Reliability, Responsiveness, and Validity of the Kansas University Standing Balance Scale

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ABSTRACT

Purpose: The purpose of this research was to investigate the reliability, responsiveness, and concurrent validity of the Kansas University Standing Balance Scale (KUSBS). **Methods**: For the reliability study, the KUSBS was used twice on 2 separate days with 23 inpatient rehabilitation patients. To assess responsiveness and concurrent validity, a retrospective chart review of 25 patients was performed to examine changes in KUSBS scores and changes in FIM™ transfer and walking scores from admission to discharge. **Results**: In the reliability study, the KUSBS was found to have good intra-rater reliability (intraclass correlation coefficient, ICC = 0.893 for novice physical therapists, ICC = 0.765 for experienced physical therapists), and moderate inter-rater reliability (ICC = 0.728). In comparing scores at admission and discharge to determine responsiveness, KUSBS scores were significantly different at these 2 times ($p = 0.001$), and the effect size was 0.58. In the concurrent validity study, changes in KUSBS scores were significantly correlated with changes in the FIM™ transfer score ($r_s = 0.486$, $p = 0.014$) but correlation with changes in the FIM™ walking score did not reach significance ($r_s = 0.383$, $p = 0.06$). **Conclusion**: The reliability, responsiveness, and concurrent validity of the KUSBS are promising, although further study is needed to examine this scale in different therapy settings with a larger sample.

Key Words: balance, postural control, assessment measures, treatment outcome

INTRODUCTION

Standing balance is an important skill that can be significantly impaired in people with multiple medical problems. A disablement model such as the International Classification of Functioning, Disability, and Health (ICF) may be useful to provide a framework to understand the importance of measuring balance.[1] In this model, *Body Functions and Structures* refer to physiologic functions of body systems. An individual patient may have sensory loss or motor weakness that impairs balance, while other body systems such as vision are used to compensate for that loss. Maintaining balance while changing and maintaining body positions is included in the category of *Activity*; this is defined as the execution of specific tasks. *Participation* refers to involvement in life situations; people with frequent loss of balance may restrict their community mobility and be unable to work.

In the acute and inpatient rehabilitation settings, physical therapists often see patients who need physical assistance to maintain an upright standing posture. It is important, therefore, to be able to evaluate standing balance at baseline to measure progress of early rehabilitation and predict discharge destination. The reliability and validity of any measurement tool must be established to determine that the measurement is reproducible and meaningful before confidence can be placed in those values.[2]

There are several valid and reliable balance assessment tools currently available to the physical therapy clinician. However, patients who are evaluated in the acute care and inpatient rehabilitation settings will often not be able to perform the tasks required to receive a minimal score on these tests, and must demonstrate considerable progress before the test is sensitive enough to register any improvement.

Many standing balance assessment instruments require patients to be able to stand unsupported to get a baseline score, including the Functional Reach Test,[3] and the Lateral Reach Test.[4] The ability to stand and walk is a prerequisite for another commonly used balance test, the Timed Up and Go.[5]

Although the Performance Oriented Mobility Assessment (POMA)[6] and Berg Balance Test [7] both include sitting and static standing balance items, there may be substantial floor effects with these tests. On the POMA, a patient must be able to demonstrate 'steady' standing balance with a cane or other support in order to score 1 point for this item. A patient must stand unsupported for at least 30 seconds in order to score a single point for this item on the Berg. These scales will not be useful in documenting progress in a patient who initially requires moderate assistance from the therapist to stand and progresses to standing independently with support from both upper extremities. This demonstrates a need for a scale that measures lower levels of function in more severely impaired patients to indicate functional progress that may justify continued skilled services.

The selection of a balance assessment instrument in the clinic is not only based on appropriateness and psychometric

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properties of the test, but also on practicality.[8] Several factors influence practicality, including time needed to administer the test, experience of the person administering the test, equipment, format of the test, and method of scoring. For these and possibly other reasons, nonstandardized assessments of balance are commonly used in the clinic. For example, balance is often described as 'normal,' 'good,' 'fair,' or 'poor' without standard criteria for these designations.

