient with the FBS was 0.83. [Conclusion] Our findings confirmed the reliability and validity of the hand-held dynamometer assessment index in stroke patients.

Key words: Hand-held dynamometer, Standing balance, Reliability

INTRODUCTION

Balance impairment greatly affects activities of daily living and other essential activities in stroke patients. The assessment of balance is therefore extremely important in clinical practice for managing stroke patients.

Currently available assessment tools for balance in stroke patients include the functional reach test (FRT)1), the functional balance scale (FBS)2)–3) and the timed “up and go” test4). These tests, all of which are performance tests, are widely used in clinical practice and research, and have the advantage that measurement can be easily performed without specific devices or instruments. However, it has been noted that patients with reduced physical fitness or paralysis due to stroke may not be able to perform these tasks, and the test results thus have limitations in terms of statistical analysis5–7).

The hand-held dynamometer (HHD) is a clinically useful device, based on its easy-to-use and easy-to-carry features, and allows quantitative measurement8, 9). To overcome the limitations of the conventional balance tests mentioned above, we previously developed a standing balance assessment index using this HHD (the HHD assessment index)10, 11). In 2004, we reported that the HHD assessment index correlated with the Brunnstrom recovery stages and walking ability, and had a satisfactory intrarater reliability measured with the intraclass correlation coefficient (ICC). In 2012, we confirmed the criterion-related validity of the HHD assessment index using the FBS as a criterion variable. However, the participants in these studies were not limited to stroke patients and the number of participants who had suffered a stroke was small.

Therefore, this study aimed to examine the reliability and validity of the HHD assessment index of standing balance in stroke patients.

*Corresponding author. Koji Iwamoto (E-mail: iwamoto@ipu.ac.jp)
©2016 The Society of Physical Therapy Science. Published by IPEC Inc.
This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <http://creativecommons.org/licenses/by-nc-nd/4.0/>.
SUBJECTS AND METHODS

The participants were 60 cerebral stroke hemiplegic patients (30 with right hemiplegia and 30 with left hemiplegia) who were able to walk indoors independently or with supervision (Table 1). Patients unable to maintain a standing position, those who could walk outdoors independently or run, those with difficulty following the testing instructions due to sensory aphasia or advanced dementia etc., and those with severe pain that prevented participation, were excluded. The objective and methods of the study were fully explained verbally and in writing to potential participants, and those who consented to participate were included in the study. The ethics committee of Ibaraki Prefectural University of Health Sciences approved all study protocols, and each participant provided written informed consent prior to enrollment.

Intrarater reliability of the HHD assessment index was evaluated by ICC for 30 randomly selected participants. Interrater reliability of the HHD assessment index was evaluated by ICC between the scores determined by two physical therapists (at the start and at the end of the session) for the 10 randomly selected participants. Validity was evaluated by Spearman’s rank correlation coefficient between the HHD assessment index and the FBS (the criterion variable of standing balance) for all 60 participants.

With regard to the evaluation of intrarater reliability of the HHD assessment index, one physical therapist conducted the measurements for each participant twice, and the correlation coefficient for the pairs of scores was calculated as the reliability coefficient for the 30 participants. With regard to the evaluation of interrater reliability, two physical therapists conducted the measurements for each participant under the same conditions, and the correlation coefficient between the two raters’ scores was calculated as the reliability coefficient for the 30 participants. The measurement device used was the MicroFet 2 HHD (Hoggan Health Industries Inc., West Jordan, UT, USA). We conducted the assessment in the physical therapy room according to the method described by Iwamoto et al[11]. Participants were asked to wear athletic shoes that they usually wore. The measurements were performed under the following conditions: the patient stood 2 m from both the anterior and the lateral walls, with eyes open; the upper limbs were down at the sides of the body, and the inner edges of the feet were parallel and at a distance of 10 cm from each other. We chose the right and left iliac crests (IC), anterior superior iliac spines (ASIS), and posterior superior iliac spines (PSIS) (a total of six sites) as measurement sites because they were easily palpated and good reliability of landmarks could be expected. The participant was instructed to maintain the standing posture, while remaining as still as possible, against a gradually increased force exerted by the examiner with the HHD: the force on the IC was applied from the lateral direction; that on the ASIS was applied from the anterior side, and that on the PSIS was applied from the posterior side, horizontally to the floor. The break test was adopted as a uniform method of measurement: a participant taking a fixed posture was given pressure through HHD until he lost the posture. Then the magnitude of the pressure to HHD was measured. As the measurement value was highest when the measurement site was pressured by HHD until the participant could no longer hold his body posture, the HDD value at that moment (N) was adopted as a measurement value. It was often the case that a part of the sole of the foot left the floor at the moment when the participant lost control of his posture, which provided a cue to stop the pressure. Therefore, the best efforts were made to set the eye level of examiners at the height of the participant’s pelvis in order to make it easier for them to see the imbalance of the posture or the sole of the foot. All measurements were completed within 10 seconds. Following the previous study, the make test to measure the pressure to HDD which was generated by the participants’ pressuring of fixed HDD was not adopted. As was already pointed out, the HDD value at the moment that the force was applied from the lateral direction of the pelvis was adopted as the measurement value. To determine the validity of the HHD assessment index, all 60 participants underwent the HHD assessment and the FBS. As for the HHD assessment, the examiner performed the measurement three times for each site, and the mean values served as the scores of the HHD assessment index. The FBS was applied to assess standing and sitting balance, etc., with a 5-stage scale for each item (a total of 56 points).

