PM R 13 (2021) 297–306

www.pmrjournal.org

Original Research

Psychometric Properties of the Walking Impact Scale (Walk-12) in Persons with Late Effects of Polio

Christina Brogårdh, RPT, PhD, Jan Lexell, MD, PhD, DPhil h.c., Albert Westergren, RN, PhD

Abstract

Background: Many persons with late effects of polio (LEoP) perceive walking limitations in everyday life. A common rating scale to assess walking limitations is the Walking Impact Scale (Walk-12). However, there is limited knowledge about its psychometric properties.
Objective: To investigate the psychometric properties of Walk-12 in persons with LEoP.
Design: Rasch model analysis of cross-sectional data.
Setting: University hospital.
Participants: A total of 325 persons with LEoP (175 women; mean age 70 ± 10 years).
Main Outcome Measurement: The Walk-12, comprising 12 items with five response categories ranging from 1 (not at all) to 5 (extremely).
Methods: Data of Walk-12 were collected by a postal survey. The Rasch model analysis was used to analyze unidimensionality of the scale, local dependency, targeting, hierarchical order of items, Differential Item Functioning (DIF), response category functioning, and reliability (Person Separation Index, PSI). Raw score transformation to interval measurements was also performed.
Results: The analysis revealed that Walk-12 was multidimensional and suffered from some local dependency. Targeting was compromised among persons with less and more walking limitations. Hierarchically, the most difficult item to perform was "running" and the easiest was "walking indoors with support". There was a minor DIF for gender in one item ("support when walking outdoors"). Reliability was high (PSI = 0.94). Disordered response category thresholds were found for three items; when merging the middle response categories for these items model fit slightly improved and unidimensionality was achieved.
Conclusions: The Walk-12, in its current version, does not fully meet the rigorous psychometric Rasch measurement standards in persons with LEoP. Further development of the scale is warranted, including merging response categories and complementing Walk-12 with objective measures of gait in order to improve targeting. As these limitations can be considered minor, the current version of Walk-12 can still be useful for research and clinical practice.

Introduction

Many people affected by an acute poliomyelitis infection in their childhood or youth experience new impairments later in life, referred to as late effects of polio (LEoP).[1] The new or increased impairments, such as muscle weakness, muscle fatigue, and musculoskeletal pain in the lower limbs,[2–5] can lead to reduced balance[6] and walking limitations[7] in daily situations. Previous studies have shown that persons with LEoP often perceive difficulties walking fast, running, climbing stairs, walking longer distances, and needing to be extra cautious when walking.[3,8] To reduce these walking limitations various forms of walking aids and orthoses are often prescribed to persons with LEoP.[7,9,10]

One rating scale that can be used to assess self-perceived walking limitations in everyday life is the 12-item Walking Impact Scale (Walk-12),[11] which is based on the Multiple Sclerosis Walking Scale (MSWS-12).[12] From a large item set of 141 items describing the impact of MS on health, 12 items were intended to assess different aspects of walking.[12,13] Even though the scale was

https://dx.doi.org/10.1002/pmrj.12403

originally developed for people with MS, the Walk-12 has been used in various neurological conditions[11,12,14-17] as well as in persons with LEoP.[3,18] Studies using classical test theory have shown that the Walk-12 has satisfying psychometric properties in persons with MS, Parkinson disease,[11,17] and stroke[11] and in persons with peripheral neuropathy.[14] The Walk-12 is also reported to be a useful complement to objective gait performance tests, such as gait speed and distance, as it provides a wider and deeper understanding of persons' walking difficulties in everyday life.[3,11] This information could assist the design of more individually targeted rehabilitation interventions to reduce self-perceived walking limitations.

In clinical practice, the response options in the Walk-12 are summed to a total score. However, data from a multi-item ordinal rating scale are nonlinear in nature and should therefore not be calculated into a sum score unless it is proven psychometrically sound and unidimensional. One approach that can be applied to provide a detailed insight into the psychometric and metrological properties of a rating scale is the Rasch model analysis.[19-22] The model tests how well the data of the studied population fit the model expectations. Data from an ordinal scale that fit the Rasch model will support a linearized model. Transforming ordinal scores into linear, interval scores can then be performed that enable a summation of the scores and the use of parametric statistics.[23] Furthermore, the score transformation, together with known measurement errors, enhances comparability of scores between persons and for a single person at different time points.[24,25]

Even though the Walk-12 is considered to be a useful scale in persons with LEoP,[3,8,18,26] no study has, to the best of our knowledge, thoroughly evaluated the scale's psychometric properties in this population. The aim of this study was therefore to investigate the psychometric properties of the Walk-12 in persons with LEoP by using the Rasch model analysis.

