TERESA S.M. YEUNG, MSc[1] • JEAN WESSEL, PhD[2] • PAUL STRATFORD, MSc[3] • JOY MACDERMID, PhD[4]

Reliability, Validity, and Responsiveness of the Lower Extremity Functional Scale for Inpatients of an Orthopaedic Rehabilitation Ward

• **STUDY DESIGN:** Single-group, repeated-measures study.

• **OBJECTIVE:** To estimate the test-retest reliability, construct validity, and responsiveness of the Lower Extremity Functional Scale (LEFS) on inpatients attending an orthopaedic rehabilitation ward.

• **BACKGROUND:** The LEFS has acceptable validity on outpatients in assessing functional mobility, but it has not been tested for use on an inpatient orthopaedic ward.

• **METHODS AND MEASURES:** Inpatients in an orthopaedic ward (n = 142) completed the 20-item, self-report LEFS on admission, 7 to 10 days after admission, and on discharge. To test reliability, 24 patients had the LEFS repeated 1 day after the admission test, and the intraclass correlation (ICC) and the standard error of measurement (SEM) were calculated. Change scores of the LEFS were evaluated against patients' and therapists' rating of improvement, and change scores of comparison measures that included pain, functional performance, and the composite index created from scores of these comparison measures. The standardized response mean (SRM) of the LEFS was also computed.

• **RESULTS:** The ICC of the LEFS was 0.88, and the SEM was 4 LEFS points (LEFS score range, 0-80). The change in LEFS correlated with changes of comparison measures in the same direction of improvement. Patients rated as improved by both themselves and their therapists had significantly larger change in LEFS scores than subjects rated as no change. The SRM of the LEFS from admission to discharge was 1.76 on patients rated as improved.

• **CONCLUSION:** The LEFS is reliable and valid to assess group and individual change, and has large responsiveness. The LEFS and the comparison measures likely assess different constructs. *J Orthop Sports Phys Ther 2009; 39(6):468-477. doi:10.2519/jospt.2009.2971*

• **KEY WORDS:** *inpatients, LEFS, orthopaedic, outcome measure*

Improvement in functional mobility is an important goal of orthopaedic rehabilitation, thus an outcome of importance to both patients and healthcare providers. It would be ideal if this outcome could be evaluated by 1 measure at all phases of rehabilitation, so that an individual's progress along the recovery pathway could be easily monitored. Hence a measure that could be used throughout the whole continuum of rehabilitation would be worth exploring.

The Functional Independence Measure (FIM) is the only outcome routinely used to assess function in all rehabilitation inpatients in Ontario, Canada. This measure assesses the amount of assistance an individual requires to perform basic activities of daily living. If "amount of assistance" is translated to "difficulty" performing a task, the FIM could be categorized as measuring "activity limitations," as described by the International Classification of Functioning, Disability and Health (ICF).[52]

The use of the FIM in assessing function is not without limitations. The FIM assessment in one setting may not be applied to a different setting, because behaviors of an individual may be different in another environment.[35] As a proprietary measure, administration of the FIM requires certified assessors in subscribed settings.[48] Administration of the FIM is also quite time consuming and may not be feasible in some busy clinical settings. The FIM was constructed to assess burden of care,[34,35] with scoring based only

[1]Physical Therapist, West Park Healthcare Centre, Toronto, ON, Canada. [2]Professor Emeritus, School of Rehabilitation Science, McMaster University, Hamilton, ON, Canada. [3]Professor, School of Rehabilitation Science, McMaster University, Hamilton, ON, Canada. [4]Associate Professor, School of Rehabilitation Science, McMaster University, Hamilton, ON; Co-director, Hand and Upper Limb Centre Clinical Research Laboratory, Saint Joseph's Health Centre, London, ON, Canada; Funded by a New Investigator Award, Canadian Institutes of Health Research. At the time of this study, Teresa S.M. Yeung was completing her MSc degree. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of West Park Healthcare Centre or McMaster University. This study was fully supported by the Arthritis Health Professions Association research grant funded by the Arthritis Society. The study protocol was reviewed and approved by the Research Ethics Boards of West Park Healthcare Centre and McMaster University. Address correspondence to Teresa S.M. Yeung, 82 Buttonwood Avenue, Toronto, ON M6M 2J5, Canada. E-mail: tyeung@westpark.org

on ratings from the assessor; the perspectives of the assessed individual is not considered.

To obtain input from the patient, self-report measures, such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Medical Outcomes Study (SF-36) physical function subscale, are used to report the function of orthopaedic patients. However, the WOMAC was designed specifically for osteoarthritis and may not be appropriate for patients with a variety of diagnoses in an orthopaedic ward. In addition, the factorial validity of the WOMAC has not been supported in the recent literature.[8,9,18,42,47] The SF-36 physical function subscale has limited use on subjects with lower levels of functioning[23] and institutionalized individuals,[10] and has limited reliability for use on an individual level.[10]

The Lower Extremity Functional Scale (LEFS) is a self-report measure designed to assess the functional status of patients with any musculoskeletal condition related to the lower extremity (**APPENDIX**). Using the ICF categorization,[52,53] this measure gathers information on "activity limitations." But most questions are framed (**APPENDIX**) such that responders are free to position themselves in their own relevant context. All questions on the LEFS can be mapped within the "Mobility" chapter of the "Activity and Participation" component under the ICF framework.[53] From a practical perspective, the LEFS is easy to complete and to score, and is likely feasible to administer in most clinical settings.

The LEFS has demonstrated acceptable validity on outpatients, but the majority of these individuals scored in the top 3 quarters of the scale range.[1,4,39,49] The validity of the LEFS in people who score in the bottom quarter of the scale range remains unknown. When compared to outpatients, orthopaedic inpatients often have more limited function and their scores are more likely to fall within the bottom quarter of the scale range. Hence, there is a need to examine the use of the LEFS on these inpatients. If shown to be useful, the LEFS could be used to track and compare an individual's progress at different stages of orthopaedic rehabilitation.

The purposes of this study were to estimate the test-retest reliability, construct validity, and responsiveness[24] of the LEFS on inpatients attending an orthopaedic rehabilitation program. The Numeric Pain Rating Scale (NPRS), the transfer and locomotion items of the FIM (TLFIM), and the timed up-and-go (TUG) test were chosen as comparison measures for the construct validation. The NPRS is categorized under the "Body Function and Structure" component of the ICF.[53] Although this component is categorized differently from the LEFS component, the NPRS was selected because pain has been associated with physical functioning[3,7] and likely has substantial impact on function shortly after orthopaedic surgery.

The TUG and the TLFIM were perceived to assess related constructs because they both assess aspects of activities of daily living that rely on lower extremity function. Items of the TLFIM and selected items on the LEFS can also be mapped using the same second-level category codes in the "Mobility" chapter under the "Activity and Participation" component of the ICF.[53] Although the TUG test as a whole cannot be mapped directly into a particular category code, individual movement components (eg, getting into and out of the sitting or standing position, walking) involved in the TUG test may be mapped into the same second-level category codes as the selected mobility items of the LEFS.

Two theories set up for the construct validation were as follows:

1. Improvement in the LEFS scores would be correlated with improvements in pain, the TLFIM, and the timed TUG test. The LEFS was expected to most highly correlate with the TLFIM, as both measures sample a broader variety of activities when compared to the other 2 measures.
2. Improvement in the LEFS scores of subjects who were considered improved (responders) would be greater than the change in LEFS scores of subjects who were not considered improved (nonresponders).

It is estimated that the LEFS would demonstrate correlations in the range of 0.3 to 0.6 with the comparison measures,[1,39] and would demonstrate large responsiveness, as quantified by a standardized response mean of 1.0 or larger.

