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To cite this article: Luke Funk, Danielle Thiessen, Virginia Wright, Jan Andrysek & Karen Rispin (2016): Reliability and validity of the Lower Limb Function Questionnaire when completed by young adult orthotic and prosthetic device users, Disability and Rehabilitation: Assistive Technology

To link to this article: http://dx.doi.org/10.3109/17483107.2015.1129458

Published online: 17 Feb 2016.
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ABSTRACT

Purpose: The Lower Limb Function Questionnaire (LLFQ) was developed as a self-report assessment of lower-limb functional ability for orthotic and prosthetic (O&P) device users to be suitable for a wide range of conditions, cultures, and ages. The measure aims to address an existing gap in tools for the assessment of functional ability in this population. The purpose of this study is to evaluate LLFQ reliability and validity in a sample of young adult O&P users.

Methods: Adolescents from a secondary school in Kenya completed the LLFQ twice, 6 d apart, and test–retest reliability was assessed using intra-class correlation coefficients. Validity evaluations involved Timed Up-and-Go, 6-min walk, 6-min obstacle course, and/or spatiotemporal gait assessments. Oxygen consumption was measured during walk tests. Associations between the LLFQ and each measure were evaluated using Pearson correlation coefficients for construct validity.

Results: LLFQ reliability was acceptable (ICC = 0.79, 95% CIs 0.64–0.89). Construct validity was demonstrated via moderate correlation (r ≈ 0.60) with obstacle course distance, gait velocity, stride length, and stance/single support/double support percent of gait cycle. Conclusions: Both LLFQ reliability and validity were acceptable in the sample of youth in Kenya. Further testing is required to determine applicability in other cultural contexts.

IMPLICATIONS FOR REHABILITATION

• The LLFQ may be clinically useful across a variety of cultures and conditions to provide feedback on the effectiveness of rehabilitative treatment or assistive devices for youth with lower limb impairments.
• The LLFQ may enable specific strengths and challenges to lower limb function to be identified to enable planning of well-targeted rehabilitation.

Introduction

Functional disabilities of various types and degrees are experienced by more than 600 million adults and up to 150 million children around the world.[1,2] For many of these individuals, assistive devices including orthoses and prostheses (O&P) are an important part of independent mobility and the rehabilitation process. The World Health Organization estimates that 25.5 million people are in need of O&P devices in the developing world alone.[3] Disabilities affecting the lower limbs are especially debilitating due to the negative impact on mobility and independence, overall health and well-being, and associated ability to participate in recreational, occupational, educational, and other developmental activities.[2,4,5] Those with disabilities also experience inequality in health-care provision as standards of care vary greatly, especially in less-resourced settings.[2,4] Currently there is a push for evidence-based practice to help establish standards of care in all areas of rehabilitation including O&P provision.[6–12] Outcome measures are a key element of best practice as they allow researchers and clinicians to establish baseline information and quantitatively assess change and the associated effectiveness of an intervention.[10,13] An outcome measure that is able to effectively evaluate health needs in a variety of settings, especially in resource-limited environments, may improve health care by reducing inequalities and differences in rehabilitation standards.[14]

A comprehensive outcome measure of lower-limb function is especially needed for O&P users, including those in less-resourced settings as no gold standard assessment of gait-related functional ability presently...
exists. This measurement gap has been identified as a key reason that evidence of effectiveness related to O&P use is lacking in both adult and pediatric rehabilitation across a variety of cultural settings. Functional gait assessment tools currently used include observational performance and function measures such as the Timed Up-and-Go (TUG), the Six-Minute Walk Test (6MWT), and the Amputee Mobility Predictor (AMP). Patient-reported outcome (PRO) measures, such as those described later, offer time and content advantages over performance measures since they go beyond a restricted set of observable items and can measure a diverse set of related functional and health-related quality of life (HRQOL) outcomes.