The intrarater and interrater reliabilities were statistically analyzed using ICC. The ICC values were classified into five categories according to the criteria of Landis et al.[12]: 0.00–0.20=slight, 0.21–0.40=fair, 0.41–0.60=moderate, 0.61–0.80=substantial, 0.81–1.00=almost perfect. To confirm the validity of the HHD assessment index as a balance test, Spearman’s rank correlation coefficients with the FBS were calculated. The statistical analysis was performed using a statistical software package (IBM SPSS Statistics 19). The significance level was set at p<0.05. In addition, based on the fact that there was no

---

Table 1. General characteristics of all the subjects included in this study

<table>
<thead>
<tr>
<th>Demographic values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (Male/Female)</td>
</tr>
<tr>
<td>Age (Mean ± SD)</td>
</tr>
<tr>
<td>Etiology (Hemorrhage/Infarct)</td>
</tr>
<tr>
<td>Affected hemisphere (Right/Left)</td>
</tr>
</tbody>
</table>
The demographic data for all participants are presented in Table 1. The scores of the HHD assessment index and the ICC values calculated to determine the intrarater and interrater reliabilities are shown in Table 2. The ICC values for both intrarater and interrater reliabilities were 0.88 or higher, indicating almost perfect correlations according to the criteria of Landis et al. To confirm the validity of the HHD assessment index as a balance test, Spearman’s rank correlation coefficient with the FBS was calculated. A significant positive correlation was found between the HHD assessment index and the FBS ($r=0.83$, $p<0.01$).

In the present study, we evaluated the reliability of the HHD assessment index in stroke patients and confirmed high reliability: 0.94–0.98 for intrarater reliability and 0.91–0.97 for interrater reliability. We also evaluated the validity of the HHD assessment index using the FBS as a reference variable, and demonstrated a significant positive correlation, showing a strong association between the HHD assessment index and the FBS. These findings confirmed the reliability and validity of the HHD assessment index as a balance test for stroke patients.

Bohannon et al.\textsuperscript{13}, Developed a trunk muscle test using a HHD in the sitting position in hemiplegic patients after cerebrovascular accidents. They demonstrated both the accuracy and the reliability of their measurement method. According to their report, the ICC values for the measurement of lateral trunk flexion muscle strength using a HHD were 0.987 on the paretic side and 0.996 on the non-paretic side. Although the ICC values calculated in the present study were slightly lower than those reported by Bohannon et al., they were within the range of almost perfect correlations (0.81–1.00) according to the criteria of Landis et al. Therefore, the results of this study showed the HHD assessment index to have satisfactory reliability. Possible explanations for our relatively low, as compared to Bohannon et al.’s study, ICC values might involve differences in the testing position (sitting position vs. standing position), directions of the applied forces (two lateral directions in Bohannon et al.’s study and six anterior-posterior and lateral directions in our study), and measurement sites (shoulder vs. pelvis). Future studies comparing measurements at the pelvis and other sites, as well as measuring the shift in center of gravity using a stabilometer during the test, may shed light on this issue.

Regarding validity, the present study showed a significant correlation between the HHD assessment index and the FBS. We therefore concluded that the criterion-related validity of the HHD assessment index as a balance test was satisfactory. The FBS, used as a reference variable in the present study, is a performance test of balance that provides scores by asking patients to perform test movements. This test has the following limitations: the test comprises multiple test movements, taking approximately 25 minutes, and may cause fatigue in frail patients with low endurance; the test may not be suitable for patients with mild motor impairment because of the ceiling effect; the ordinal scale, which is employed for the test, limits carrying out statistical analysis; and the test does not allow identification of the cause or the mechanism of balance problems\textsuperscript{14}.