METHODS

Subjects

All consecutive and eligible patients admitted to the inpatient orthopaedic rehabilitation program in West Park Healthcare Centre between January 2005 and August 2006 were approached to participate in the study. The first 31 consented patients were also invited to participate in the reliability estimation. Patients were excluded from the study if they were unable to read or comprehend English, were unable to perform the TUG test without physical assistance, had spinal injuries requiring log-roll in bed, or used any rigid spinal braces. The study was reviewed and approved by the Research Ethics Board of both the West Park Healthcare Centre and McMaster University. Informed consent was obtained from all participating subjects and their rights as human subjects were protected. Based on a reliability estimate of 0.9[1,4,39,49] and correlation estimate of 0.6[1,39] with the comparison measures, the estimated sample sizes for test-retest reliability[45] and construct validity[15] were, respectively, 21 and 135 subjects.

Study Design

The study followed a longitudinal single-group repeated-measures design. **TABLE 1** summarizes measures conducted at different time points. For reliability estimation, subjects were tested on admission and retested within 24 hours, with no therapy in between. To examine the construct validity of the LEFS, the NPRS,

TABLE 1 Assessment Times of the Lower Extremity Functional Scale (LEFS) and Other Comparison Measures

Tests	Assessment Times	Measures
Admission test	Day 0-3 after admission*	LEFS, TUG, NPRS, TLFIM
Retest for reliability	24 h after admission test	LEFS
Second test	7-10 d after admission	LEFS, TUG, NPRS
Discharge test	Day 0-3 before discharge	LEFS, TUG, NPRS, TLFIM, GFCS

Abbreviations: GFCS, Global Functional Change Survey; NPRS, Numeric Pain Rating Scale; TLFIM, transfer and locomotion items of the Functional Independence Measure; TUG, timed up-and-go test.
** Admission for inpatient rehabilitation from acute care settings.*

TUG test, and TLFIM were used as comparison measures. All measures but the TLFIM were administered on admission, 7 to 10 days after admission, and on discharge. Scores of the TLFIM on admission and discharge were extracted from the medical records. To examine the ability of the LEFS to measure meaningful change, referred to as responsiveness,[24] a Global Functional Change Survey was used at discharge. This survey is used to differentiate between subjects who were believed to have changed and subjects who were not believed to have changed. Details on this survey will be described in the following section.

Measures

The LEFS is a 20-item, region-specific measure asking patients for their perceived difficulties in activities of daily living. Each item is rated on a 5-point scale. Total scores range from 0 to 80, with a higher score indicating better function.[4] Both clinimetric and statistical approaches were used in the development of the LEFS.[4]

The LEFS had very high[46] internal consistency (alpha coefficient ranged from 0.93 to 0.96) and good[50] test-retest reliability (0.85 to 0.98) on outpatients with a variety of orthopaedic conditions.[1,4,39,49] The standard error of measurement (SEM) of the LEFS ranged from 3 to 4 LEFS points on the same samples of outpatients.[1,4,39,49]

Several authors[1,4,39] have demonstrated good construct validity of the LEFS. The Pearson correlations of the LEFS with the SF-36 physical function subscale and physical component summary scores were 0.80 and 0.64 in a cross-sectional study on outpatients with a variety of orthopaedic diagnoses.[4] The LEFS was correlated 0.36 to 0.48 with impairment measures on outpatients with ankle sprains,[1] and 0.68 with a pooled index comprising performance measures and pain on outpatients with total joint arthroplasty.[39] The correlation between the change scores of the LEFS and the same pooled index of change was 0.64.[39]

The TUG test is frequently used to evaluate basic mobility for rehabilitation patients.[28,31,33] The test-retest reliability of the TUG test on inpatients with orthopaedic conditions was found to be 0.80 ($ICC_{2,2}$).[54] The TUG test has been validated for use with orthopaedic conditions and in a rehabilitation setting.[5,11,22,30,54]

For the TUG test, subjects were asked to stand up from a chair, walk with their assistive devices at a comfortable pace to a 3-m marked line, return to the chair, and sit down. Time taken to complete the test was recorded to the nearest 1/100 of a second using a stopwatch. Two trials were administered and the average used for analysis. To address the different angles of hip flexion restriction on patients after hip replacement, seat height for the test was not standardized across subjects. The flexibility with seat height also allowed patients with different orthopaedic conditions (eg, patients who could only stand up from a raised seat height following bilateral knee replacements) to participate in the study. A subject always used the same chair and seat height for subsequent testing, although his/her assistive device or weight-bearing status might change. These procedures were set up to reflect the reality in practice when the TUG test is applied to inpatients on an orthopaedic rehabilitation ward.

The 11-point NPRS is designed to measure pain intensity with scores ranging from 0 (no pain) to 10 (pain as bad as it can be).[10,17,29] The NPRS was found to be efficient in assessing pain in clinical practice.[44] Subjects were instructed to record their pain on the NPRS at the time of the assessment.

The FIM is an 18-item tool used by health professionals to assess patients' performance on selected basic activities of daily living.[35,36] The TLFIM used in the present study comprised 3 transfer (bed/chair/wheelchair, toilet, tub/shower) and 2 locomotion (walk/wheelchair, stair climbing) items. The total score could range from 5 to 35, a higher score indicating better function. Although the psychometric properties of the TLFIM have not been reported, the items have been used previously to measure outcome[6,30] and evaluate measurement instruments.[39]

The Global Functional Change Survey had 2 questions that were completed independently by subjects and their therapists. They each rated subjects' improvement in self-care (eg, dressing and toileting) and mobility (eg, getting up to sitting from bed or walking) from admission to discharge. The possible ratings were "worse," "about the same," or "better."

All measures were performed by following standardized operational procedures. Subjects were asked to complete the LEFS on their own. The TUG test and the NPRS were administered by either a physical therapist or a research assistant. The research assistant was trained by the physical therapist to conduct the measures. Interrater and intrarater reliabilities on the TUG test were not assessed in this study. To minimize the threats to internal validity, random measurement error was limited by using the average

on 2 trials of the TUG test for analysis. The physical therapist and the research assistant had also audited each other on 2 separate occasions at the beginning of the study period to ensure uniform compliance of the standardized procedure; no discrepancy was identified between these 2 assessors.

Subjects were followed by the same assessor throughout the study period. All subjects were blinded to their previous measurement results until after the final assessment was completed.

Analyses

All descriptive and inferential statistics were computed using the SPSS, Version 13. Means, medians, and SDs were computed for all measures.

To provide estimates of the test-retest reliability, the type 2,1 intraclass correlation coefficient ($ICC_{2,1}$)[32] was computed for the scores of LEFS on admission and retest. The SEM[37] that expressed the test-retest error in LEFS point, was computed by taking the square root of the mean-square error.[37] The 2-sided 95% confidence interval for the SEM was also estimated.[40] The error associated with an observed LEFS score with 90% confidence level was computed by $1.65 \times \text{SEM}$.[37] The minimal detectable change (MDC) was computed from the SEM[37] to indicate the amount of change required to be confident that a true change occurred rather than a change due only to error variation.[12] The MDC of the LEFS at 90% confidence interval (MDC90) was estimated by $1.65 \times \text{SEM} \times \sqrt{2}$.[37]

Because the score distributions of some measures were not normal, nonparametric statistics were used for the analyses of construct validity. The Spearman rank correlations were computed to examine the associations between the change scores of the LEFS and the change scores of the comparison measures. Because each individual comparison measure is expected to assess only some aspects of lower extremity function, a pooled index of change made up from the change scores of all comparison measures was created to reflect a more comprehensive view on lower extremity function. This strategy of using a pooled index has been used in a previous measurement study.[39] To create the pooled index of change, a standard change score was computed for each subject for each comparison measure. To compute this standard change score, each subject's change score on a comparison measure was subtracted from the mean change score of that measure and divided by the SD of the change score. The pooled index of change was obtained by averaging the standard score of change from all 3 comparison measures for each subject.

