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|  | **FOTO** **Hip,Knee,& Foot/Ankle CAT scales** | **Lower Extremity Functional Scale (LEFS)\*** |
| **Background**The Hip CAT, Knee CAT, and Foot/Ankle CAT measures were developed using items from the LEFS. There are three major differences between the original LEFS and the Hip CAT, Knee CAT, and Foot/Ankle CAT measures. First, the original LEFS is consisted of 20 items, while the CAT measures use 18 items. Of the original 20 LEFS items, 2 items (sitting for 1 hour, rolling over in bed) were removed to improve unidimensionality and model fit. Second, the original LEFS is administered through paper & pencil survey, while the CAT measures are administered using the computer adaptive testing to reduce administrative burden (70% more efficient than using all LEFS items) while the measurement precision is maintained. Third, the scoring scale of the original LEFS ranges from 0 to 80, while the scores on all CAT measures are converted to a 0-100 scale with higher score representing higher functioning to assist in score interpretability.The LEFS can be used to evaluate the impairment of a patient with lower extremity musculoskeletal condition or disorders.Development, simulation, and use of the Hip CAT, [1](#_ENREF_1), [2](#_ENREF_2) Knee CAT,[2-7](#_ENREF_2) and Foot/Ankle CAT[2](#_ENREF_2), [8](#_ENREF_8), [9](#_ENREF_9) have been described. The LEFS items demonstrated differential item functioning (DIF) by body part affected of the lower extremity (hip, knee or foot/ankle), i.e., item difficulty parameter estimates varied across different body part impairment groups after controlling for the patient’s underlying ability. Therefore, the LEFS CAT was developed with items calibrated using data for each impaired body part, which makes the Hip CAT, Knee CAT, and Foot/Ankle CAT body part specific or condition specific CAT measures.  |
| 1. Mode of Data Collection |  |  |
| a. computer vs. paper and pencil | Computer adaptive testing | Paper and pencil survey |
| b. patient and clinician burden |  |  |
| i. number of survey items | On average only 7 items[1](#_ENREF_1), [4](#_ENREF_4), [9](#_ENREF_9) of the 18 question item bank are required | All 20 questions must be answered |
| ii. Burden: time to complete and score surveys | Average less than 2 minutes | Average 5-6 minutes |
| iii. scoring surveys | Scoring scale 0-100Item response options 1-5 | Scoring scale 0-80Item response options 0-4 |
| 2. Data Interpretability |  |  |
| a. risk adjusted vs raw data | Risk adjusted data allow meaningful interpretation of scores between patients/providers | Raw data unable to meaningfully interpret scores between patients/providers |
| b. Functional staging vs. empirical categories created by authors | Provide (a) percentile rank of an FS score, (b) statistically reliable change, (c) minimal detectable change (MDC), (d) clinical important change (MCII), and (e) functional staging classification system to assist in clinical interpretation. [3](#_ENREF_3), [8](#_ENREF_8), [10](#_ENREF_10)  | Provide only (a) MDC and (b) MCII to assist in clinical interpretation. |
| 3. Measure Psychometrics |  |  |
| 0. Sample size in the literature | n = 1,772[2](#_ENREF_2) to 28,320[5](#_ENREF_5) | n = 25[11](#_ENREF_11) to 306[12](#_ENREF_12) |
| a. Reliability |  |  |
| Test-retest Reliability | - | Excellent test-retest reliability: r =0.85-0.94; ICC=0.88-0.96 [11](#_ENREF_11), [13-18](#_ENREF_13) |
| Interrater/Intrarater Reliability | - | Excellent inter-rater reliability: ICC=0.84-0.90 [11](#_ENREF_11), [13](#_ENREF_13), [15](#_ENREF_15), [16](#_ENREF_16) |
| Internal Consistency | Excellent internal consistency: alpha=0.96 | Excellent internal consistency: alpha=0.90-0.94[12](#_ENREF_12), [15](#_ENREF_15) |
| SEM | SEM=2.86 points[9](#_ENREF_9)SEM=2.95 points[8](#_ENREF_8)SEM=2.99 points[3](#_ENREF_3) | SEM=3.4-5.3 points[11](#_ENREF_11), [13-16](#_ENREF_13), [18](#_ENREF_18), [19](#_ENREF_19) |
| b. Validity |  |  |
| Content Validity | Content validity was supported because LEFS items are commonly used in both clinical and research community in assessing  | - |
| Criterion Validity (Predictive/Concurrent) | - | Criterion validity was supported.[12](#_ENREF_12), [20](#_ENREF_20), [21](#_ENREF_21)