The Kansas University Standing Balance Scale (KUSBS) was developed over a 2-year time span by physical therapists at the University of Kansas Hospital and is described in Table 1. Prior to the development of this tool, a series of different standardized balance instruments were used by the therapists at this institution, and the compliance rate of the therapists using these instruments was unsatisfactory as measured by quality improvement chart reviews. Therapists frequently documented balance using nonstandardized descriptors such as 'fair' without further explanation.

The physical therapists believed that if they developed their own tool, compliance with using a standardized assessment tool to document balance would improve. The standing balance scale was developed to meet the following criteria: (1) appropriate for lower-functioning patients (ie, a person who is unable to stand unsupported), (2) able to document progress in an objective and quantifiable way, (3) quick to administer, (4) does not require mathematical calculations, and (5) does not require special space or equipment. As the scale was being developed, therapists were encouraged to talk to each other about their experiences with the scale. A script of therapist instructions to the patient was subsequently developed (see footnote in Table 1). This instrument was used for about 1 year prior to initiating the reliability study. Quality improvement chart reviews demonstrated 75% compliance with use of these tools to document balance in the first quarter after implementation, and this increased to 100% in the second quarter.

The KUSBS consists of an ordinal rating system (0 – 5 grades with plus values), which provides 10 levels. This system was chosen to be similar to the manual muscle test numbering system[9] because that is familiar to therapists, physicians, and other health care professionals. Two separate studies are presented that investigated: (1) the reliability, and (2) the responsiveness and concurrent validity of the KUSBS.

RELIABILITY STUDY

The purpose of this first study was to investigate the intra-rater and inter-rater reliability of the KUSBS with patients admitted to an inpatient rehabilitation department. Reliability is an indication of the consistency of the measure and is a fundamental measurement characteristic.[10] This project received approval from the institutional Human Subjects Committee prior to beginning the investigation.

Table 1. Kansas University Standing Balance Scale (KUSBS)[a]

KUSBS Score	Ordinal Ranking of Score	Description of Patient Performance for KUSBS Scores
0	1	Performs 25% or less of standing activity (maximum assist).
1	2	Supports self with upper extremities but requires therapist assistance. Patient performs 25-50% of effort (moderate assist).
1+	3	Supports self with upper extremities but requires therapist assistance. Patient performs >50% of effort (minimal assist).
2	4	Independently supports self with both upper extremities.
2+	5	Independently supports self with one upper extremity.
3	6	Independently stands without upper extremity support for up to 30 seconds.
3+	7	Independently stands without upper extremity support for 30 seconds or greater.
4	8	Independently moves and returns center of gravity 1-2 inches in 1 plane.
4+	9	Independently moves and returns center of gravity 1-2 inches in multiple planes.
5	10	Independently moves and returns center of gravity in all planes greater than 2 inches.

[a] Each patient is first instructed: "Stand up and continue standing." If patient requires assistance or supports self with one or both arms, no further instructions are given, and the appropriate grade is assigned from 0 to 2+. If the patient stands independently without upper extremity support for less than 30 seconds, a grade 3 is assigned. If the patient stands independently for 30 seconds or longer (grade 3+), the therapist places their hand 1-2 inches beyond the patient's reach. The patient is instructed to "Reach forward and touch my hand." If successful, a grade 4 is assigned. If the patient succeeds in reaching forward, the therapist asks the patient to reach 1-2 inches in multiple planes (grade 4+). If the patient succeeds in reaching in multiple planes, the therapist moves the hand more than 2 inches in different planes, including reaching and grasping for an object such as a cone or throwing a ball (grade 5).