To estimate responsiveness, standardized response means (SRMs) were com-

TABLE 2 Demographic Characteristics of All Subjects*

	Number (%)†	Majority
Body mass index, kg/m²‡§		>24.9
<18.5	6 (4.0)	
18.5-24.9	49 (34.5)	
25.0-29.9	42 (29.6)	
30.0-45.0	43 (30.3)	
Gender		Female
Female	93 (65.5)	
Male	49 (34.5)	
Etiology‡		Osteoarthritis
Osteoarthritis	86 (60.6)	
Rheumatoid arthritis	24 (16.9)	
Others	27 (19.0)	
Reason for admission		Hip replacement
Hip replacement	72 (50.7)	
Knee replacement	49 (34.5)	
Others‖	21 (14.8)	
Types of surgery‡		Revision
First joint replacement	43 (30.3)	
First revision	50 (35.2)	
Second revision or more	27 (19.0)	
Others‖	21 (14.8)	
Weight-bearing status		Weight bearing as tolerated
No weight bearing	31 (21.8)	
Touch weight bearing	11 (7.7)	
Partial weight bearing	11 (7.7)	
Weight bearing as tolerated	89 (62.7)	
Number of joint replacement surgeries in lower extremities¶		3-7
0	17 (12.0)	
1	23 (16.2)	
2	42 (30.0)	
3-7	60 (42.2)	

** For all subjects: n = 142; mean ± SD age, 64.9 ± 12.9 years; range, 24.0-66.0 years; mean ± SD body mass index, 27.4 ± 6.1 kg/m²; range, 16.7-45.0 kg/m².*
† Percentages may not add up to 100 due to missing data and/or rounding errors.
‡ Missing data.
§ Body mass index categorization based on Canadian Guidelines for Body Weight Classification in Adults.[14]
‖ Soft tissue injuries and/or fractures with/without internal or external fixations.
¶ Accumulated number of joint replacement surgeries in the lower extremities.

puted for "responders" for all periods between the 3 assessments. Responders were subjects who were considered changed. Subjects were categorized as responders when both the subject and the physical therapist answered "better" in both questions of the Global Functional Change Survey. An SRM is the mean change score divided by the SD of the change scores. The 95% confidence intervals were computed using the bootstrap method.[13] In addition, the Wilcoxon rank sum test was used to compare the change scores of the LEFS of the responders and nonresponders.

RESULTS

From January 2005 to August 2006, 150 subjects consented to participate in the study, with the first 31 subjects being recruited for the reliability testing as well. Some subjects only participated in the reliability portion of the study. Final analyses included 24 subjects for reliability estimation and 142 subjects for validity estimation. Seven subjects were excluded from the reliability estimation because of sickness (3 subjects), unavailability (1 subject), or because therapy was conducted prior to the retest (3 subjects). Eight subjects were excluded from the validity estimation due to acute changes in medical status (1 subject), consent withdrawal (2 subjects), or unexpected discharges (1 subject released herself from hospital against medical advice, 4 subjects were transferred to acute care hospitals because of hip infection/dislocations). All 8 subjects excluded in the validity estimation dropped out prior to the second assessment. Eighteen subjects had a short stay and did not have the second assessment.

The descriptive statistics on the characteristics of all participating subjects are presented in **TABLE 2**. The majority of subjects were female with revision joint replacements related to osteoarthritis. Sixty percent of the subjects were classified as overweight or obese.[14] Almost 40% of subjects were admitted with restricted weight-bearing status, and more than 50% of the sample were admitted because of revision joint replacement. Over 40% of this sample had undergone multiple joint(s) replacement surgeries (3-7 times) in the lower limb(s). Sixty subjects (41%) had previous joint replacements in the lower extremity contralateral to the currently affected side, and 15 subjects (11%) had surgeries on both lower limbs on this admission (not shown in **TABLE 2**). There were no differences ($P<.05$) in the subject characteristics of the reliability and validity groups.

Eighty percent of the sample was tested within 8 days after surgery. The time lapse among surgery, admission, and admission test, and the time lapse among different assessments, are presented in **TABLE 3**. The median length of stay was 18 days and the interquartile range was 9 days. All subjects were discharged home

TABLE 3 Median Number of Days Between Surgery, Admission to Rehabilitation Program, and Testing Times*

Period	Median (d)	Interquartile Range
Surgery to admission to rehabilitation program*	5	3
Surgery to admission test*	6	3
Admission test to second test	7	1
Second test to discharge test	11	12
Admission test to discharge test	17	14

** Acute care admission in nonsurgical cases. All surgical cases done prior to admissions to rehabilitation program.*

TABLE 4 Descriptive Data for the Lower Extremity Functional Scale (LEFS) and Comparison Measures for the Whole Sample (n = 142), Responders (n = 125), and Nonresponders (n = 17)*

Measures	Admission Score	Discharge Score	Change Score†
LEFS (0-80)			
Whole sample	14, 12, 9	31, 30, 11	17, 16, 10
Responders	13, 11, 8	31, 29, 11	18, 17, 10
Nonresponders	20, 20, 9	33, 35, 11	12, 9, 11
TUG (s)			
Whole sample	63, 52, 48	23, 21, 10	41, 29, 48
Responders	67, 55, 50	23, 21, 10	44, 32, 50
Nonresponders	36, 33, 22	21, 15, 11	10, 8, 10
NPRS (0-10)			
Whole sample	4, 4, 3	2, 2, 2	2, 2, 2
Responders	4, 4, 3	2, 2, 2	2, 2, 2
Nonresponders	4, 4, 2	3, 2, 3	1, 1, 3
TLFIM (5-35)			
Whole sample	15, 14, 4	28, 29, 4	13, 14, 5
Responders	15, 14, 4	28, 29, 4	13, 14, 5
Nonresponders	17, 16, 5	28, 29, 3	11, 13, 5

Abbreviations: NPRS, Numeric Pain Rating Scale; TLFIM, transfer and locomotion items of the Functional Independence Measure; TUG, timed up-and-go test.
** Data are mean, median, and SD. Two missing observations in discharge score and change score.*
† Orientations of signs adjusted so positive signs denote improvements.

and required the use of gait aids to move around.

The $ICC_{2,1}$ of the LEFS was 0.88 (95% CI: 0.74, 0.95). The SEM was 3.5 LEFS points (95% CI: 2.7, 4.9 LEFS points) and the error associated with an observed LEFS score with 90% confidence level was ±5.8 LEFS points. The MDC_{90} was 8.2 LEFS points. The mean scores of the admission test and the retest were both 14.0 LEFS points (SD, respectively, 8.6 and 10.7 LEFS points).

Descriptive data of all measures and the correlations of the LEFS with the comparison measures are presented in **TABLE 4** and **5**. The median LEFS score on admission was 12 and fell in the bottom quarter of the scale range. The correlations between the LEFS and the individual comparison measures range from 0.28 to 0.36. No significant correlation in change scores was found between the LEFS and the NPRS. The Spearman correlation on the change scores of the LEFS with the pooled index of change was 0.38 (95% CI: 0.23, 0.51).

There was a significant difference (w = 653.5, $P<.01$) between the LEFS change scores of the responders (n = 125; quartiles: 11, 17, and 23 LEFS points) and the nonresponders (n = 15; quartiles: 6, 9, and 14 LEFS points). The SRMs of the responders in all measures are shown in **TABLE 6**. The SRM of the LEFS for the nonresponders from admission to discharge was 1.08.

TABLE 5 Correlations of Scores and Change Scores Between the LEFS and Comparison Measures*

	Admission	Discharge	Change†
TUG (s)	0.47 (0.33, 0.59)	0.32 (0.16, 0.50)	0.36 (0.21, 0.54)
NPRS (0-10)	0.18 (0.02, 0.33)	0.24 (0.07, 0.41)	0.15 (−0.02, 0.31)
TLFIM (0-35)	0.29 (0.13, 0.46)	0.15 (-0.02, 0.31)	0.28 (0.12, 0.46)

Abbreviations: CI, confidence interval; LEFS, Lower Extremity Functional Scale; NPRS, Numeric Pain Rating Scale; TLFIM, transfer and locomotion items of the Functional Independence Measure; TUG, timed up-and-go test.
** Data are Spearman rho (95% CI); n = 140.*
† Orientations of signs adjusted so positive correlations denote improvements in both measures.