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| Pearson r | LEFS |
| Activity Scale for Arthroplasty Patients | 0.77 |
| Olerud Mo- lander Ankle Score | 0.80 |
| SF-36 | 0.71 |
| Berg Balance Scale | 0.59 |
| 6-MWT | 0.69 |
| 5-MWT | 0.40 |
| Timed Up and Go Test | -0.54 |
| Linear Analog Scale | 0.60 |

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| Construct Validity (Convergent/Discriminant) | Construct validity was supported. * Based on factor analysis, the scale is unidimensional.
* Known group construct validity was supported for patients (a)who were older, (b) patients who had more chronic symptoms, (c) had more surgeries, (d) had more medical comorbidities, and (e) did not exercise prior to receiving rehabilitation. Above patient characteristics were associated withworse FS outcomes at discharge.[9](#_ENREF_9), [21](#_ENREF_21), [22](#_ENREF_22)
* A majority (i.e., 61%-69%) of patients with FS follow-up scores had statistically reliable change as estimated via MDC95.[9](#_ENREF_9), [14](#_ENREF_14)
 | Construct validity was supported. * All items of the LEFS had a positive correlation with the overall scale, ranging from 0.21 to 0.86.
* Item hierarchy is clinical logical in a Rasch analysis study conducted by Christine et al. 2009.
* Known-group validity was supported only between patients with and without surgery at initial assessment.
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| c. Responsiveness |  |  |
| i. MDC95 |

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| FS Range | Hip | Knee | Foot/ankle |
| 0-10 | 32.5 | 29.1 | 21.9 |
| 11-20 | 21.3 | 14.3 | 12.9 |
| 21-30 | 9.9 | 9.1 | 8.1 |
| 31-40 | 6.8 | 6.7 | 7.0 |
| 41-50 | 6.1 | 6.1 | 6.2 |
| 51-60 | 6.7 | 6.5 | 6.6 |
| 61-70 | 8.5 | 8.1 | 7.7 |
| 71-80 | 12.3 | 10.9 | 11.1 |
| 81-90 | 20.3 | 17.1 | 13.8 |
| 91-100 | 42.3 | 29.7 | 40.3 |

 | MDC=8.7 to 9 points [11](#_ENREF_11), [13-16](#_ENREF_13), [18](#_ENREF_18)Guyatt response ratio=1.99 |
| ii. MCID/MCII | To improve clinical precision, MCII values were calculated and reported by quartiles of FS range at intake.

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| Hip CAT |
| Intake FS | MCII |
| 0-40 | 11 |
| >40-48 | 6 |
| >48-59 | 4 |
| >59-100 | 2 |

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| Knee CAT |
| Intake FS | MCII |
| 0-34 | 13 |
| >34-45 | 9 |
| >45-54 | 6 |
| >54-100 | 4 |

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| Foot/Ankle CAT |
| Intake FS | MCII |
| 0-39 | 12 |
| >39-47 | 8 |
| >47-57 | 7 |
| >57-100 | 5 |