Methods

Subjects

All eligible patients admitted to the inpatient rehabilitation unit during a 3-month period at the University of Kansas Hospital participated in this study. Subjects were excluded if any of the following applied: acute illness, contraindication to lower extremity weight bearing, severe cognitive impairment (determined by the patient's inability to follow a 1 step command), insufficient physical endurance to repeat the test twice on 2 days, inability to perform the test, or use of medications that significantly impaired balance, blood pressure, cognition, or level of consciousness.

Procedures

Four physical therapists were involved in testing subjects for this experiment. Two of the physical therapists were operationally defined as 'novice' because they had less than 2 years of experience, and 2 were operationally defined as 'experienced' because they had greater than 10 years of experience. One of the novice physical therapists and 1 of the experienced physical therapists administered the KUSBS to each patient twice on 2 consecutive days, as illustrated in Figure 1. The choice of who would administer the test first was randomized for each patient, and the assessments were done at approximately the same time of day for each therapist (about 24 hours apart). Although the therapists were blinded as to the other's score, they obviously could not be blinded to their own scoring on the previous day.

Data Analysis

All data were analyzed using SPSS 14.0 for Windows. Descriptive statistics were used to characterize the patient sample. KUSBS scores were transformed to a 10-point ordinal scale for data analysis as presented in Table 1. Although the data from this scale is ordinal, the use of nonparametric indexes of reliability such as weighted kappa was not feasible given the sample size and number of balance categories. The Bland-Altman plot is a graph used for investigating the reliability of 2 measurements (x and y).[11] The graph is a scatter plot with the difference on the vertical axis (x-y) and the average on the horizontal axis [(x+y)/2]. The plot is useful for determining the shift in the measurement and the variability in the measurement. For 2 measures that are measuring the exact same thing, we would expect the Bland-Altman plot to be horizontal on 0 with no variability. However, in all experiments we expect some variability. To visualize this, we place the plots on the scale of possible difference in the vertical axis. For example, in this study since there is a scale from 1-10, we placed the vertical axis on a scale from -10 to 10. The horizontal axis is on the possible values of (x+y)/2. The height of the plot is a measure of the technical error and is typically measured using the standard deviation of x-y.

If we treat the data as interval level, it is possible to calculate the intraclass correlation coefficient (ICC) which is useful to compare the reliability of the KUSBS to other balance measures. ICC model 2 is appropriate for use in inter-rater reliability studies where all subjects are measured by the raters,[10] and single measurements were used. A significance level of 0.05 was used. Intra-rater reliability for the novice physical therapists and experienced physical therapists was determined by comparing KUSBS ordinal rankings on day 1 and day 2 for type of rater. Inter-rater reliability was determined by comparing KUSBS ordinal rankings on day 1 between the novice and experienced physical therapists.

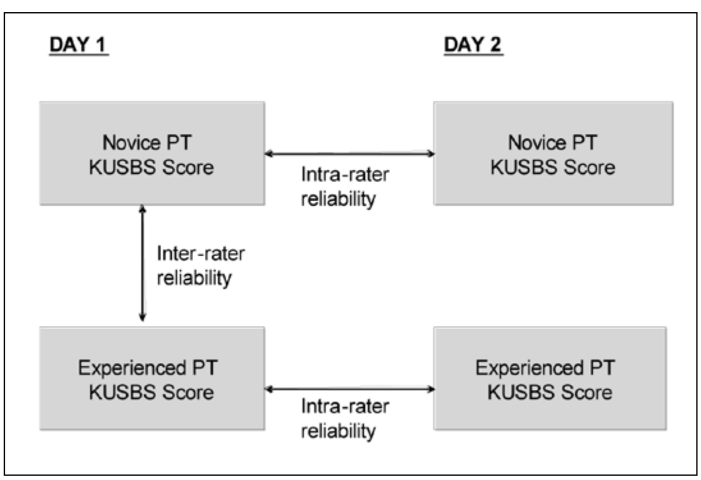

Figure 1. Illustration of sequence used for reliability study. KUSBS refers to the Kansas University Standing Balance Scale.