TABLE 6 The Standardized Response Means of the LEFS and Comparison Measures for the Responders*

	Admission to Discharge (n = 125)	Second Test to Discharge (n = 115)	Admission to Second Test (n = 115)
LEFS	1.76 (1.56, 2.08)	1.15 (0.97, 1.39)	0.92 (0.74, 1.11)
TUG†	0.89 (0.72, 1.34)	0.91 (0.78, 1.08)	0.74 (0.62, 1.06)
NPRS†	0.84 (0.66, 1.03)	0.45 (0.28, 0.64)‡	0.45 (0.27, 0.63)‡
TLFIM	2.65 (2.07, 3.42)	NA	NA

Abbreviations: LEFS, Lower Extremity Functional Scale; NA, not applicable; NPRS, Numeric Pain Rating Scale; TLFIM, transfer and locomotion items of the Functional Independence Measure; TUG, timed up-and-go test.
** Data are standardized response means (95% confidence interval).*
† Orientation of signs adjusted so positive standardized response mean denote improvements.
‡ n = 114.

DISCUSSION

The test-retest reliability of the LEFS in this sample of orthopaedic inpatients was very good ($ICC_{2,1}$ = 0.88), indicating that the LEFS is appropriate for group and individual applications.[50] The SEM and the MDC_{90} of the LEFS were reported to enhance clinical interpretation. A clinician can be 90% confident that an observed score varies within ±6 LEFS points and that a change of greater than 8 LEFS points can be considered a true change. The observed point estimate of ICC, SEM, and MDC_{90} were consistent with previous studies.[1,4,39]

The construct validity of the LEFS was only partially supported by this study. Change in the LEFS correlated with changes in all comparison measures in the expected direction. These correlations were generally low, and may reflect differences in sensitivity to change between the measures used. It is also possible that the LEFS and the selected comparison measures assess different attributes.

Biases in validation of a measure may occur when there is a restriction in scale range of the candidate measure and/or the comparison measures.[46] Results of this study show that improvements in LEFS scores were not consistently matched with corresponding improvements in scores of the TUG test and TLFIM. This finding was likely related to the ceiling effect of these comparison measures. Here, ceiling effect refers to inadequate room on a scale to record further improvement.

The large number of subjects scoring at just below the maximum score at discharge reflects the potential ceiling effect on the scale of the TLFIM (**FIGURE**). The TUG score might also have reached a ceiling level unique to this sample of subjects. At discharge, the majority of subjects scored between 15 and 30 seconds on the TUG test (**FIGURE**), with a mean and median of 23 and 21 seconds, respectively. These values were similar to the means (range, 18 to 28 seconds) observed on samples with comparable or less disability.[5,21,26,30] Hence, many subjects in the present study may have had little room for further improvement of their TUG scores.

An inaccurate hypothetical construct may also explain the low correlations observed between the self-report LEFS and the selected performance measures. In cross-sectional studies, the reported Pearson correlations between self-report

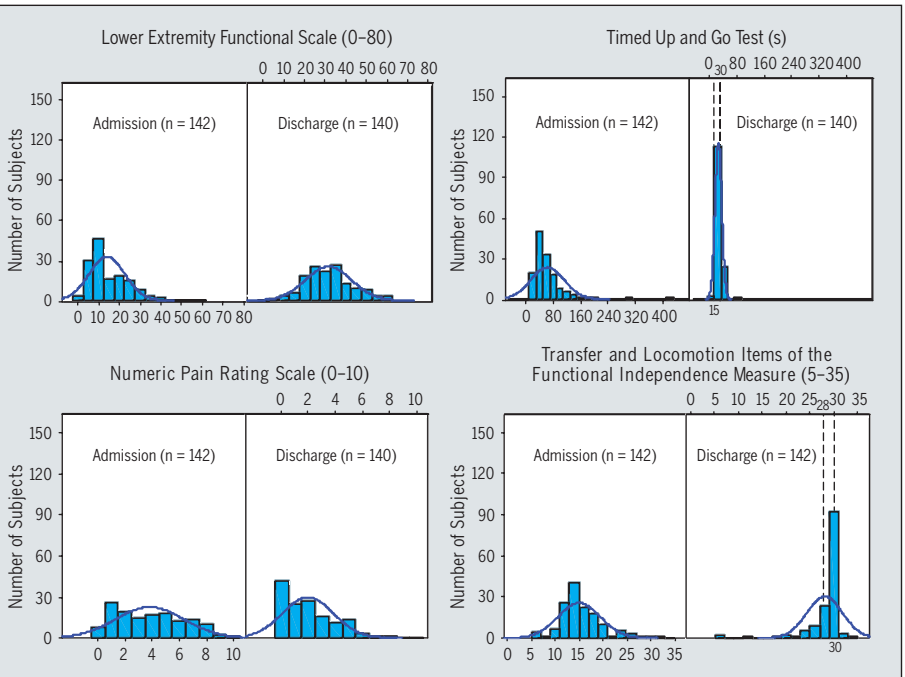

FIGURE. Histograms showing the admission and discharge scores of all measures.

and performance measures ranged from 0.21 to 0.61 in community-dwelling individuals with osteoarthritis of the hip/knee or in those awaiting total joint arthroplasty.[19,27,41] Correlations observed in this study were within the range observed in these previous studies but in the lower side of the range.[19,27,41]

It was expected that using a pooled index of change created from the selected comparison measures would capture broader attributes of lower extremity function, and would result in a higher correlation with the LEFS. However, the observed correlation in this study was only 0.38. Stratford et al[39] reported a Pearson correlation of 0.64 between the LEFS and a pooled index on subjects with total joint replacements. The differences may be attributed to the composition of the pooled indices used. It is possible that the addition of the 6-minute walk test and the timed stairs test as component measures in their pooled index[39] might have inflated the contribution of timed scores to lower extremity function. Their subjects were also less disabled (baseline TUG scores, 27 seconds) and less acute (22 days after surgeries), and their sampling intervals were longer (4 weeks).

As has been mentioned earlier, it is possible that the LEFS and the comparison measures assess constructs that have limited association. Although some studies[41,51] released in the conception period of this study had demonstrated generally low associations between self-report and performance measures on outpatients with similar orthopaedic conditions, there were reasons to examine their relationships on inpatients. Self-report measures of function were conceived to assess function, and, as they are increasingly being used in research,[2] it is important to understand how well performance is actually represented by these measures at different phases of rehabilitation. Studies in the past 2 years[16,43] found consistently low associations between self-report and performance measures on individuals with osteoarthritis or hip/knee arthroplasties, suggesting that these measures may not assess the same construct. Results of this study are consistent with these findings.[16,41,43,51]

The ICF[52] is a framework that may help to explain the low correlations between the LEFS and the comparison measures. Although the acts/task assessed in the LEFS, the TUG, and the TLFIM all belong to the "Mobility" chapter under the "Activities and Participation" component of the ICF,[53] the environmental and personal factors that likely interact with these tasks are not being considered equally in these 3 measures. The TUG test and the TLFIM assessed mobility of the individual in an inpatient setting. Assistance to complete these measures was not offered unless the external assessor determined that the help was needed. Consequently, these measures only present the behavior of the individual in this specific setting, and this behavior may change in a different context. Unlike the TUG and the TLFIM, which are context restricted in an artificial setting with an external assessor, the choice of context is more flexible in the LEFS. Questions framed as "do you" or "would you" allow individuals the freedom to position themselves in their own personal and/or environmental context when they answer. This contextual difference may explain the low correlations between the LEFS and the comparison measures.

For the LEFS, perhaps the "difficulty" reported on a certain item was gauged on a complex interaction of individuals' perceptions. These perceptions might depend on the specific time frame of the questions on the LEFS (eg, "today"), the affect of an individual when he/she completes the LEFS, and the standard employed by an individual for comparison. Such comparison standards may be conditional to the situation (eg, different stages of rehabilitation). Therefore, responses gathered from the LEFS may be impacted at different times, to a different extent, by different factors (eg, pain, anxiety, or muscle strength). Depending on the course of recovery, physical components of function, such as endurance and coordination, may not be readily reflected by the LEFS. This contextual-dependent response is unlikely unique to the LEFS and probably happens in a similar manner to other self-report measures. Hence, concurrent use of both self-report and

performance measures is recommended when a comprehensive picture of function is considered.