In contrast, the balance assessment using a HHD evaluates the degree to which the patient can maintain the standing

<table>
<thead>
<tr>
<th>Side</th>
<th>Measurement sites</th>
<th>Rater 1 Mean ± standard deviation</th>
<th>Rater 2 Mean ± standard deviation</th>
<th>Re-test Mean ± standard deviation</th>
<th>Test Mean ± standard deviation</th>
<th>ICC(2,1)</th>
<th>ICC(1,1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected</td>
<td>ASIS</td>
<td>29.6 ± 14.7</td>
<td>23.7 ± 13.7</td>
<td>26.3 ± 13.1</td>
<td>27.4 ± 13.2</td>
<td>0.95</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>IC</td>
<td>43.8 ± 19.2</td>
<td>43.1 ± 18.0</td>
<td>40.9 ± 16.8</td>
<td>40.6 ± 19.3</td>
<td>0.91</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>PSIS</td>
<td>38.1 ± 16.5</td>
<td>37.0 ± 13.6</td>
<td>38.1 ± 16.5</td>
<td>38.0 ± 14.7</td>
<td>0.92</td>
<td>0.96</td>
</tr>
<tr>
<td>Unaffected</td>
<td>IC</td>
<td>24.6 ± 11.4</td>
<td>24.0 ± 11.3</td>
<td>24.6 ± 11.4</td>
<td>24.3 ± 9.9</td>
<td>0.91</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>ASIS</td>
<td>41.5 ± 15.3</td>
<td>39.2 ± 18.0</td>
<td>39.6 ± 15.8</td>
<td>40.0 ± 17.5</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>PSIS</td>
<td>29.7 ± 12.1</td>
<td>28.4 ± 8.8</td>
<td>27.8 ± 8.6</td>
<td>28.4 ± 10.4</td>
<td>0.91</td>
<td>0.94</td>
</tr>
</tbody>
</table>

ASIS: anterior superior iliac spine, IC: iliac crest, PSIS: posterior superior iliac spine
ICC(2,1) was used for inter-rater reliability.
ICC(1,1) was used for intra-rater reliability.
posture against the force exerted by the examiner and has the advantage that the measurements can be performed in less time than performance tests, although the examinees are required to be able to maintain a standing position without aid. At present, we are considering approaches and modifications that would allow the time required for the HHD assessment index to be reduced, by minimizing the measurement times to once per site because the present results showed good reliability. In addition, the score of the HHD assessment index is an interval scale that provides a broader range of options for statistical analysis. Furthermore, the HHD assessment index is a disturbance load test, which may contribute to analyzing the causes of and mechanisms underlying balance impairment in the future.

This study determined the reliability and validity of the HHD assessment index of standing balance in stroke patients. The intrarater and interrater reliabilities were evaluated by ICC. The criterion-related validity was evaluated based on correlations with the FBS, which is an established balance test with evidence of both reliability and validity. The results confirmed the reliability and validity of the HHD assessment index suggesting it to be a useful balance test not only for healthy, including elderly, people but also for stroke patients.

The HHD assessment index can be applied to evaluate stability in the standing position. It can be used for a wide variety of subjects, including healthy individuals who may have ceiling effects when conventional balance tests are employed and stroke patients with poor standing balance due to paralysis. We consider the HHD assessment index to be a potentially useful part of the test battery for balance employed in clinical practice.

Finally, the significance of measuring HHD evaluation indicators is considered to be that, different from FBS and the Tinetti Balance Test (TBT), it is available even for healthy people who cannot undergo the measurement because of the ceiling effect, it requires less time and is convenient, and it is an interval scale. Its different from TUG with the same scale as the interval scale is that it is available even for cases where the subject can stand erect but cannot walk. Its difference from other evaluation indicators, such as FRT, is that it can sense the pressure on the sensor of the pressure receiver of HHD as a resistance that is the body’s reaction to the subject. However, given that the HHD evaluation indicator is specialized only for standing balance and that the balancing ability during walking cannot be measured, the author et al. consider that it is important to compare the processes as an interval scale by using other evaluation indicators.

REFERENCES

8) Bohannon RW: Adoption of hand-held dynamometry. Percept Mot Skills, 2001, 92: 150. [Medline] [CrossRef]