Material and Method

Study Design

In this cross-sectional project data were collected by a postal survey, where a set of questionnaires and rating scales about falls, fear of falling, self-perceived impairments, and walking limitations were mailed to persons with LEoP.[26] In the present study, only data on self-perceived walking limitations are presented.

Participants

A convenience sample of 356 ambulant community-dwelling persons with LEoP participated in the postal survey.[26] The participants were recruited from a clinical database at a postpolio rehabilitation clinic at a university hospital in southern Sweden. Inclusion criteria were (1) a confirmed history of acute poliomyelitis affecting their lower limbs; (2) a period of recovery and functional stability of at least 15 years; (3) clinically verified post-polio including new symptoms, such as muscle weakness and/or loss of functioning in one or both lower limbs, that had persisted for at least a year; (4) ability to walk indoors with or without an assistive device; and (5) ability to understand Swedish. Exclusion criterion was other diseases, such as stroke, Parkinson disease, or severe osteoarthritis, that could have an impact on the persons' mobility. Of the 356 persons, 34 did not respond to the survey despite being reminded once and four declined to participate. Thus, a total of 325 participants (91% response rate) were included in the present study.

Ethics

All participants gave their written informed consent to participate in the study. The principles of the Declaration of Helsinki were followed, and the study was approved by the Regional Ethical Review Board in Lund, Sweden (Dnr 2011/582).

The Walking Impact Scale (Walk-12)

The Walk-12 comprises 12 items (see Table 2) that ask about a person's self-perceived walking limitations during the past 2 weeks in activities related to walking, running, climbing stairs, standing, walking distance and effort, need for support indoors and outdoors, gait quality aspects, and concentration when walking.[11] The scale has five response options: 1 = not at all, 2 = a little, 3 = moderately, 4 = quite a bit, and 5 = extremely. In clinical practice, the response options from each item are summed into a total score ranging from 12 to 60 points. In this study a Swedish version of the Walk-12 was used.[3,8,18]

Analysis

The participants' demographics and clinical characteristics were analyzed using the IBM SPSS Statistics version 25 (IBM Corporation, Armonk, NY) and presented as mean, SD or percentage. The Rasch model analysis, partial credit version[19,27,28] was used to judge whether the Walk-12 met the measurement requirements of the Rasch model (RUMM 2030, RUMM Laboratory, Perth, Australia). This included testing of unidimensionality, local dependency, targeting, hierarchical order of items, Differential Item Functioning (DIF), response category functioning, and reliability (Person Separation Index, PSI). The Rasch model analysis was also used for raw score transformation to interval measurements (linearized scores).

Unidimensionality and Local Dependency

Unidimensionality (ie, when all items in a questionnaire together measure a single construct) and local dependency (ie, when items are linked in some way and the response to one item determines the response to another)[29] of Walk-12 were analyzed. Although the Walk-12 was developed and psychometrically evaluated based on classical test theory, and thus can be expected to be unidimensional, we here explored this assumption in a sample of persons with LEoP. Unidimensionality was pursued by means of principal component analysis (PCA) of the residual correlations and by scrutinizing item fit residuals as well as the residual correlations between items. An analysis of the residuals was conducted in RUMM2030 to identify potential subdimensions in the Walk-12. Person location estimates were derived from two subsets of items, one that loaded positively and one that loaded negatively on the first principal component of residuals. If violation of unidimensionality is negligible, the number of person locations that differ between the two item sets is small. The overall proportion of persons with significantly different measures from the two item subsets should be <5% to support unidimensionality.[30,31]

Another aspect of unidimensionality (ie, local dependency) was assessed by inspecting item fit residuals. As a rule of thumb, fit residuals (ie, residual equals observed minus expected score) estimates for each item should be within ± 2.5. Negative values (<-2.5) suggest local dependency, and positive values (>2.5) imply multidimensionality.[32] Item characteristic curves (ICCs) illustrate this relationship, enhancing the interpretation of the magnitude and pattern of the numerical fit statistics.