The SRM was used to quantify the responsiveness of the LEFS. There is no standardized way to interpret the magnitude of SRM. In general, a larger value reflects better ability to detect change.[25] Applying the recommendation of Liang,[25] where a magnitude of 1.0 or greater is large, the SRMs of the LEFS from admission to discharge were large in both the responders (1.76) and the nonresponders (1.08).

One concern of these results in SRM is that the LEFS may detect change that did not occur. However, the large SRM observed in the nonresponders may be related to the stringent criterion used to dichotomize subjects into responders or nonresponders. Any disagreement in response between subjects and clinicians on any of the 2 questions on the Global Functional Change Survey categorized a subject as a nonresponder. This criterion may have overestimated the number of nonresponders. In spite of this possible overestimation, improvements in the LEFS score, TUG test, and TLFIM were all significantly lower in the nonresponders.

As can be seen in **TABLE 4**, the nonresponders in general had better baseline function in all measures when compared to the responders. The expectation of "change" in mobility may be affected by the starting point. Subjects who started with better function may have a higher threshold of perception for "change" when compared to responders. These observations may also reflect the limitations of using the anchor-based approach to determine if observed changes in the candidate measure are meaningful.[38] The Global Functional Change Survey is not a standardized measure superior to the LEFS, but it was used as the criterion standard to assess the ability of the LEFS to measure change. Because the same subject completed both these measures, scoring on the Survey is not independent of the LEFS being assessed.

In summary, the LEFS has demonstrated high SRM in the responders, and improvement in the LEFS scores of responders was greater than the nonresponders. These results are consistent with the second theory set up for the construct validation of the LEFS. Taken together with the previously established reliability[1,4,39,49] and validity[1,4,39] in outpatient settings, the LEFS is a useful measure to track an individual's progress from inpatient to outpatient rehabilitation.

Other limitations of the study are related to weight-bearing status, gender, and language of the subjects. There were uncontrolled changes in weight-bearing restriction, gait aid, and lower extremity braces across different TUG tests. Standardization was not always feasible because changes in the 3 factors at times relate to safety concerns. It was assumed that scores from all measures would be similarly impacted by these changes. This study also did not take into account the difference in functional recovery between the 2 genders.[20] However, the correlations between measures were generally similar for the entire sample and for the gender subgroups. Finally, results may only be generalizable to English-speaking patients with conditions similar to those seen in this study. Because the majority of subjects in the current study had revision joint replacements and/or previous lower-limb surgeries, it is unknown if these are typical inpatients seen in other orthopaedic wards.

CONCLUSIONS

The LEFS is reliable for individual and group use on an orthopaedic inpatient ward and has demonstrated large responsiveness. Improvement in the LEFS scores of subjects who were considered improved were greater than the change in LEFS scores of subjects who were not considered improved. The LEFS is a useful measure to track an individual's progress from inpatient to outpatient rehabilitation. The TLFIM and the TUG test also measure changes for inpatients, but the constructs assessed by these measures and the LEFS likely have minimum overlapping characteristics. The patterns of change in the LEFS were different from those of the performance measures. Further research is needed to examine the construct validity of the LEFS. ◉

KEY POINTS

FINDINGS: This study found that the LEFS has good reliability and large responsiveness, and can assess both individual and group changes on inpatients of an orthopaedic ward.

IMPLICATIONS: The LEFS can be used to assess valid change in inpatients of an orthopaedic ward. The LEFS is a useful measure to track an individual's progress from inpatient to outpatient rehabilitation.

LIMITATIONS: Results may be limited to inpatients with a high level of disability, and who can speak and comprehend English.

ACKNOWLEDGEMENTS: *The authors acknowledge Eve Huxley for her assistance in data collection. Thanks to Lynda Woon, John Tagg, and all participating subjects and team members of the Musculoskeletal Service in West Park Healthcare Centre for their support in making the completion of this study possible.*

REFERENCES

1. Alcock GK, Stratfod PW. Validation of the lower extremity functional scale on athletic subjects with ankle sprains. *Physiother Can.* 2002;54:233-240.
2. Beaton DE, Schemitsch E. Measures of health-related quality of life and physical function. *Clin Orthop Relat Res.* 2003;90-105. http://dx.doi.org/10.1097/01.blo.0000079772.06654.c8
3. Berge DJ, Dolin SJ, Williams AC, Harman R. Pre-operative and post-operative effect of a pain management programme prior to total hip replacement: a randomized controlled trial. *Pain.* 2004;110:33-39. http://dx.doi.org/10.1016/j.pain.2004.03.002
4. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American Ortho-