Results

Thirty-two subjects were recruited for this study, and 23 patients participated in all 4 KUSBS assessments over 2 days. The remaining 9 patients were assessed twice on the first day but were unavailable for testing on the second day, and their data is not included in the analysis.

The 23 subjects (12 males, 11 females) had a mean age (± SD) of 58.1 (± 20.7) with a range in age from 13 to 97 years. The most common primary diagnosis was stroke (n = 13), followed by multiple sclerosis (n = 4). Other diagnoses included brain tumor, end-stage renal disease, total knee replacement, and lumbar discectomy.

The mean (± SD) KUSBS ordinal rankings for the novice and experienced physical therapists' rating of the same patients are presented in Table 2. The rankings ranged from a 4 (corresponding to a KUSBS score of 2) to a 10 (corresponding to a KUSBS score of 5).

Intra-rater reliability

The Bland Altman plot for the KUSBS ordinal rankings obtained by the novice PTs on day 1 and day 2 are illustrated in Figure 2A, and the rankings obtained by the experienced PTs on day 1 and day 2 are illustrated in Figure 2B. Both pairs indicate no shift and low variability.

The ICC (2,1) for the novice raters was 0.893. The ICC (2,1) for the experienced raters was 0.765. Values above 0.75 generally indicate good reliability.[10] The lower score for the experienced

PTs may have been affected by the single score that appears to be an outlier as observed on the Bland Altman scatterplot (Figure 2B).

Inter-rater reliability

The Bland Altman plot for the KUSBS ordinal rankings obtained by the novice physical therapists and experienced physical therapists on day 1 are illustrated in Figure 2C. This pair indicates no shift and low variability. The ICC (2,2) for the 2 raters was 0.728. Values below 0.75 are generally considered to indicate moderate reliability.[10]

RESPONSIVENESS AND VALIDITY STUDY

The purpose of this second study was to assess responsiveness and concurrent validity of the KUSBS in an inpatient rehabilitation setting. Responsiveness refers to the ability of a measure to detect change over time, and is a component of test validity.[10,12] Simple change scores may be used as an index of responsiveness, but comparisons of change scores can not be made between tests with different units. Effect size (ES) is a standardized index of change that can be used to interpret responsiveness, or the extent of change following an intervention.

The development of the KUSBS by physical therapists interested in assessing balance ensures that the instrument has acceptable face validity,[10] as judged by those who administer it. A more objective way to assess validity is to test the results of a new test against those of a previously-validated test, referred to as concurrent validity.[10] This can present a problem in the absence of a 'gold standard' test, as is the case for measurements of standing balance.

The Functional Independence Measure (FIM™) is commonly used in inpatient rehabilitation clinical settings to determine patient function at admission and discharge. This scale has been found to be both valid and reliable for patients with stroke,[13] traumatic brain injury,[14] and other diagnoses seen in neurologic rehabilitation.[15] Items on the FIM™ include assessments of functional mobility, but they do not specifically include sitting or standing balance assessment.

Methods

A retrospective chart review was used to assess responsiveness to change and concurrent validity of the KUSBS, using the admission and discharge FIM™ chair transfer and walking scores as a comparison, in a separate study from that described above for reliability.

Table 2. Kansas University Standing Balance Scale (KUSBS) Ordinal Ranking Ratings (mean ± standard deviation) by 2 Novice and 2 Experienced Physical Therapists (n=23)

	Novice	Experienced
Day 1	8.4 ± 1.7	8.3 ± 1.8
Day 2	8.7 ± 1.6	8.4 ± 1.7

Procedures

All available charts of patients admitted to and discharged from the inpatient rehabilitation unit during a 4-month period at the University of Kansas Hospital were reviewed. FIM™ scores and KUSBS scores are routinely completed on all inpatient rehabilitation patients within 48 hours of admission and on the day of discharge. Only the FIM™ scores for chair transfers and walking were selected, as it was expected that these would be most relevant for comparison to the KUSBS scores.