The Prosthesis Evaluation Questionnaire (PEQ) is an 82-question, nine-subscale functional mobility and HRQOL PRO measure developed by Legro et al. for use with adult unilateral prosthesis users. Scores for each item are reported on a continuous visual analogue scale (VAS), with a final section for additional explanatory comments. Good to excellent intra-rater reliability has been reported for its subscales (intra-class correlation coefficients [ICCs] = 0.56–0.89), as well as moderate construct validity when evaluated alongside several other HRQOL scales (r = 0.49–0.61). However, the PEQ did not discriminate between above- and below-knee prosthesis users, and a PEQ literature review revealed that only two of the subscales measured significant differences in studies comparing prosthetic technologies. This lack of sensitivity may be linked to an observed ceiling effect. A conceptual drawback of the PEQ is that users have to recall activity and ability from the past four weeks, limiting its applicability with assessment of newly fitted devices or within short-term studies. Other challenges encountered with the PEQ include its length (82 items) and the associated completion time. This has led some investigators to streamline the measure by using modified mobility-focused subscales derived from the PEQ.

The Orthotics and Prosthetics Users’ Survey (OPUS) was designed to evaluate lower-extremity functional status, HRQOL, and device satisfaction related to O&P provision for both children and adults. It contains 64 questions divided across four instruments that employ 4- and 5-level ordinal response scales. A small comment section for respondents is included at the end. Test–retest reliability for a combined children and adult sample was reported as adequate for the HRQOL instrument (ICC = 0.85), while the lower-extremity function (ICC = 0.67) and device satisfaction (ICC = 0.50) instrument estimates were lower than desirable. An additional OPUS limitation is the inclusion of questions that do not pertain to some cultural environments, e.g. user’s ability on an escalator. The lack of its use in published studies may be related to both the length and reliability limitations.

The Prosthetic Profile of the Amputee (PPA) was developed for amputee adults as a PRO measure of factors relating to prosthetic use, including HRQOL and mobility. Its 44 items use nominal, ordinal, or ratio response scales. The Locomotor Capabilities Index (LCI) is an embedded component of the PPA containing 14 items that use a 4-level ordinal scale to rate ability on specific mobility tasks, e.g. going up and down stairs. The LCI has often been used independently from the PPA in order to shorten and simplify the tool. While the original LCI has shown low sensitivity in measuring improvement during amputee rehabilitation and discriminating between above- and below-knee prosthesis users, a modified version with five response levels demonstrated greater responsiveness to change. Like the PEQ, a ceiling effect may still limit the LCI’s sensitivity. In addition, the applicability of the PPA and LCI in younger O&P user populations as well as in resource-limited environments has not been assessed, and applicability in clinical settings may be limited due to the need for specialized training.

The Lower Extremity Functional Scale (LEFS) is a 20-item functional status PRO designed for use with a wide range of orthopedic lower-limb conditions and adult age groups. Each item presents a simple functional activity to be rated on a 5-level ordinal difficulty scale. LEFS test–retest reliability was reported with adult nonamputees (ICC = 0.86) and validated alongside the physical function subscale of the SF-36, a HRQOL PRO (r = 0.80). Similar to the OPUS, the LEFS includes items that would not be relevant in some cultures, e.g. getting in and out of a bath tub or car. In addition, the LEFS’s lack of validation and usage with amputees and O&P users limits its applicability.

The Lower Limb Function Questionnaire (LLFQ) was developed by members of our investigative team as an outcome measure of lower-limb functional ability for O&P device users that would address the aforementioned content, length, and psychometric limitations of existing measures. The overall goal was to promote universal applicability across cultures, ages (youth through adulthood), and conditions that result in lower-limb impairments, e.g. cerebral palsy, spina bifida, and trauma. An early prototype of the LLFQ, known as the LEGS Functional Parameters Questionnaire, was developed first, and preliminary construct validity and sensitivity were reported with adult transfemoral amputees. This early work resulted in several iterations of revision, such that the current version of the LLFQ contains 20 items that focus
on universal concerns for lower-limb function, e.g. comfort and pain, stability and balance, ability to walk long distances, and complete simple tasks. Topics that would be specific to certain cultures, conditions, or ages were not included so as to provide a tool that can be used as a common metric across diverse O&P user groups. Items are worded to ask about current lower-limb function and related aspects of HRQOL and include both performance and nonperformance characteristics of function. The LLFQ can be accessed at http://www.letu.edu/LLFQ (Appendix A).