paedic Rehabilitation Research Network. *Phys Ther.* 1999;79:371-383.
5. Brooks D, Davis AM, Naglie G. Validity of 3 physical performance measures in inpatient geriatric rehabilitation. *Arch Phys Med Rehabil.* 2006;87:105-110. http://dx.doi.org/10.1016/j.apmr.2005.08.109
6. Buxbaum LJ, Ferraro M, Whyte J, Gershkoff A, Coslett HB. Amantadine treatment of hemispatial neglect: a double-blind, placebo-controlled study. *Am J Phys Med Rehabil.* 2007;86:527-537. http://dx.doi.org/10.1097/PHM.0b013e31806e3392
7. Childs JD, Piva SR, Erhard RE, Hicks G. Side-to-side weight-bearing asymmetry in subjects with low back pain. *Man Ther.* 2003;8:166-169.
8. Faucher M, Poiraudeau S, Lefevre-Colau MM, Rannou F, Fermanian J, Revel M. Algo-functional assessment of knee osteoarthritis: comparison of the test-retest reliability and construct validity of the WOMAC and Lequesne indexes. *Osteoarthritis Cartilage.* 2002;10:602-610.
9. Faucher M, Poiraudeau S, Lefevre-Colau MM, Rannou F, Fermanian J, Revel M. Assessment of the test-retest reliability and construct validity of a modified WOMAC index in knee osteoarthritis. *Joint Bone Spine.* 2004;71:121-127. http://dx.doi.org/10.1016/S1297-319X(03)00112-X
10. Finch E, Brooks D, Stratford P, Mayo *N. Physical Rehabilitation Outcome Measures: A Guide to Enhanced Clinical Decision Making.* 2nd ed. Baltimore, MD: Lippincott, Williams & Wilkins; 2002.
11. Freter SH, Fruchter N. Relationship between timed 'up and go' and gait time in an elderly orthopaedic rehabilitation population. *Clin Rehabil.* 2000;14:96-101.
12. Haley SM, Fragala-Pinkham MA. Interpreting change scores of tests and measures used in physical therapy. *Phys Ther.* 2006;86:735-743.
13. Haukoos JS, Lewis RJ. Advanced statistics: bootstrapping confidence intervals for statistics with "difficult" distributions. *Acad Emerg Med.* 2005;12:360-365. http://dx.doi.org/10.1197/j.aem.2004.11.018
14. Health Canada. Canadian Guidelines for Body Weight Classification in Adults. Available at: http://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/nutrition/weight_book-livres_des_poids-eng.pdf. Accessed April 20, 2009, 2003.
15. Hulley SB. *Designing Clinical Research: An Epidemiologic Approach.* 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2001.
16. Johnson SR, Archibald A, Davis AM, Badley E, Wright JG, Hawker GA. Is self-reported improvement in osteoarthritis pain and disability reflected in objective measures? *J Rheumatol.* 2007;34:159-164.
17. Katz WA, Rothenberg R. Section 2: The importance of improving function in patients with pain. *J Clin Rheumatol.* 2005;11:S6-9, discussion S9-10.
18. Kennedy D, Stratfod PW, Pagura SM, Wessel J, Gollish JD, Woodhouse LJ. Exploring the factorial validity and clinical interpretability of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). *Physiother Can.* 2003;55:160-168.
19. Kennedy D, Stratford PW, Pagura SM, Walsh M, Woodhouse LJ. Comparison of gender and group differences in self-report and physical performance measures in total hip and knee arthroplasty candidates. *J Arthroplasty.* 2002;17:70-77.
20. Kennedy DM, Hanna SE, Stratford PW, Wessel J, Gollish JD. Preoperative function and gender predict pattern of functional recovery after hip and knee arthroplasty. *J Arthroplasty.* 2006;21:559-566. http://dx.doi.org/10.1016/j.arth.2005.07.010
21. Kennedy DM, Stratford PW, Hanna SE, Wessel J, Gollish JD. Modeling early recovery of physical function following hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2006;7:100. http://dx.doi.org/10.1186/1471-2474-7-100
22. Kennedy DM, Stratford PW, Wessel J, Gollish JD, Penney D. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. *BMC Musculoskelet Disord.* 2005;6:3. http://dx.doi.org/10.1186/1471-2474-6-3
23. Latham NK, Haley SM. Measuring functional outcomes across postacute care: current challenges and future directions. *Crit Rev Phys Rehabil Med.* 2003;15:83-98.
24. Liang MH. Longitudinal construct validity: establishment of clinical meaning in patient evaluative instruments. *Med Care.* 2000;38:II84-90.
25. Liang MH, Fossel AH, Larson MG. Comparisons of five health status instruments for orthopedic evaluation. *Med Care.* 1990;28:632-642.
26. Lusardi MM, Pellecchia GL, Schulman M. Functional performance in community living older adults. *J Geriatr Phys Ther.* 2003;26:14-22.
27. Maly MR, Costigan PA, Olney SJ. Determinants of self-report outcome measures in people with knee osteoarthritis. *Arch Phys Med Rehabil.* 2006;87:96-104. http://dx.doi.org/10.1016/j.apmr.2005.08.110
28. Mathias S, Nayak US, Isaacs B. Balance in elderly patients: the "get-up and go" test. *Arch Phys Med Rehabil.* 1986;67:387-389.
29. McCahon S, Strong J, Sharry R, Cramond T. Self-report and pain behavior among patients with chronic pain. *Clin J Pain.* 2005;21:223-231.
30. Mendelsohn ME, Leidl DS, Overend TJ, Petrella RJ. Specificity of functional mobility measures in older adults after hip fracture: a pilot study. *Am J Phys Med Rehabil.* 2003;82:766-774.
31. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc.* 1991;39:142-148.
32. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psycho Bull.* 1979;86:420-428.
33. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther.* 2000;80:896-903.
34. Stineman MG, Maislin G. Validity of functional independence measure scores. *Scand J Rehabil Med.* 2000;32:143-144.
35. Stineman MG, Ross RN, Fiedler R, Granger CV, Maislin G. Functional independence staging: conceptual foundation, face validity, and empirical derivation. *Arch Phys Med Rehabil.* 2003;84:29-37. http://dx.doi.org/10.1053/apmr.2003.50061
36. Stineman MG, Shea JA, Jette A, et al. The Functional Independence Measure: tests of scaling assumptions, structure, and reliability across 20 diverse impairment categories. *Arch Phys Med Rehabil.* 1996;77:1101-1108.
37. Stratford PW. Getting more from the literature: estimating the standard error of measurement from reliability studies. *Physiother Can.* 2004;56:27-30.
38. Stratford PW, Binkley FM, Riddle DL. Health status measures: strategies and analytic methods for assessing change scores. *Phys Ther.* 1996;76:1109-1123.
39. Stratford PW, Binkley JM, Watson J, Heath-Jones T. Validation of the LEFS on patients with total joint arthroplasty. *Physiother Can.* 2000;52:97-105, 110.
40. Stratford PW, Goldsmith CH. Use of the standard error as a reliability index of interest: an applied example using elbow flexor strength data. *Phys Ther.* 1997;77:745-750.
41. Stratford PW, Kennedy D, Pagura SM, Gollish JD. The relationship between self-report and performance-related measures: questioning the content validity of timed tests. *Arthritis Rheum.* 2003;49:535-540. http://dx.doi.org/10.1002/art.11196
42. Stratford PW, Kennedy DM. Does parallel item content on WOMAC's pain and function subscales limit its ability to detect change in functional status? *BMC Musculoskelet Disord.* 2004;5:17. http://dx.doi.org/10.1186/1471-2474-5-17
43. Stratford PW, Kennedy DM. Performance measures were necessary to obtain a complete picture of osteoarthritic patients. *J Clin Epidemiol.* 2006;59:160-167. http://dx.doi.org/10.1016/j.jclinepi.2005.07.012
44. Stratford PW, Spadoni G. The reliability, consistency, and clinical application of a numeric pain rating scale. *Physiother Can.* 2001;53:88-91, 114.
45. Stratford PW, Spadoni GF. Sample size estimation for the comparison of competing measures' reliability coefficients. *Physiother Can.* 2003;55:225-229.
46. Streiner DL, Norman GR. *Health Measurement Scales. A Practical Guide to their Development and Use.* 3rd ed. Oxford, UK: Oxford University Press; 2003.
47. Thumboo J, Chew LH, Soh CH. Validation of the Western Ontario and McMaster University osteoarthritis index in Asians with osteoarthritis in Singapore. *Osteoarthritis Cartilage.* 2001;9:440-446. http://dx.doi.org/10.1053/joca.2000.0410

48. Uniform Data System for Medical Rehabilitation. About the FIM System. Available at: http://www.udsmr.org/WebModules/FIM/Fim_About.aspx. Accessed April 20, 2009, 2009.

49. Watson CJ, Propps M, Ratner J, Zeigler DL, Horton P, Smith SS. Reliability and responsiveness of the lower extremity functional scale and the anterior knee pain scale in patients with anterior knee pain. *J Orthop Sports Phys Ther.* 2005;35:136-146. http://dx.doi.org/10.2519/jospt.2005.1403

50. Weiner EA, Stewart BJ. *Assessing Individuals: Psychological and Educational Tests and Measurements.* Boston, MA: Little, Brown; 1984.

51. Witvrouw E, Victor J, Bellemans J, et al. A correlation study of objective functionality and WOMAC in total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.* 2002;10:347-351. http://dx.doi.org/10.1007/s00167-002-0302-2

52. World Health Organization. ICF Browser. Available at: http://www.who.int/classifcations/icfbrowser/. Accessed April 20, 2009, 2009.

53. World Health Organization. International Classification of Functioning, Disability, and Health. Geneva, Switzerland: 2001.

54. Yeung TS, Wessel J, Stratford PW, MacDermid JC. The timed up-and-go test for use on an inpatient orthopaedic rehabilitation ward. *J Orthop Sports Phys Ther.* 2008;38:410-417. http://dx.doi.org/10.519/jospt.2008.2657

APPENDIX

LOWER EXTREMITY FUNCTIONAL SCALE

We are interested in knowing whether you are having any difficulty at all with the activities listed below because of your lower limb problem for which you are currently seeking attention. Please provide an answer for each activity.