Individual residual correlations are considered relative to the average observed residual correlation, rather than to a uniform value.[33] Residual correlations that are high, relative to the overall set of correlations, indicate violation of the local independence assumption.[34] Thus, the critical value (Q_3*) for relative residual correlations was also identified following the procedures described in detail by Christensen et al[33] and by using the online resource URL: http://publicifsv.sund.ku.dk/~kach/Q3/critical_values_Yens_Q3.html.

Targeting

The sample's targeting to the scale was also analyzed. Good targeting means that the scale represents the levels of ability (or limitation) reported by the person in the sample; poor targeting undermines good measurement of persons' perceived abilities that are not covered by the scales' range of measurement. Mistargeting results in lower precision and problems with differentiating between persons' abilities along the latent scale.[35] An indicator of the targeting of a scale is the mean person location, which expresses the average magnitude and direction by which the person locations differ from the item locations. In terms of the Walk-12, positive person logit locations indicate that the sample experiences more walking limitations than represented by the scale and vice versa for negative person logit locations.[35] In general, mean person locations up to ± 0.5 logits indicate good targeting.[36,37]

Hierarchical Ordering of Items

To assess the internal validity of items in the Walk-12, the logical hierarchical ordering of items along the quantitative continuum, from less to more, was also assessed.[32] It is reasonable to consider the Walk-12 item locations as a hierarchy from negative (more difficult tasks) to positive (less difficult tasks) locations.

Differential Item Functioning (DIF)

To assess if items work the same across different groups of people, DIF was analyzed. In the present study, DIF (ie, bias for an item among subgroups in the sample[38]) was evaluated for gender (men and women) and age (65 years or younger, 66 years and older). If DIF can be clinically justified, it should not be resolved by means of splitting the item for the person factor (eg, gender or age groups).[39]

The clinical significance of DIF was studied by anchoring items without DIF in the original scale by their item locations from the DIF-adjusted scale to ensure that these two sets of person estimates are on the same metric.[40] The correlation between DIF-adjusted person locations and the nonadjusted locations was calculated.

Response Category Functioning

To assess the response category functioning of each item, the threshold ordering was analyzed. A threshold is the point between two categories in which either response is equally probable. As described before, Walk-12 has five response categories ranging from 1 (not at all) to 5 (extremely), resulting in four thresholds. Disordered thresholds imply that response categories are not functioning as expected, for instance that persons have difficulties to distinguish between "a little" and "moderately." To resolve disordered thresholds items can be rescored by collapsing the response categories.[35]

Reliability

To assess the reliability of the Walk-12, the Person Separation Index (PSI) value was inspected. PSI indicates the power of the construct to discriminate among persons; that is, walking limitations among groups of persons with

late effects of polio. The PSI is analogous to Cronbach's alpha[41-43] and can be used to derive the number of strata (ie, statistically distinct groups of persons) that can be distinguished by the scale.[42] Higher PSI values indicate greater detection of reliable differences between persons.

Raw Score Transformation to Interval Measurements

Raw score transformation to interval measurements was performed to facilitate use of total sum scores of Walk-12 in clinical practice and research. Because the Walk-12 score is ordinal in nature and the total score is computed through the sum of the 12 individual ordinal score items, one point on an ordinal scale is not necessarily the same across the measurement spectrum. Through the Rasch model analysis in RUMM2030 the raw scores can be translated into logits. Given an appropriate solution, the Rasch person estimates in logits can be transformed into convenient interval measurements (linearized scores).[23]

Results

In Table 1, the demographics and characteristics of the 325 participants (175 women and 150 men) are presented. Their mean age was 70 (SD 10) years, the mean age at the acute poliomyelitis infection was 6 (SD 6) years, and the mean duration of new symptoms was 20 (SD 9) years. A majority (69%) lived with a partner and 39% lived in housing with stairs. Their perceived impairments was on average 27 (SD 7) points on the Self-reported Impairments in Persons with late effects of Polio (SIPP) rating scale, indicating mild to moderate impairments related to their LEoP.[44,45] All participants were ambulatory, but more men than women could walk >1000 m and they used mobility aids to a lesser extent.