Each LLFQ item is scored using a VAS format with emoticons (pictorial representations of facial expressions) and item-specific descriptors as anchors at either end of a 100-mm VAS line (Figure 1). The underlying purpose of the VAS format is to provide an interval-based response scale, supporting the use of parametric statistical analysis, increasing sensitivity of the scale beyond what ordinal responses alone would allow, and potentially reducing the occurrence of a ceiling effect.[12] Responses are recorded as the measured distance in millimeters from the left end of the scale to the participant’s mark on the VAS line. The team hypothesized that adults and school children would have a strong understanding of school grades as a rating scale; therefore, school grades were placed as point markers under the VAS line to serve as a scoring response frame of reference. The respondents are instructed to mark anywhere they like on the VAS line to reflect their response choice, i.e. directly above or anywhere in between the indicated grades. Overall lower-limb function then is summarized via a single mean LLFQ score of all 20 VAS items, while identification of specific strengths and challenges is based on individual item scores. LLFQ items also ask for qualitative comments concerning each aspect of function, which are essential for understanding and explaining quantitative ratings during clinical interpretation.[33]

As an important step in the development process for this new outcome measure, the purpose of this study was to report on the LLFQ’s psychometric properties in a resource-limited environment to test the LLFQ’s suitability in a setting of particular need.[3,5,14,34] The LLFQ was hypothesized to demonstrate excellent test–retest reliability (ICC ≥ 0.80, 95% CI ≥ 0.60) and at least moderate correlations with accepted measures of lower-limb function (r ≥ 0.60) in this study sample.

Methods

Participants

All students eligible for the study at a secondary boarding school in Kenya for youth (aged 13–20 years) with lower-limb impairments were invited to participate. A student was eligible if he/she: used an orthotic or prosthetic device; was identified by school personnel as a community ambulator; and had no known cardiovascular, pulmonary, or other condition that might cause gait-based testing to be unsafe. In addition, subjects must have demonstrated English proficiency by passing the Kenya Certificate of Primary Education exam to be eligible.[35] The study protocol was approved by the institutional review board of LeTourneau University, the ethics committee of our partner organization at the study site, and a letter of support was received from the Ministry of Medical Services of Kenya. Eligible students were identified by the school administration and a facilitating teacher who understood all aspects of the study. Students were invited to join each aspect of the study by group announcements in classrooms. All participants and guardians completed consent and assent forms, which each included all aspects of the study; participants were free to withdraw or opt out of the entire study or any aspect of the study at any point.

Reliability study design

The LLFQ was administered to all participants at the same time in a classroom setting during 20-min test–retest sessions. Each participant had their own paper copy of the LLFQ. After initial directions were read aloud, the questionnaire administrator read the questionnaire item by item. The administrator waited until all participants had completed each item on their individual...
questionnaire before proceeding to the following item; time was allowed for rereading the item as needed, marking responses on the VAS line, and providing any relevant comments. This group approach was taken to efficiently accommodate the large sample size and support the same retest interval across all participants. The questionnaire was completed similarly at the test-retest sessions, which were 6 d apart.

**Construct validity study design**

Construct validity evaluation was divided into two sub-studies of distinct measures to permit an efficient and feasible data collection process within the school day, i.e. it was considered to be too time intensive for each participant to complete all measures in one test session. The first sub-study consisted of the 6MWT [18,19] performed on a 35.1-meter course and a custom-designed 6-min-timed obstacle walking test performed on a 78.4-meter loop course. Participants for the first sub-study were invited from those identified by the facilitating teacher as strong enough to complete the obstacle course test without undue stress. The obstacle course tasks consisted of walking at a self-selected pace up and down five stair steps, up and down a low-incline ramp, and weaving between four chairs placed 0.5 meters apart (Figure 2). These tasks were chosen to reflect specific LLFQ items for construct validity analysis, e.g. climbing up and down stairs and walking in tight spaces. The 6MWT was also chosen to relate to those LLFQ items that refer to endurance, e.g. maximum time and distance of walking. In both tests, distance traveled in 6 min was measured using a surveyor’s wheel. Participants sat and rested between the two tests and rode in a wheelchair between testing locations to ensure they were rested at the start of each test.