Today, do you or would you have any difficulty at all with:

Activities (circle 1 number on each line)	Extreme Difficulty or Unable to Perform Activity	Quite a Bit of Difficulty	Moderate Difficulty	A Little Bit of Difficulty	No Difficulty
A. Any of your usual work, housework or school activities	0	1	2	3	4
B. Your usual hobbies, recreational or sporting activities	0	1	2	3	4
C. Getting into or out of the bath	0	1	2	3	4
D. Walking between rooms	0	1	2	3	4
E. Putting on your shoes or socks	0	1	2	3	4
F. Squatting	0	1	2	3	4
G. Lifting an object, like a bag of groceries from the floor	0	1	2	3	4
H. Performing light activities around your home	0	1	2	3	4
I. Performing heavy activities around your home	0	1	2	3	4
J. Getting into or out of a car	0	1	2	3	4
K. Walking 2 blocks	0	1	2	3	4
L. Walking a mile	0	1	2	3	4
M. Going up or down 10 stairs (about 1 flight of stairs)	0	1	2	3	4
N. Standing for 1 hour	0	1	2	3	4
O. Sitting for 1 hour	0	1	2	3	4
P. Running on even ground	0	1	2	3	4
Q. Running on uneven ground	0	1	2	3	4
R. Making sharp turns while running fast	0	1	2	3	4
S. Hopping	0	1	2	3	4
T. Rolling over in bed	0	1	2	3	4
Column totals:					

Error (single measure): ±6 scale points; MDC, 9 scale points; MCID, 9 scale points.
Score: _____/80

This article has been cited by:

1. L.E. Kanko, T.B. Birmingham, D.M. Bryant, K. Gillanders, K. Lemmon, R. Chan, M. Postic, J.R. Giffin. 2019. The star excursion balance test is a reliable and valid outcome measure for patients with knee osteoarthritis. *Osteoarthritis and Cartilage* **27**:4, 580-585. [Crossref]
2. Andrea J Ikeda, John R Fergason, Jason M Wilken. 2019. Clinical Outcomes with the Intrepid Dynamic Exoskeletal Orthosis: A Retrospective Analysis. *Military Medicine* **21**. . [Crossref]
3. Shaw Bronner, Evie Chodock, Igor Edwardo Reis Urbano, Teresa Smith. 2019. Psychometric Properties of the Dance Functional Outcome Survey (DFOS): Reliability, Validity, and Responsiveness. *Journal of Orthopaedic & Sports Physical Therapy* **49**:2, 64-79. [Abstract] [Full Text] [PDF] [PDF Plus]
4. Yi-Shiung Horng, Wen-Hsuan Hou, Huey-Wen Liang. 2019. Responsiveness of the modified lower extremity functional scale in patients with low back pain and sciatica. *Medicine* **98**:14, e15105. [Crossref]
5. Paul Stratford, Deborah Kennedy, Hance Clarke. 2018. Confounding pain and function: the WOMAC's failure to accurately predict lower extremity function. *Arthroplasty Today* **4**:4, 488-492. [Crossref]
6. Mohamed M. Abu Elyazed, Shaimaa F. Mostafa. 2018. A randomized trial of ultrasound-guided adductor canal block versus fascia iliaca compartment block for postoperative analgesia after arthroscopic knee surgery. *Egyptian Journal of Anaesthesia* . [Crossref]
7. Kathryn Dailey, Michael McMorris, Michael T. Gross. 2018. Tibiofemoral joint mobilizations following total knee arthroplasty and manipulation under anesthesia. *Physiotherapy Theory and Practice* **79**, 1-8. [Crossref]
8. Jussi P. Repo, Erkki J. Tukiainen, Risto P. Roine, Mika Sampo, Henrik Sandelin, Arja H. Häkkinen. 2018. Rasch analysis of the Lower Extremity Functional Scale for foot and ankle patients. *Disability and Rehabilitation* **79**, 1-7. [Crossref]
9. Isaäc Bos, Klaske Wynia, Gea Drost, Josué Almansa, Jan B. M. Kuks. 2018. The extremity function index (EFI), a disability severity measure for neuromuscular diseases: psychometric evaluation. *Disability and Rehabilitation* **40**:13, 1561-1568. [Crossref]
10. Rich Maas, Scott Wallentine, Dale Gerke, Sam Crager, Jessica Stewart. 2017. Posterior hip instability relocation testing: a resident's case report. *Journal of Manual & Manipulative Therapy* **41**, 1-6. [Crossref]
11. Sue D. Barber-Westin, Frank R. Noyes. Rating of Athletic and Daily Functional Activities 1211-1221. [Crossref]
12. Seung Suk Seo, Ok Gul Kim, Jin Hyeok Seo, Do Hoon Kim, Youn Gu Kim, Beyoung Yun Park. 2017. Comparison of the Effect of Continuous Femoral Nerve Block and Adductor Canal Block after Primary Total Knee Arthroplasty. *Clinics in Orthopedic Surgery* **9**:3, 303. [Crossref]
13. Miguel A. Fernandez, Alexander L. Aquilina, Matthew L. Costa. 2016. Outcome score measurement and clinical trials for hip fracture patients. *Orthopaedics and Trauma* **30**:2, 159-163. [Crossref]
14. Saurabh P. Mehta, Allison Fulton, Cedric Quach, Megan Thistle, Cesar Toledo, Neil A. Evans. 2016. Measurement Properties of the Lower Extremity Functional Scale: A Systematic Review. *Journal of Orthopaedic & Sports Physical Therapy* **46**:3, 200-216. [Abstract] [Full Text] [PDF] [PDF Plus]
15. Stephanie R. Albin, Mark W. Cornwall, Thomas G. McPoil, Drew H. Van Boerum, James M. Morgan. 2015. Plantar Pressure and Gait Symmetry in Individuals with Fractures versus Tendon Injuries to the Hindfoot. *Journal of the American Podiatric Medical Association* **105**:6, 469-477. [Crossref]
16. Masafumi Terada, Abbey C. Thomas, Brian Pietrosimone, Claire E. Hiller, Samantha Bowker, Phillip A. Gribble. 2015. The Consequence of a Medial Ankle Sprain on Physical and Self-reported Functional Limitations: A Case Study Over a 5-Month Period. *Journal of Orthopaedic & Sports Physical Therapy* **45**:10, 756-764. [Abstract] [Full Text] [PDF] [PDF Plus]
17. Nilen A. Shah, Nimesh P. Jain, Karnav A. Panchal. 2015. Adductor Canal Blockade Following Total Knee Arthroplasty—Continuous or Single Shot Technique? Role in Postoperative Analgesia, Ambulation Ability and Early Functional Recovery: A Randomized Controlled Trial. *The Journal of Arthroplasty* **30**:8, 1476-1481. [Crossref]
18. Lee N. Marinko, Renee E. Christie, Cara L. Lewis. 2015. Successful Rehabilitation of a Young Adult With Total Hip Arthroplasty a Decade After a Girdlestone Procedure: A Case Presentation. *PM&R* **7**:8, 895-900. [Crossref]
19. AF Adeniyi, OS Aiyegbusi, OO Ogwumike, PO Adejumo, AA Fasanmade. 2015. Habitual physical activity, peripheral neuropathy, foot deformities and lower limb function: characterising prevalence and interlinks in patients with type 2 diabetes mellitus. *Journal of Endocrinology, Metabolism and Diabetes of South Africa* **20**:2, 101-107. [Crossref]
20. Andrew P. Hawkins, Jonathan C. Sum, Daniel Kirages, Erica Sigman, Soma Sahai-Srivastava. 2015. Pelvic Osteomyelitis Presenting as Groin and Medial Thigh Pain: A Resident's Case Problem. *Journal of Orthopaedic & Sports Physical Therapy* **45**:4, 306-315. [Abstract] [Full Text] [PDF] [PDF Plus]