 | MCID = 9 points [11](#_ENREF_11), [13](#_ENREF_13), [15](#_ENREF_15), [16](#_ENREF_16), [18](#_ENREF_18) MCID is less precise for patients functioning at very high or very low FS levels. |
| iii. Effect Size | ES = 0.86 (Hip CAT)ES = 1.06 (Knee CAT)ES = 0.97 (Foot/Ankle CAT) | ES=1.92 (short-term 4 wk follow-up)[12](#_ENREF_12) |
| iv. Floor/Ceiling Effects | Negligible floor or ceiling effects in patients with hip, knee, and foot/ankle impairments seeking outpatient rehabilitation.[8](#_ENREF_8), [10](#_ENREF_10) | Negligible floor or ceiling effects in patients with ankle fracture, or lower-extremity musculoskeletal dysfunction..[13](#_ENREF_13) |
| d. Item Response Theory | * Previous results supported the LEFS CAT met essential item response theory (IRT) assumptions of item unidimensionality and local independence.
* Test information functions and standard errors supported FS measure precision.[19](#_ENREF_19)
* Item difficulty hierarchy is consistent with the previous literature[12](#_ENREF_12).
* Differential item functioning was negligible for acuity of symptoms, surgical history, prior exercise history, condition complexity,[9](#_ENREF_9) intake and discharge,[9](#_ENREF_9) and language (English or Hebrew). [5](#_ENREF_5)
 | * Difficulty of the items ranged from “sitting for 1 hour” (least difficult) to “making sharp turns while running fast” or “running on uneven ground” (most difficult). [12](#_ENREF_12)
* The mis-fitting occurred in the outfit statistics for all of the misfit items. “Sitting for 1 hour” was a misfit. [12](#_ENREF_12)
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| 4. Mode of Future Growth | New items can be added to improve measure precision for high (athletes) and low (wheelchair or home bound) level patients. | Fixed format.  |
| 5. Citations | See References section. | See References section. |

Abbreviations:

5-MWS=Five Meter Walk Test

6-MWT=Six Minute Walk Test

ASAP= Activity Scale for Arthroplasty Patients

BBS=Berg Balance Scale

FS = functional status (scores measured by FOTO measures)

LAS= Linear Analog Scale

MCII= Minimally Clinically Important Difference

MDC= Minimal Detectable Change

SEM=Standard Error of Measurement

TUG=Timed Up and Go Test

\* Part of the information was obtained from the Rehabilitation Measures Database (http://www.rehabmeasures.org/)**References**

1. **FOTO Hip, Knee, & Foot/Ankle CAT Scales**
* [1](#_ENREF_1)Hart DL, Wang YC, Stratford PW, Mioduski JE. A computerized adaptive test for patients with hip impairments produced valid and responsive measures of function. Arch Phys Med Rehabil. 2008;89(11):2129-39.
* [2](#_ENREF_2)Hart DL, Mioduski JE, Stratford PW. Simulated computerized adaptive tests for measuring functional status were efficient with good discriminant validity in patients with hip, knee, or foot/ankle impairments. J Clin Epidemiol. 2005 Jun;58(6):629-38. PubMed PMID: 15878477.
* [3](#_ENREF_3)Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of computerized adaptive test-generated outcome measures in patients with knee impairments. Arch Phys Med Rehabil. 2009 Aug;90(8):1340-8. PubMed PMID: 19651268.
* [4](#_ENREF_4)Hart DL, Wang YC, Stratford PW, Mioduski JE. Computerized adaptive test for patients with knee impairments produced valid and responsive measures of function. J Clin Epidemiol. 2008;61:1113-24.
* [5](#_ENREF_5)Hart DL, Deutscher D, Crane PK, Wang YC. Differential item functioning was negligible in an adaptive test of functional status for patients with knee impairments who spoke English or Hebrew. Qual Life Res. 2009;18(8):1067-83.
* [6](#_ENREF_6)Deutscher D, Hart DL, Stratford PW, Dickstein R. Construct validation of a knee-specific functional status measure: a comparative study between the United States and Israel. Phys Ther. 2011;91(7):1072-84.
* [7](#_ENREF_7)Deutscher D, Hart DL, Crane PK, Dickstein R. Cross-cultural differences in knee functional status outcomes in a polyglot society represented true disparities not biased by differential item functioning. Phys Ther. 2010 Dec;90(12):1730-42. PubMed PMID: 20947673.
* [8](#_ENREF_8)Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of computerized adaptive test generated outcomes measures in patients with foot/ankle impairments. J Orthop Sport Phys 2009;39(10):753-64.
* [9](#_ENREF_9)Hart DL, Wang YC, Stratford PW, Mioduski JE. Computerized adaptive test for patients with foot or ankle impairments produced valid and responsive measures of function. Qual Life Res. 2008;17:1081-91.
* [10](#_ENREF_10)Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of a lower-extremity functional scale-derived computerized adaptive test. Phys Ther. 2009 Sep;89(9):957-68. PubMed PMID: 19628577.