In the last 4 min of both timed walk tests, average oxygen consumption rates were collected using FitMate Pro portable metabolic units from COSMED [36] and standardized by subject weight. Oxygen consumption is a measure of energy expenditure during exercise, relating to the LLFQ items concerning energy cost of walking, that has been used with a variety of subject groups, including prosthesis users.[37] Use of the last 4 min was an attempt to ensure participants had passed the anaerobic threshold. A researcher walked slightly behind each participant during both walk tests in order to carry the FitMate device. The researcher kept the participant’s self-selected pace and instructed them, before beginning the test, not to alter their pace due to the researcher’s presence.

The second sub-study consisted of the TUG test [17] and gait analysis using the GAITRite, a 14-foot-long instrumented gait analysis mat.[38] Participants from the reliability study who used assistive devices with protruding edges, including crutches and canes, were not included in this sub-study to avoid damage to the GAITRite mat. The TUG was completed once by each participant as a well-validated measure of a specific aspect of functional mobility, standing up and sitting down, that is also measured as an LLFQ item. The GAITRite measured participants’ velocity, stride length, cadence, and heel-to-heel base of support as well as stance, single support, and double-support phase percent of the gait cycle. These measures were chosen due to their relevance to functional ability and stability,[39–44] topics that relate to the LLFQ’s overall functional score as well as several specific stability and balance items. Participants walked across the GAITRite mat 15 times at a self-selected pace and chairs were placed at each end of the mat to enable subjects to rest at any time. Each spatiotemporal gait parameter was averaged across the 15 trials.

Both validity sub-studies were completed in the 6 d between the two administrations of the LLFQ. Because each test in the sub-studies could only be administered to one person at a time, these sub-studies were completed in an order of convenience, determined by eligible participant and researcher availability; a participant eligible for all sub-studies may have completed them in any order. Participant diet and footwear were deliberately not controlled, but were those required by normal everyday life at the boarding school, i.e. leather school uniform shoes, and were likely more reflective of the functional performance participants represented in their LLFQ responses.

**Data analysis**

Dot plots of all participants’ VAS scores for each item were created for the first LLFQ session to enable visual
The LLFQ has been developed to address a number of gaps pertaining to existing measures which can limit their universal applicability across cultures and patient groups. The findings of this study present initial evidence that supports the reliability and construct validity of the LLFQ when used with youth in Kenya. The test–retest reliability ICC estimate was very near the target of ICC > 0.80 and met the traditionally accepted minimum reliability threshold of 0.70. Additionally, the 95% lower CI was well above the target of 0.60. One potential reason for the slightly lower than anticipated LLFQ reliability was a tendency for accumulation of data near grade anchors (Figure 3), essentially making the LLFQ’s designed interval scale to function more like an ordinal scale (reduced sensitivity). This may have been caused by some participants misunderstanding the response format directions and limiting their response to the VAS regions directly above grade anchors.

LLFQ ICC values are comparable to test–retest results of similar self-report outcome measures, including the PEQ ambulation subscale (ICC = 0.81, 0.90),[22,26] two modified PEQ mobility subscales (ICC = 0.77, 0.85),[23,26] the LEFS (ICC = 0.86),[31] and the LCI (ICC = 0.80, 0.88).[23,28] While typical retest intervals are on the order of 1–4 weeks,[22,23,26,28] we felt that 6 d was acceptable for the LLFQ given the number of items present, leading to a low likelihood of participants remembering their responses.

LLFQ construct validity is supported by significant correlations with velocity, stride length, stance time, single support time, and double support time. The desired $r > 0.60$ correlation was reached for each of these variables, even though each functional test only encompassed at most a few individual items of the LLFQ. Stride length has been previously reported as a measure of functional walking ability [39] and exhibited the strongest correlation of any variable in this study. Velocity has also been shown to be an indicator of
mobility and lower-limb function [39–42] and similarly had a strong positive correlation with mean LLFQ scores. In addition, stance, single-, and double-support phase percentages of the gait cycle are interrelated variables that have been demonstrated as measures of stability in previous studies,[39,41,42] and each was strongly correlated with the LLFQ. Each of these correlations demonstrates the LLFQ’s ability to produce scores that are associated with accepted gait outcomes measuring similar constructs. However, while other studies found wider base of support to be indicative of poor stability,[41,42,44,47] no significant correlation with LLFQ scores in the present study was found. This may be due to the use of a self-selected pace during measurement, as lack of stability has been shown to be alternatively compensated for by reducing gait velocity.[48]

TUG test correlation with LLFQ scores came close to significance ($r = 0.45, p = 0.02$), but fell short in the presence of the Bonferroni correction. The TUG had the smallest number of participants ($n = 25$) due to one participant opting out, and is primarily used clinically with elderly adults [17] and may not have the same functional discrimination in younger populations.