Data Analysis

All data were analyzed using SPSS 14.0 for Windows. Descriptive statistics were used to characterize the patient sample, and KUSBS scores were transformed to a 10-point ordinal scale as previously described for the reliability study. Nonparametric statistics were used for analysis as is appropriate for ordinal-level data. The changes in KUSBS scale ordinal rankings, FIM™ chair transfer, and walking scores were calculated by subtracting scores documented at discharge from scores documented at admission.

To determine responsiveness, the effect size (ES) for the KUSBS was calculated as an index of responsiveness using the formula $ES = mean_{change\ score}/standard\ deviation_{admission\ scores}$.[12] The Wilcoxon matched-pairs signed rank test was used to test for a difference between scores at admission and discharge.

To examine concurrent validity, the correlations between the KUSBS and FIM™ change scores were determined using the Spearman rank correlation coefficient. Bland-Altman plots were used to examine the shift in the measurement and the variability in the KUSBS and FIM™ change scores. To visualize this, we place the plots on the scale of possible difference in the vertical axis, and the horizontal axis is on the possible values of (x+y)/2. For measures that are measuring a shift, we would expect the plots to be short and wide below (or above) 0. A significance level of 0.05 was used for all statistical tests.

Results

Thirty-two charts were initially reviewed for this study, but 7 charts were excluded from the analysis because either KUSBS scores or FIM™ scores were missing at either admission or discharge, and change scores could not be calculated. The data from the remaining 25 charts were analyzed.

The 25 subjects (11 males, 14 females) had a mean age (±SD) of 63.2 (±14.8) with a range in age from 31 to 85 years. The most common primary diagnosis was stroke (n=5), followed by multiple sclerosis (n=4), multiple trauma (n=2), and cerebral hemorrhage (n=2). There was 1 patient with each of the following other diagnoses: brain tumor resection, cervical myelopathy, cancer, COPD, deconditioning, diabetes, Guillain-Barré syndrome, Parkinson disease, Shy-Drager syndrome, spinal stenosis, traumatic brain injury, and unknown.

The mean ($\pm$ SD) KUSBS ordinal rankings and FIM™ scores for the patients at admission and discharge, and the change scores for each measure are presented in Table 3. One patient received the maximum KUSBS score (10) on admission, and 4 subjects received the maximum score at discharge.

KUSBS scores at admission were significantly different than KUSBS scores at discharge (Z = -3.18, p = 0.001), and the ES for the change in KUSBS ordinal rankings is 0.58. An ES value of 0.5 is considered moderate, and a value of 0.8 or greater is viewed as large.[12]

Changes in KUSBS ordinal rankings were correlated with changes in the FIM™ chair transfer score (r_s = 0.486, p = 0.014) but correlations with changes in the FIM™ walking score did not reach significance (r_s = 0.383, p = 0.06). Scatterplots with trendlines to illustrate the correlational relationships are presented in Figure 3. The Bland-Altman plots in Figure 4 illustrate the presence of a shift in all three measures, with relatively low variability.