Unidimensionality and Local Independence

Analysis of all items showed quite good fit to the Rasch model (X^2 = 64.63; P = .055; item mean [SD] fit residual =0.0 [1.92] and person mean [SD] fit residual = −0.28 [1.08]). PCA of the residuals indicated multidimensionality, that is, the 95% confidence interval (CI) did not include 5% (9.85% with significantly different measures from the two item subsets, 95% CI, 7.5%-12.2%).

Item 10 "slowed down your walking" had a fit residual below −2.5 indicating local dependency. Inspection of the item characteristic curve for this item showed only a slight deviation of the observed score compared to the expected score. Because the critical value ($Q_3^* = Q_{3,}max - \bar{Q}_3$ *mean* = 0.392 - [−0.076] = 0.468) was above the Q_3^* value for the 95th percentile (0.18) it can be concluded that there was significant local dependency in the data set, that is, that responses to one or a few items possibly were dependent on responses to one or a few other items.

Sample-to-Scale Targeting

As can be seen in Figure 1, the sample-to-scale targeting was suboptimal. Measurements for some persons on the left (floor effect: less walking limitation) and for some persons on the right (ceiling effect: more walking limitations) were not matched by any items of equivalent difficulty in relation to walking ability. The mean person location was 0.345 (SD 2.272), indicating that the sample on average reported somewhat more walking limitations than expected.

Hierarchical Order of Items

As can be seen in Table 2, where the hierarchical ordering of the items in the Walk-12 is presented, item 2 "running" was perceived as the most difficult to perform whereas item 8 "need of support when walking indoors" was perceived as the easiest to perform. The ordering between the items seemed clinically reasonable.

Table 1
Demographics and characteristics of the 325 participants

	Women (n = 175)	Men (n = 150)	All participants
Age; mean years ±SD (range)	69 ± 10 (35-91)	70 ± 9 (36-91)	70 ± 10 (35-91)
Age at acute polio infection; mean years ±SD (range)	6 ± 5 (1-30)	7 ± 6 (0-27)	6 ± 6 (0-30)
Years with late effects of polio; mean years ±SD (range)	21 ± 9 (4-56)	19 ± 9 (3-52)	20 ± 9 (3-56)
Self-reported impairments; mean years ±SD (range) *	27 ± 7 (13-46)	27 ± 7 (13-45)	27 ± 7 (13-46)
Living situation (%)			
Living with a partner	62	76	69
Living in a housing with stairs	40	37	38
Walking ability (%)			
Less than 100 m	27	21	24
Between 100 m and 1000 m	42	42	42
More than 1000 m	31	37	34
Using mobility aids (%)	78	70	74

SD = SD; *Assessed with the Self-reported Impairments in Persons with late effects of Polio (SIPP) rating scale (reference 44).