Construct validity of the LLFQ was also supported by the functional walk tests. The obstacle course used a format similar to the 6MWT but presented specific walking challenges adapted from LLFQ items including moving around and between obstacles and going up and down stairs and ramps. This likely resulted in the observed stronger correlation with LLFQ scores, which encompass aspects of gait beyond the flat over-ground walking implemented in the 6MWT. However, oxygen consumption did not correlate significantly with LLFQ scores for either test. This may be due to the participants’ maintenance of consistent energy expenditure rather than of consistent speed. Gard [40] similarly reported a natural tendency for prosthesis users to adopt a slower walking speed as a strategy for reducing energy cost, and several other studies found distance travelled but not metabolic cost to correlate with functional gait levels during walk tests.[47,49]

Overall, the LLFQ addresses a number of important limitations of the current lower-limb outcome measures. The 20-item questionnaire has a simple format, allows respondents to provide comments on each aspect of function, and has a reasonable length, completed by all participants within a 20-min group session. Although completion time has not been reported, similar measures, such as the OPUS and PEQ, may have required a longer time period, containing 64 and 82 items respectively. The LCI has been used independently from the PPA, and the PEQ has been condensed into mobility subscales in order to shorten the full measures,[23,26,29,30] but this limits the understanding of lower-limb function: important HRQOL associated aspects, such as lower-limb pain, are absent and no qualitative aspects such as explanatory comments are considered. Qualitative comments are important for explaining and complementing quantitative scores, enabling greater clinical understanding of the respondent’s status.[33] A reasonable length of self-report questionnaires is important for maintaining acceptability.

### Table 1. Participant demographics.

<table>
<thead>
<tr>
<th></th>
<th>Total LLFQ participants ($n = 40$)</th>
<th>Reliability sample ($n = 39$)</th>
<th>6MWT and obstacle sample ($n = 30$)</th>
<th>Gait test and TUG sample ($n = 26$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years; M ± SD (range)</td>
<td>16.3 ± 2.2 (13–25)</td>
<td>16.3 ± 2.3 (13–25)</td>
<td>16.4 ± 2.5 (13–25)</td>
<td>16.3 ± 2.1 (13–21)</td>
</tr>
<tr>
<td>Gender: n</td>
<td>Male: 17</td>
<td>Male: 16</td>
<td>Male: 14</td>
<td>Male: 10</td>
</tr>
<tr>
<td></td>
<td>Female: 23</td>
<td>Female: 23</td>
<td>Female: 16</td>
<td>Female: 16</td>
</tr>
<tr>
<td>Disability: n</td>
<td>CP: 11</td>
<td>CP: 11</td>
<td>CP: 6</td>
<td>CP: 5</td>
</tr>
<tr>
<td></td>
<td>TR: 10</td>
<td>TR: 9</td>
<td>TR: 8</td>
<td>TR: 7</td>
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<td></td>
<td>SB: 7</td>
<td>SB: 7</td>
<td>SB: 5</td>
<td>SB: 4</td>
</tr>
<tr>
<td></td>
<td>O: 6</td>
<td>O: 6</td>
<td>O: 5</td>
<td>O: 4</td>
</tr>
<tr>
<td></td>
<td>KAFO: 7</td>
<td>KAFO: 7</td>
<td>KAFO: 5</td>
<td>KAFO: 3</td>
</tr>
<tr>
<td></td>
<td>AFO: 8</td>
<td>AFO: 8</td>
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<tr>
<td></td>
<td>BK: 3</td>
<td>BK: 2</td>
<td>BK: 3</td>
<td>BK: 2</td>
</tr>
</tbody>
</table>
| CP, cerebral palsy; TR, trauma and infections; CG, congenital malformation; SB, spina bifida; O, other/unknown; RS, raised shoe; KAFO, knee ankle foot orthoses; AFO, ankle foot orthoses; AK, above-knee prostheses; BK, below-knee prostheses; GA, other gait abnormality, mostly participants with CP.