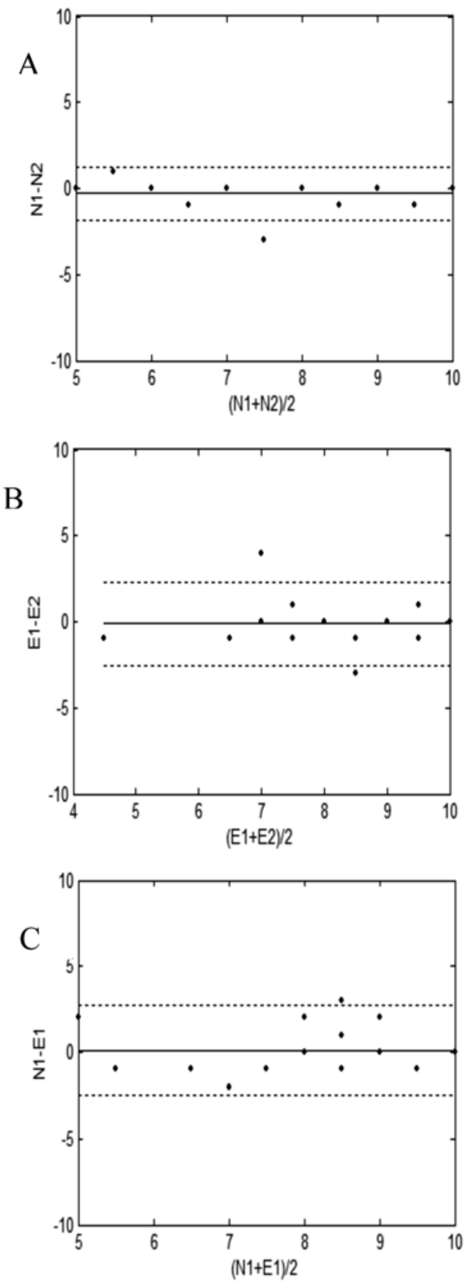

Figure 2. Bland Altman plots of Kansas University Standing Balance Scale (KUSBS) scores for A) novice day 1 (N1) vs. novice day 2 (N2); B) expert day 1 (E1) vs. expert day 2 (E2); and C) novice day 1 (N1) vs. expert day 1 (E1). For each plot the vertical is the difference in pairs and the horizontal is the average of the pairs. All three pairs indicate no shift and low variability.

DISCUSSION

Reliability, responsiveness, and concurrent validity of the KUSBS were investigated with patients who had a wide variety of diagnoses in an inpatient rehabilitation setting. The KUSBS was developed in response to a need for a test to evaluate patients who could not stand independently. No training sessions were required to learn the scales, as the physical therapists were simply asked to follow the written instructions presented in the footnote of Table 1.

Descriptive analysis with the Bland Altman plots revealed that the KUSBS has no shift and low variability within and between raters. Reliability coefficients above 0.75 are generally considered to be good and values below 0.75 indicate poor to moderate reliability.[10] The intra-rater reliability of the KUSBS as measured by the ICC was greater than 0.75 for both novice and experienced raters. Surprisingly, the experienced physical therapists demonstrated lower reliability than the novice physical therapists but this may be explained by the presence of a single outlier score in the data recorded by the experienced physical therapists. The inter-rater reliability between novice and experienced PTs was slightly below 0.75 and so could be considered moderate, which might be expected when using raters with different levels of experience.

The KUSBS demonstrated moderate responsiveness to change as determined by the ES, difference in admission and discharge scores, and a shift noted in the Bland Altman plots. An ES value below 0.4 is considered small, 0.5 is considered moderate, and 0.8 or greater is viewed as large.[12] Because ES is standardized and can be used to compare different instruments, we note that the FIM™ chair transfer and walking score effect sizes are of much greater magnitude than KUSBS. Changes in function may well be of greater magnitude than

Table 3. Kansas University Standing Balance Scale (KUSBS) Ordinal Rankings and Functional Independence Measure (FIM™) Scores (mean ± standard deviation) at Admission and Discharge (n=25)

	KUSBS	FIM™ transfer	FIM™ walking
Admission	4.4 (± 2.5)	3.8 (± 1.5)	1.9 (± 1.6)
Discharge	5.8 (± 2.4)	5.6 (± 1.2)	5.0 (± 1.7)
Change Scores	1.5 (± 1.7)	1.8 (± 1.5)	3.1 (±2.2)
Effect Size	0.588	1.195	1.937
Z Scores for Admission vs. Discharge	-3.18 [a]	-3.96 [a]	-3.94 [a]