21. M. Gabrielle Pagé, Joel Katz, E. Manolo Romero Escobar, Noga Lutzky-Cohen, Kathryn Curtis, Samantha Fuss, Hance A. Clarke. 2015. Distinguishing problematic from nonproblematic postsurgical pain. *PAIN* **156**:3, 460-468. [Crossref]
22. Pia Jæger, Zbigniew J. Koscielniak-Nielsen, Karen Lisa Hilsted, Maria Louise Fabritius, Jørgen B. Dahl. 2015. Adductor Canal Block With 10 mL Versus 30 mL Local Anesthetics and Quadriceps Strength. *Regional Anesthesia and Pain Medicine* **40**:5, 553-558. [Crossref]
23. Noah G. Oliver, John S. Steinberg, Kelly Powers, Karen K. Evans, Paul J. Kim, Christopher E. Attinger. 2015. Lower Extremity Function following Partial Calcanectomy in High-Risk Limb Salvage Patients. *Journal of Diabetes Research* **2015**, 1-7. [Crossref]
24. Nilen A. Shah, Nimesh P. Jain. 2014. Is Continuous Adductor Canal Block Better Than Continuous Femoral Nerve Block After Total Knee Arthroplasty? Effect on Ambulation Ability, Early Functional Recovery and Pain Control: A Randomized Controlled Trial. *The Journal of Arthroplasty* **29**:11, 2224-2229. [Crossref]
25. Shin-Liang Pan, Huey-Wen Liang, Wen-Hsuan Hou, Tian-Shin Yeh. 2014. Responsiveness of SF-36 and Lower Extremity Functional Scale for assessing outcomes in traumatic injuries of lower extremities. *Injury* **45**:11, 1759-1763. [Crossref]
26. Christopher J. Hoekstra, David A. Deppeler, Richard A. Rutt. 2014. Criterion validity, reliability and clinical responsiveness of the CareConnections Functional Index. *Physiotherapy Theory and Practice* **30**:6, 429-437. [Crossref]
27. Wen-Hsuan Hou, Tian-Shin Yeh, Huey-Wen Liang. 2014. Reliability and validity of the Taiwan Chinese version of the Lower Extremity Functional Scale. *Journal of the Formosan Medical Association* **113**:5, 313-320. [Crossref]
28. D.K. Tumusiime, A. Stewart, F.W.D. Venter, E. Musenge. 2014. The reliability of the modified lower extremity functional scale among adults living with HIV on antiretroviral therapy, in Rwanda, Africa. *SAHARA-J: Journal of Social Aspects of HIV/AIDS* **11**:1, 178-186. [Crossref]
29. Hossein Negahban, Masumeh Hessam, Saeid Tabatabaei, Reza Salehi, Soheil Mansour Sohani, Mohammad Mehravar. 2014. Reliability and validity of the Persian lower extremity functional scale (LEFS) in a heterogeneous sample of outpatients with lower limb musculoskeletal disorders. *Disability and Rehabilitation* **36**:1, 10-15. [Crossref]
30. Colleen Cupido, Devin Peterson, Melanie Stevens Sutherland, Olufemi Ayeni, Paul W. Stratford. 2014. Tracking Patient Outcomes after Anterior Cruciate Ligament Reconstruction. *Physiotherapy Canada* **66**:2, 199-205. [Crossref]
31. Joseph L. Verheijde, Fred White, James Tompkins, Peder Dahl, Joseph G. Hentz, Michael T. Lebec, Mark Cornwall. 2013. Reliability, Validity, and Sensitivity to Change of the Lower Extremity Functional Scale in Individuals Affected by Stroke. *PM&R* **5**:12, 1019-1025. [Crossref]
32. Huey-Wen Liang, Wen-Hsuan Hou, Kai-Shiang Chang. 2013. Application of the Modified Lower Extremity Functional Scale in Low Back Pain. *Spine* **38**:23, 2043-2048. [Crossref]
33. S. Stasi, G. Papathanasiou, N. Korres, G. Marinakis, E. Chronopoulos, P.I. Baltopoulos, N.A. Papaioannou. 2013. Validation of the Lower Extremity Functional Scale in community-dwelling elderly people (LEFS-Greek); determination of functional status cut-off points using TUG test. *European Geriatric Medicine* . [Crossref]
34. Eric J. Hegedus, Ben Stern, Michael P. Reiman, Dan Tarara, Alexis A. Wright. 2013. A suggested model for physical examination and conservative treatment of athletic pubalgia. *Physical Therapy in Sport* **14**:1, 3-16. [Crossref]
35. Pia Jæger, Zbigniew J.K. Nielsen, Maria H. Henningsen, Karen Lisa Hilsted, Ole Mathiesen, Jørgen B. Dahl. 2013. Adductor Canal Block versus Femoral Nerve Block and Quadriceps Strength. *Anesthesiology* **118**:2, 409-415. [Crossref]
36. Pia Jæger, Dusanka Zaric, Jonna S. Fomsgaard, Karen Lisa Hilsted, Jens Bjerregaard, Jens Gyrn, Ole Mathiesen, Tommy K. Larsen, Jørgen B. Dahl. 2013. Adductor Canal Block Versus Femoral Nerve Block for Analgesia After Total Knee Arthroplasty. *Regional Anesthesia and Pain Medicine* **38**:6, 526-532. [Crossref]
37. Scott Cheatham. 2013. Management of Hip Pain in a 25-Year-Old Female Runner. *International Journal of Athletic Therapy and Training* **18**:1, 15-20. [Crossref]
38. Steven M McPhail, Joel Dunstan, Julie Canning, Terry P Haines. 2012. Life impact of ankle fractures: Qualitative analysis of patient and clinician experiences. *BMC Musculoskeletal Disorders* **13**:1. . [Crossref]
39. Leonardo Metsavaht, Gustavo Leporace, Marcelo Riberto, Maria Matilde M. Sposito, Letícia N.C. del Castillo, Liszt P. Oliveira, Luiz Alberto Batista. 2012. Translation and Cross-cultural Adaptation of the Lower Extremity Functional Scale Into a Brazilian Portuguese Version and Validation on Patients With Knee Injuries. *Journal of Orthopaedic & Sports Physical Therapy* **42**:11, 932-939. [Abstract] [Full Text] [PDF] [PDF Plus]
40. Emily J. Slaven. 2012. Prediction of Functional Outcome at Six Months Following Total Hip Arthroplasty. *Physical Therapy* **92**:11, 1386-1394. [Crossref]

41. Valerie J. Williams, Sara R. Piva, James J. Irrgang, Chad Crossley, G. Kelley Fitzgerald. 2012. Comparison of Reliability and Responsiveness of Patient-Reported Clinical Outcome Measures in Knee Osteoarthritis Rehabilitation. *Journal of Orthopaedic & Sports Physical Therapy* **42**:8, 716-723. [Abstract] [Full Text] [PDF] [PDF Plus]
42. Greg K. Alcock, Melanie S. Werstine, Shawn M. Robbins, Paul W. Stratford. 2012. Longitudinal Changes in the Lower Extremity Functional Scale After Anterior Cruciate Ligament Reconstructive Surgery. *Clinical Journal of Sport Medicine* **22**:3, 234-239. [Crossref]
43. Erik A. Wikstrom. 2012. Validity and Reliability of Nintendo Wii Fit Balance Scores. *Journal of Athletic Training* **47**:3, 306-313. [Crossref]
44. Florent Lebon, Aymeric Guillot, Christian Collet. 2012. Increased Muscle Activation Following Motor Imagery During the Rehabilitation of the Anterior Cruciate Ligament. *Applied Psychophysiology and Biofeedback* **37**:1, 45-51. [Crossref]
45. A. Williams Andrews. 2012. Self-report Measures of Mobility. *Topics in Geriatric Rehabilitation* **28**:1, 2-10. [Crossref]
46. Lynn Hutchings, Rebecca Fox, Tim Chesser. 2011. Proximal femoral fractures in the elderly: How are we measuring outcome?. *Injury* **42**:11, 1205-1213. [Crossref]
47. Ying-Chih Wang, Dennis L. Hart, Paul W. Stratford, Jerome E. Mioduski. 2011. Baseline Dependency of Minimal Clinically Important Improvement. *Physical Therapy* **91**:5, 675-688. [Crossref]
48. Christopher E. Gibbons, Brian G. Pietrosimone, Joseph M. Hart, Susan A. Saliba, Christopher D. Ingersoll. 2010. Transcranial Magnetic Stimulation and Volitional Quadriceps Activation. *Journal of Athletic Training* **45**:6, 570-579. [Crossref]
49. Paul W. Stratford, Deborah M. Kennedy, Monica R. Maly, Norma J. MacIntyre. 2010. Quantifying Self-Report Measures' Overestimation of Mobility Scores Postarthroplasty. *Physical Therapy* **90**:9, 1288-1296. [Crossref]
50. Trevor A. Lentz, Zach Sutton, Scott Greenberg, Mark D. Bishop. 2010. Pain-Related Fear Contributes to Self-Reported Disability in Patients With Foot and Ankle Pathology. *Archives of Physical Medicine and Rehabilitation* **91**:4, 557-561. [Crossref]