Figure 3. Representative dot plot of all first session responses of an LLFQ item (item 15).
LOWER LIMB FUNCTION QUESTIONNAIRE RELIABILITY AND VALIDITY

Table 2. Construct validity correlations.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>M ± SD (range)</th>
<th>LLFQ correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>6MWT and obstacle course sub-study (n = 30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6MWT distance travelled (m)</td>
<td>276.6 ± 85.6 (72.1–421.2)</td>
<td>0.28</td>
</tr>
<tr>
<td>6MWT oxygen consumption (mL/min/kg)</td>
<td>13.0 ± 4.3 (7.1–26.0)</td>
<td>0.27</td>
</tr>
<tr>
<td>Obstacle course distance travelled (m)</td>
<td>278.5 ± 86.5 (93.0–423.8)</td>
<td>0.62</td>
</tr>
<tr>
<td>Obstacle course oxygen consumption (mL/min/kg)</td>
<td>15.8 ± 3.8 (10.3–25.7)</td>
<td>0.06</td>
</tr>
<tr>
<td>Gait evaluation and TUG sub-study (n = 26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity (cm/s)</td>
<td>77.8 ± 19.8 (40.5–122.2)</td>
<td>0.66</td>
</tr>
<tr>
<td>Stride length (cm)</td>
<td>105.3 ± 19.1 (62.9–133.9)</td>
<td>0.76</td>
</tr>
<tr>
<td>Cadence (steps/min)</td>
<td>88.7 ± 11.8 (65.9–109.2)</td>
<td>0.19</td>
</tr>
<tr>
<td>Heel-to-heel base of support (cm)</td>
<td>9.8 ± 6.1 (2.7–29.5)</td>
<td>-0.24</td>
</tr>
<tr>
<td>Stance % of gait cycle</td>
<td>65.0 ± 2.8 (59.2–71.5)</td>
<td>-0.70</td>
</tr>
<tr>
<td>Single support % of gait cycle</td>
<td>35.0 ± 2.8 (28.6–40.8)</td>
<td>0.70</td>
</tr>
<tr>
<td>Double support % of gait cycle</td>
<td>30 ± 5.6 (19.0–43.0)</td>
<td>-0.70</td>
</tr>
<tr>
<td>TUG (s)</td>
<td>14.2 ± 21.7 (6.0–119.5)</td>
<td>-0.45</td>
</tr>
</tbody>
</table>

*Statistically significant correlation with mean LLFQ scores (p < 0.01).

for users and ease of score calculation in clinical environments.[13] Given that time constraints are a primary factor limiting evidence-based practice in O & P,[50] a simple and efficient tool may be more suitable for use in the day-to-day provision of O&P clinical services, thus potentially leading to improved patient care.

As part of the push for evidence-based practice internationally, the specific need for O&P outcome measurement in resource-limited environments is highly relevant.[14] Although this current investigation involved a sample of young O&P users from a single location, the content of the LLFQ was designed to be suitable for a wide range of applications including other cultural settings, ages, and any type of gait aberration due to age, neurological, or physical impairment as well as limb insufficiencies resulting in O&P use. Additional testing of the measure within different populations, cultures, and ages is underway to verify this. The mid-range mean scores and an absence of floor or ceiling effects in the LLFQ from this study’s diverse adolescent and young adult sample population indicate a potential for detecting sensitive changes in lower-limb function across a broad spectrum of functional abilities and ages; however, further sensitivity analysis is needed to determine this.