[a] p ≤ 0.001

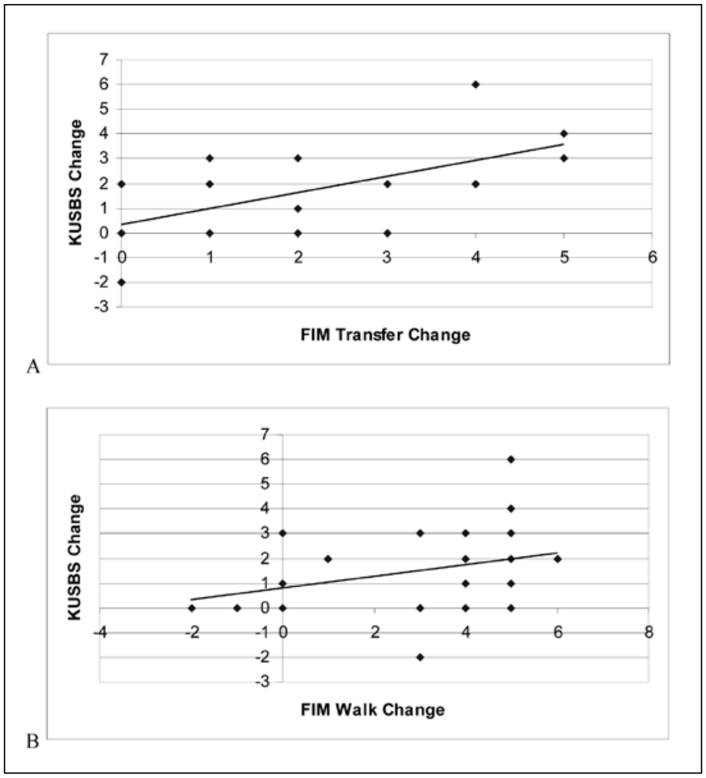

Figure 3. Scatterplots with trend lines to illustrate the correlational relationship between (A) changes in Functional Independence Measure (FIM™) transfer score and Kansas University Standing Balance Scale (KUSBS) ordinal ranking, and (B) changes in FIM™ walking score and KUSBS ordinal ranking.