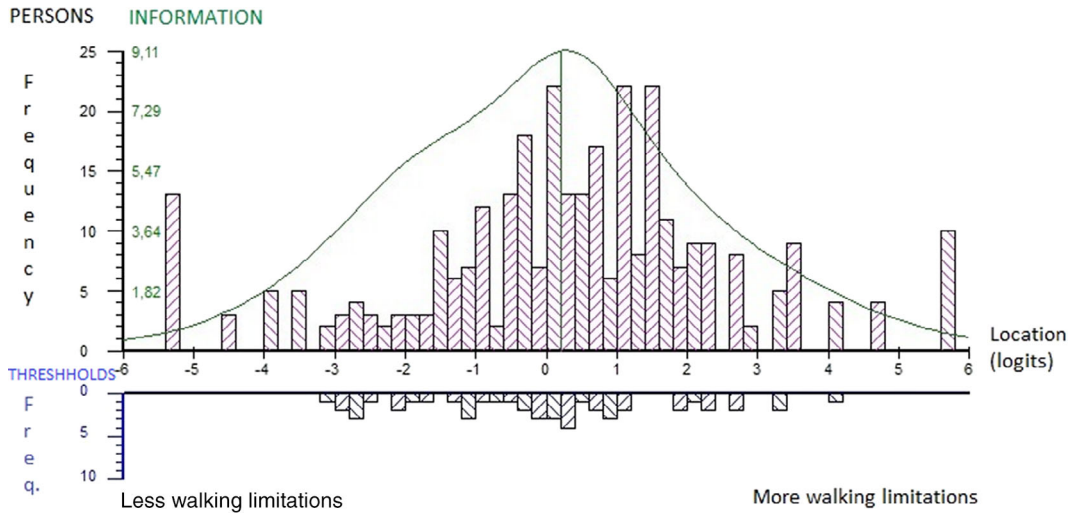

Figure 1. Distribution of the location of people (upper panel), Walk-12 category thresholds (lower panel) on the common logit metric (x-axis; positive values = more walking limitations). Superimposed on the person distribution graph is the information function curve (higher values = less error and more information in scores, ie, better measurement precision). Maximum information (vertical line under the curve) corresponds to a location at 0.3 logit (representing a Walk-12 score of 39).

DIF

There was no DIF for age, but a gender DIF was seen for item 9 "need of support when walking outdoors" (P <.001), where women needed to use mobility aids to a greater extent than men (Figure 2). There was a strong correlation between DIF-adjusted person locations and the nonadjusted locations (Pearson correlation = 0.99983), indicating that the DIF was of minor importance.

Response Category Functioning

Response category thresholds worked as intended in nine items, whereas disordered thresholds were evident for three items: items 2 "limited in running," 8 "need of support when walking indoors," and 9 "need of support when walking outdoors." For these three items the participants had difficulty distinguishing between the response options "a little" and "moderately" (Figure 3A-C).

For an explorative purpose, we merged the three middle response categories for each of the items 2, 8, and 9. This improved, to some extent, the fit to the Rasch model (X^2 = 61.38; P = .093; item mean [SD] fit residual = −0.08 [1.89] and person mean [SD] fit residual = 0.34 [1.14]). In addition, the PCA of the residuals now indicated unidimensionality, that is, the 95% CI included 5% (6.5%, 95% CI, 4.1%-8.8%).

Reliability

Reliability was high for both the original version of Walk-12, and the version where the response categories

Table 2
Item-level Rasch model fit of the Walk-12 items, ordered by location from the most difficult task (Item 2) to the easiest (Item 8)

Item	Location	Location SE	Fit Residual*	$X^{2\dagger}$	P
Item 2, Limited ability to run	−2.001	0.098	1.071	8.309	.080
Item 6, Limited how far you are able to walk	−0.443	0.08	−1.651	7.945	.094
Item 10, Slowed down your walking	−0.415	0.078	−4.229	13.584	.009‡
Item 11, Affected how smoothly you walk	−0.394	0.08	−1.658	4.459	.347
Item 3, Limited ability to climb up or down stairs	−0.344	0.081	1.322	1.545	.819
Item 7, Increased effort needed for you to walk	−0.17	0.083	−1.115	6.91	.141
Item 12, Made you concentrate on your walking	0.081	0.077	1.942	5.258	.262
Item 5, Limited your balance when standing or walking	0.412	0.081	1.684	5.388	.250
Item 9, Made it necessary for you to use support when walking outdoors	0.512	0.064	1.53	3.109	.540
Item 4, Made standing when doing things more difficult	0.711	0.077	0.665	0.498	.974
Item 1, Limited ability to walk	0.756	0.081	−1.071	4.901	.298
Item 8, Made it necessary for you to use support when walking indoors	1.294	0.069	1.541	2.727	.604

*Should be between −2.5 and 2.5 (if negative a sign of local dependency and if positive a sign of that the question measures something else than the other questions in the scale).
†Summarize the deviation of observed from expected responses across sample class intervals. Higher values represent larger deviations.
‡Not significant following Bonferroni correction.