B. **FOTO Hip, Knee, & Foot/Ankle CAT Scales: Additional References**

1. Hart DL, Wang YC, Stratford PW, Mioduski JE. A computerized adaptive test for patients with hip impairments produced valid and responsive measures of function. Arch Phys Med Rehabil. 2008;89(11):2129-39.

2. Hart DL, Mioduski JE, Stratford PW. Simulated computerized adaptive tests for measuring functional status were efficient with good discriminant validity in patients with hip, knee, or foot/ankle impairments. J Clin Epidemiol. 2005 Jun;58(6):629-38. PubMed PMID: 15878477.

3. Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of computerized adaptive test-generated outcome measures in patients with knee impairments. Arch Phys Med Rehabil. 2009 Aug;90(8):1340-8. PubMed PMID: 19651268.

4. Hart DL, Wang YC, Stratford PW, Mioduski JE. Computerized adaptive test for patients with knee impairments produced valid and responsive measures of function. J Clin Epidemiol. 2008;61:1113-24.

5. Hart DL, Deutscher D, Crane PK, Wang YC. Differential item functioning was negligible in an adaptive test of functional status for patients with knee impairments who spoke English or Hebrew. Qual Life Res. 2009;18(8):1067-83.

6. Deutscher D, Hart DL, Stratford PW, Dickstein R. Construct validation of a knee-specific functional status measure: a comparative study between the United States and Israel. Phys Ther. 2011;91(7):1072-84.

7. Deutscher D, Hart DL, Crane PK, Dickstein R. Cross-cultural differences in knee functional status outcomes in a polyglot society represented true disparities not biased by differential item functioning. Phys Ther. 2010 Dec;90(12):1730-42. PubMed PMID: 20947673.

8. Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of computerized adaptive test generated outcomes measures in patients with foot/ankle impairments. J Orthop Sport Phys 2009;39(10):753-64.

9. Hart DL, Wang YC, Stratford PW, Mioduski JE. Computerized adaptive test for patients with foot or ankle impairments produced valid and responsive measures of function. Qual Life Res. 2008;17:1081-91.

10. Wang YC, Hart DL, Stratford PW, Mioduski JE. Clinical interpretation of a lower-extremity functional scale-derived computerized adaptive test. Phys Ther. 2009 Sep;89(9):957-68. PubMed PMID: 19628577.

11. Alcock GK, Werstine MS, Robbins SM, Stratford PW. Longitudinal changes in the lower extremity functional scale after anterior cruciate ligament reconstructive surgery. Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine. 2012 May;22(3):234-9. PubMed PMID: 22450593.

12. Lin CW, Moseley AM, Refshauge KM, Bundy AC. The lower extremity functional scale has good clinimetric properties in people with ankle fracture. Phys Ther. 2009 Jun;89(6):580-8. PubMed PMID: 19423644.

13. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. Phys Ther. 1999;79(4):371-83.

14. Kennedy DM, Stratford PW, Riddle DL, Hanna SE, Gollish JD. Assessing recovery and establishing prognosis following total knee arthroplasty. Phys Ther. 2008 Jan;88(1):22-32. PubMed PMID: 17986495.

15. Pua YH, Cowan SM, Wrigley TV, Bennell KL. The Lower Extremity Functional Scale could be an alternative to the Western Ontario and McMaster Universities Osteoarthritis Index physical function scale. J Clin Epidemiol. 2009 62(10):1103-11.

16. Stratford PW, Kennedy DM, Maly MR, Macintyre NJ. Quantifying self-report measures' overestimation of mobility scores postarthroplasty. Phys Ther. 2010;90(9):1288-96.