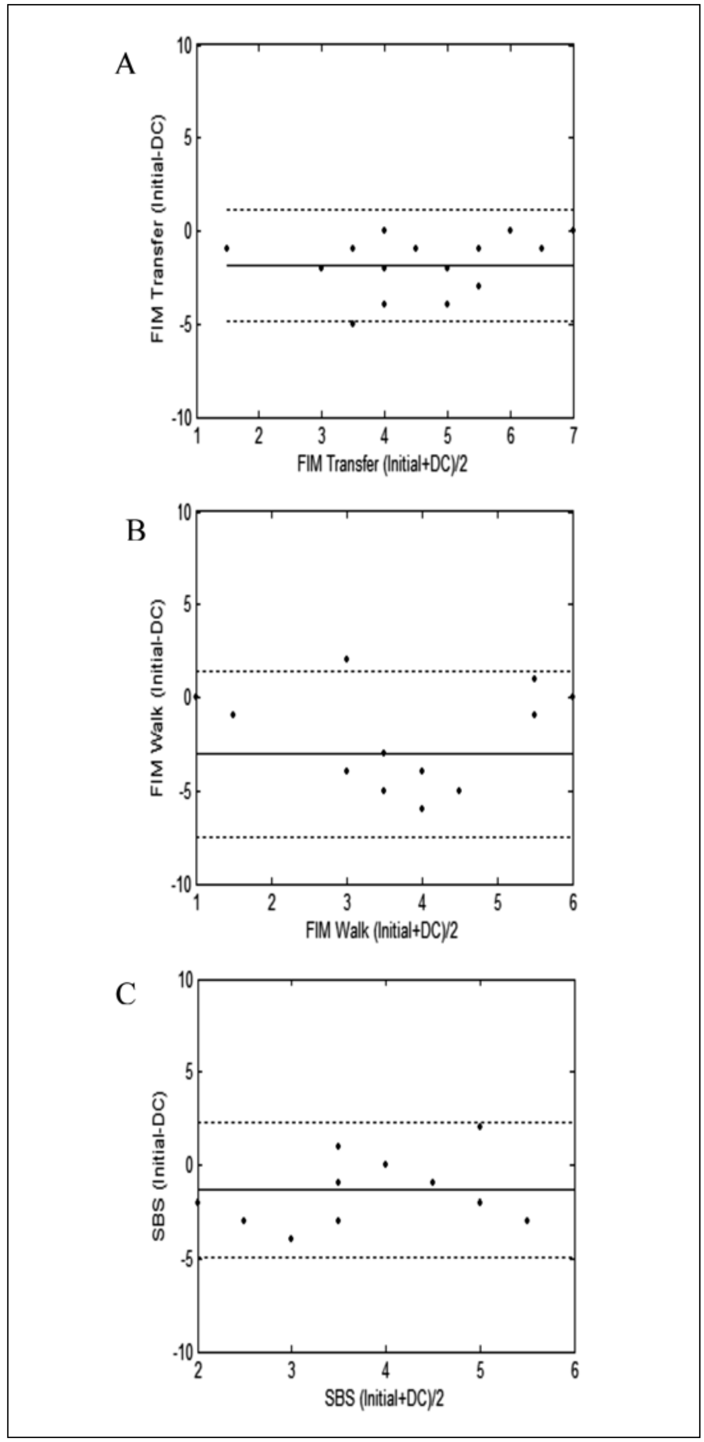

Figure 4. Bland Altman plots for the combinations (A) Functional Independence Measure (FIM™) transfer (initial and discharge); (B) FIM™ walk (initial and discharge); and (C) Kansas University Standing Balance Scale (SBS) (initial and discharge). A detection of differences is detected when the vertical axis varies from 0. All 3 pairs indicate a shift and low variability.

changes in static balance during an inpatient rehabilitation stay. Use of the KUSBS to document progress may help to justify the need for continued skilled services to treat limitations in balance in lower functioning patients.

Concurrent validity was demonstrated for the KUSBS because changes in the KUSBS ordinal rankings were strongly correlated to change in the FIM™ chair transfer score although not significantly correlated to change in the FIM™ walking score. The FIM™ is not a true balance measure, and certainly could not be considered a 'gold standard' to compare to the KUSBS. However, the FIM™ chair transfer and walking subscales are an indication of functional mobility which could be influenced by standing balance abilities. We chose to use the FIM™ mobility scores because they are routinely collected on every patient on admission and discharge in our facility.

Ideally, concurrent validity of the KUSBS would be established using a gold standard for balance. However, the majority of balance measures that have been validated for use with people who have impaired functional mobility are not appropriate for people unable to stand unsupported at baseline,[3-7] so this may be an impossible task. Predictive validity, or the ability of the KUSBS to predict improvement in functional outcomes, would be an important avenue of future investigation.

This study evaluated KUSBS scores of patients in the inpatient rehabilitation setting, and patients in the 2 studies had scores ranging from the lowest to the highest values. We recognize that there is a ceiling effect with this measure because it only measures static balance. Clinicians are encouraged to use the balance measure that is most appropriate to the functioning of their patients. The application of this scale may be most appropriate in skilled nursing and acute care settings, where patients are least likely able to meet the minimal criteria for testing with other standardized balance tests. Further study is needed to see if the KUSBS is reliable, responsive to change, and valid in patients undergoing rehabilitation in the skilled nursing and acute care settings. This study was limited by a small sample size; with a larger sample the correlation between change in KUSBS and FIM™ walking scores may have approached significance and an analysis of regression would be appropriate.

In conclusion, the reliability and validity of the Kansas University Standing Balance Scale (KUSBS) appears to be promising when used with patients in the inpatient rehabilitation setting. We suggest that this instrument is worthy of further study in different settings with a larger sample size.

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