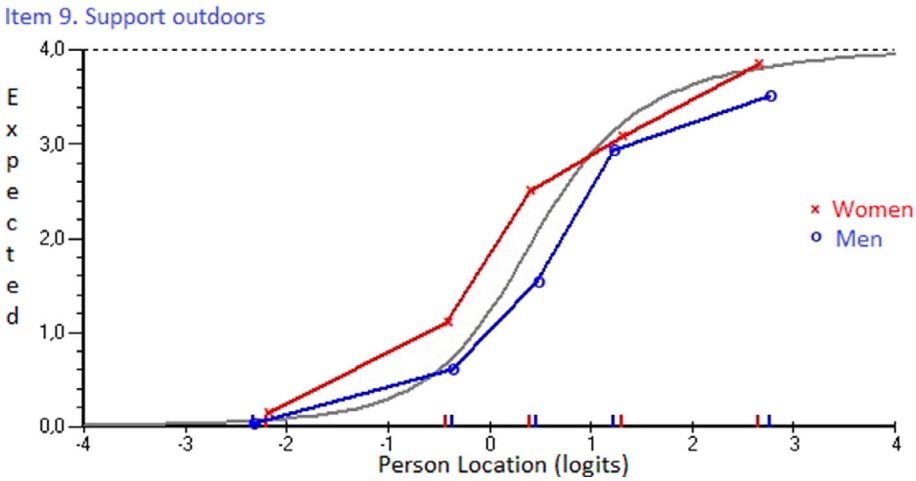

Figure 2. Item (item 9, support outdoors) characteristic curve (the gray curve) represent the expected item responses (y-axis) at various levels of the walking ability (x-axis) for women (red curve) and men (blue curve). Despite the same level of walking limitations (x-axis) men reported use of walking aids to a less extent than women.

for items 2, 8, and 9 were merged (PSI with extremes 0.94; Cronbach's alpha 0.96 in both analyses), implying that almost six (ie, 5.79 strata) distinct levels of walking ability can be identified.[42]

Raw Score Transformation to Interval Measurements

In the Appendix, raw scores are transformed to linear logit values (together with their standard errors) and to linearized scores, for both the original scale as well as for the merged scale where items 2, 8, and 9 have only three response categories. The highest information function with the lowest measurement error corresponded to a raw score of 39 (location 0.341) and a linearized score of 36.78. With merged middle response categories for items 2, 8, and 9, the highest information function with the lowest measurement error corresponded to a score of 32 (location −0.177) and a linearized score of 32.16. This indicates that the scores for the "merged Walk-12 scale" are very similar before and after transformation to interval measurements.

Discussion

Many persons with LEoP perceive walking limitations in everyday life, and therefore the Walk-12 can be a useful rating scale. In the present study we have, for the first time, evaluated the psychometric properties of the Walk-12 in persons with LEoP by using the Rasch model analysis. Our analyses revealed that Walk-12 is multidimensional and to some extent suffered from local dependency. Targeting of the scale was compromised among persons with less and more walking limitations. Hierarchically, the most difficult item to perform was "running" and the easiest was "walking indoors with support." There was a minor gender DIF for one item ("need of support when walking outdoors"). Reliability in terms of the PSI was high (0.94). Disordered response category thresholds were found for three items; when merging the middle response categories for these items model fit improved and unidimensionality was achieved.

The items in Walk-12, originally developed to evaluate how a neurological condition affects walking,[11] cover a continuum of aspects of self-perceived walking limitations in everyday life. The 12 items include various activities related to standing and walking that require sensorimotor function and postural control. The activity that our participants perceived most difficult to perform was "running" and the activity that they perceived easiest to perform was "need of support when walking indoors." This finding is in agreement with previous studies of self-perceived walking limitations in persons with LEoP.[3,8] Activities such as running, climbing stairs, walking outdoors, walking a longer distance or with a higher velocity are perceived challenging, whereas walking indoors is perceived as less challenging.[3,26]

Targeting of the Walk-12 to the persons' walking ability was somewhat suboptimal in our analysis. Measurements for persons with less self-perceived walking limitation and those with more self-perceived walking limitations were not entirely matched (Figure 1). In other words, persons with higher and lower levels of walking limitations tended to be measured with somewhat less precision, as illustrated by the lower information at the end of the scale. Hobart and Cano[32] have previously described that rating scales, developed based on classical test theory criteria, may be expected to have a more narrow spectrum than a person's ability represent. Therefore, in recent studies of the Rasch model analysis the measurement spectrum of Walk-12 has been extended by adding gait items in order to improve sensitivity and to detect clinical change in walking ability for higher functioning patients with