17. 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(4):535-40.

18. Stratford PW, Kennedy DM, Riddle DL. New study design evaluated the validity of measures to assess change after hip or knee arthroplasty. J Clin Epidemiol. 2009 Mar;62(3):347-52. PubMed PMID: 18834709.

19. Yeung TS, Wessel J, Stratford P, Macdermid J. Reliability, validity, and responsiveness of the lower extremity functional scale for inpatients of an orthopaedic rehabilitation ward. J Orthop Sports Phys Ther. 2009;39(6):468-77.

20. Domzalski T, Cook C, Attarian DE, Kelley SS, Bolognesi MP, Vail TP. Activity scale for arthroplasty patients after total hip arthroplasty. The Journal of arthroplasty. 2010 Jan;25(1):152-7. PubMed PMID: 19106027.

21. Verheijde JL, White F, Tompkins J, Dahl P, Hentz JG, Lebec MT, et al. Reliability, validity, and sensitivity to change of the lower extremity functional scale in individuals affected by stroke. PM R. 2013 Dec;5(12):1019-25. PubMed PMID: 23876934.

22. Stratford PW, Kennedy DM, Hannaa SE. Condition-specific Western Ontario McMaster Osteoarthritis Index was not superior to region-specific Lower Extremity Functional Scale at detecting change. J Clin Epidemiol. 2004;57:1025-32.

**C. Lower Extremity Functional Scale (LEFS)**

* [11](#_ENREF_11)Alcock, G. K., Werstine, M. S., et al. (2012). "Longitudinal changes in the lower extremity functional scale after anterior cruciate ligament reconstructive surgery." Clin J Sport Med 22(3): 234-239.
* [12](#_ENREF_12)Lin, C. W., Moseley, A. M., et al. (2009). "The lower extremity functional scale has good clinimetric properties in people with ankle fracture." Phys Ther 89(6): 580-588.
* [13](#_ENREF_13)Binkley, J. M., Stratford, P. W., et al. (1999). "The Lower Extremity Functional Scale (LEFS): scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network." Phys Ther 79(4): 371-383.
* [14](#_ENREF_14)Kennedy, D. M., Stratford, P. W., et al. (2008). "Assessing recovery and establishing prognosis following total knee arthroplasty." Phys Ther 88(1): 22-32.
* [15](#_ENREF_15)Pua, Y. H., Cowan, S. M., et al. (2009). "The Lower Extremity Functional Scale could be an alternative to the Western Ontario and McMaster Universities Osteoarthritis Index physical function scale." J Clin Epidemiol 62(10): 1103-1111.
* [16](#_ENREF_16)Stratford, P. W., Kennedy, D. M., et al. (2010). "Quantifying self-report measures' overestimation of mobility scores postarthroplasty." Phys Ther 90(9): 1288-1296.
* [17](#_ENREF_17)Stratford, P. W., Kennedy, D., et al. (2003). "The relationship between self-report and performance-related measures: questioning the content validity of timed tests." Arthritis Rheum 49(4): 535-540.
* [19](#_ENREF_19)Yeung, T. S., Wessel, J., et al. (2009). "Reliability, validity, and responsiveness of the lower extremity functional scale for inpatients of an orthopaedic rehabilitation ward." J Orthop Sports Phys Ther 39(6): 468-477.
* [20](#_ENREF_20)Domzalski, T., Cook, C., et al. (2010). "Activity scale for arthroplasty patients after total hip arthroplasty." J Arthroplasty 25(1): 152-157.
* [21](#_ENREF_21)Verheijde, J. L., White, F., et al. (2013). "Reliability, Validity, and Sensitivity to Change of the Lower Extremity Functional Scale in Individuals Affected by Stroke." PM R 5(12):1019-25.
* [22](#_ENREF_22)Stratford, P. W., Kennedy, D. M., et al. (2004). "Condition-specific Western Ontario McMaster Osteoarthritis Index was not superior to region-specific Lower Extremity Functional Scale at detecting change." J Clin Epidemiol 57(10): 1025-1032.