Study limitations and future work

Concurrent administration of another validated questionnaire was not possible in this study as no similar PRO measure has been validated for use in less-resourced settings such as the study site. Because the LLFQ includes diverse aspects of lower-limb function, only moderate correlations were expected between LLFQ mean scores and sub-study tests, e.g. TUG and 6MWT, which are limited to measuring only one or a small sampling of lower-limb function aspects. Evaluating the LLFQ’s ability to discriminate between different functional abilities and to detect improvement during rehabilitation is needed to demonstrate sensitivity of the measure. Initial utilization of the LLFQ to measure the performance of two prosthetic knees has been promising, finding it to be highly sensitive to detecting differences, more so than the concurrently used PEQ.[51] The LLFQ’s ability to detect changes in lower-limb function is critical for clinical applications, where evaluating patient improvement is the goal.

In response to the accumulation of some scores near grade-letter anchors, members of our investigation team are currently evaluating the usefulness of these anchors within the standard VAS format. Preliminary positive results have led to the recommendation of minor changes to the scoring instructions, encouraging participants to mark anywhere along the VAS line including between grade-letter anchors, with an example item illustrating a response mark at an intermediate grade, e.g. between ‘C’ and ‘D.’ It is hoped that these small modifications to the instruction wording will help participants better understand the VAS format, reduce score accumulation near grade-letter anchors, and consequently improve the already-acceptable LLFQ test–retest reliability.

Conclusion

The LLFQ is a 20-item self-report questionnaire that provides an efficient measure of lower-limb function. The present study’s participant sample of adolescents and young adults in a less-resourced setting with a wide variety of conditions and functional gait levels demonstrates the LLFQ’s potential for broad applicability. Future sensitivity evaluation, as well as testing within more diverse populations and settings, is needed to complete validation of LLFQ and determine its potential as a universally applicable outcome measure of lower-limb function. In addition, validation of the
LLFQ in populations who do not use O&P devices would be advantageous for increased applicability in comparing function across the diverse conditions experiencing lower-limb limitations, especially in less-resource settings. This could reduce the total number of outcome tools necessary for use in clinical environments and also provide a baseline measure prior to an assistive device fitting to enable future analysis of the device’s impact.

Acknowledgements

The authors would like to thank our universities, our partner organization at the study site, and the staff and students at the boarding school for their contributions to this investigation. Funding for travel and research was provided through private fundraising by individual researchers. The authors would like to thank those who personally donated to enable this study.

Disclosure statement

The authors report no declarations of interest.

References


[34] WHO/USAID. Key points from the Wheelchair Futures Follow-Up Meeting. 2012; 2012-08-31.


## Appendix A.

**LLFQ excerpt (Page 1).**

### Lower Limb Function Questionnaire (LLFQ)

<table>
<thead>
<tr>
<th>Participant’s ID:</th>
<th>Participant’s Age: ___ years</th>
<th>Sex: M/F</th>
</tr>
</thead>
</table>

#### Diagnosis:

Type of Assistive Device:

Condition of Device: (circle one)  Newly fitted  Good working condition  Poor/needs replacing

Other/details:

Participant’s profession or current school grade level:

Date: __/__/____  Researcher’s Name: ______________________

**Instructions:** We would like you to compare your lower limb function and movement to that of a person of your age and gender who does not have a physical disability or need an assistive device. Answer each question by placing a vertical mark anywhere on the line (as shown below). Do not circle the letter grades that are below the line - they are only a reference point for placing your mark. You can mark anywhere along the line including in between the letter grades as shown below. There is no right or wrong answer, just give the answer that best describes you and your experience. Please explain your score in the comments section below each line.

In the example below, a mark a little higher than a C was given.

---

**An example showing how to answer:** Rate the difficulty of getting onto a commercial airplane (from "poor" – very difficult, to “excellent” – not very difficult at all.)

<table>
<thead>
<tr>
<th>Poor</th>
<th>E/F</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
<th>Excellent</th>
</tr>
</thead>
</table>

Comment: *My leg is a very weak muscle, general study, it’s slower than most people, but I can do it eventually.*

1. **Rate how your gait looks while you are walking** (from “poor” – very abnormal, to “excellent” – very normal).

<table>
<thead>
<tr>
<th>Poor</th>
<th>E/F</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
<th>Excellent</th>
</tr>
</thead>
</table>

Comment: ________________________________

2. **Rate how you sound while walking** (from “poor” – very abnormal, to “excellent” – very normal).

<table>
<thead>
<tr>
<th>Poor</th>
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<th>D</th>
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</table>

Comment: ________________________________