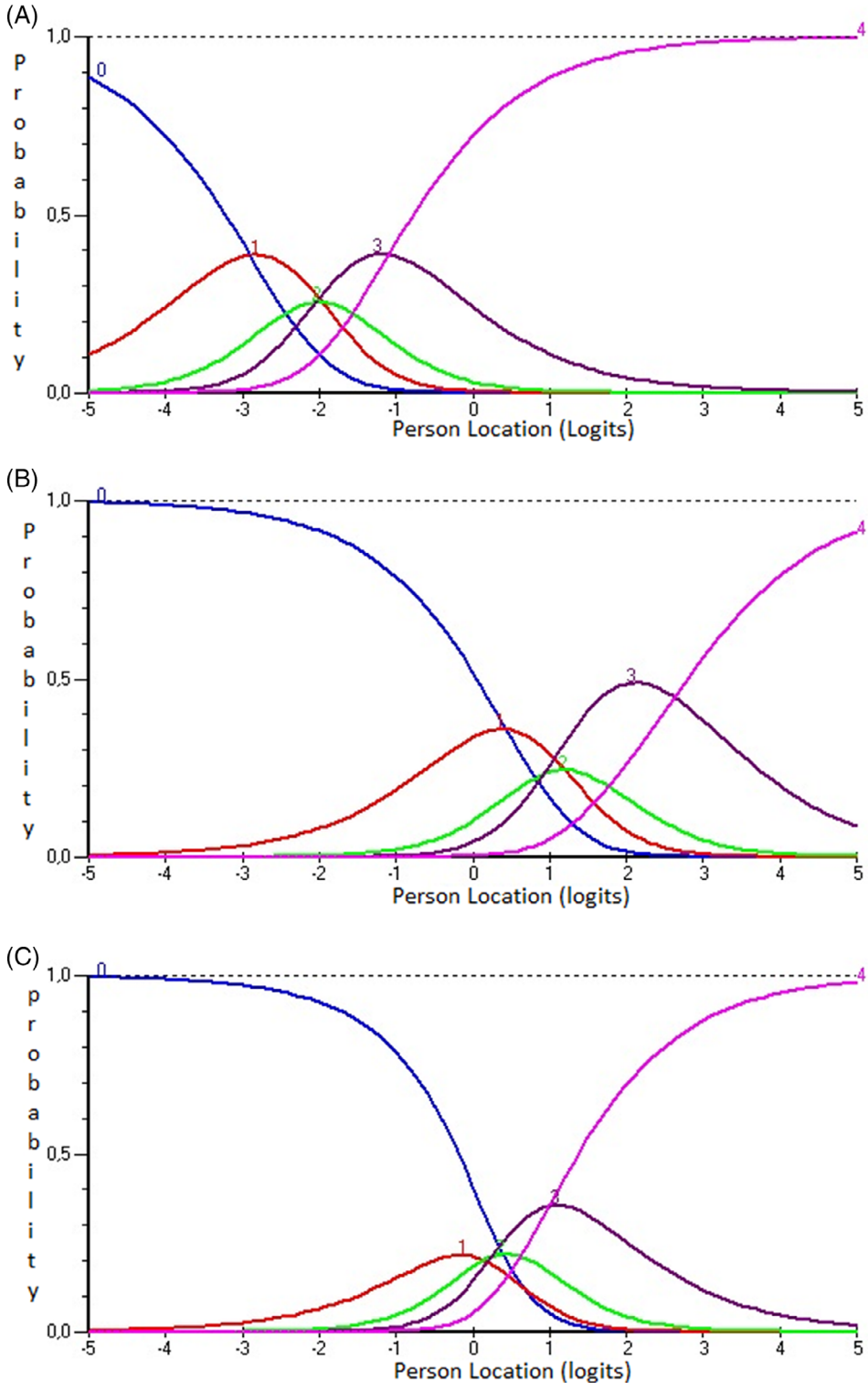

Figure 3. (A-C) Category probability curves representing the probability (y-axis) of responding in the respective categories at various locations on the measured variable (x-axis, positive values = more walking limitations). The figure shows disordered thresholds in (A) item 2, running; (B) item 8, support indoor; and (C) item 9, support outdoor.

MS.[13] That other gait parameters could also be used in addition to Walk-12 is in line with our previous studies in persons with LEoP and stroke.[3,16] In those studies, we demonstrated that objective gait measurements (such as the 10 m walk test for assessing gait speed in m/s and the 6-minute walk test for assessing gait distance and endurance in meters) could be a good complement to Walk-12 when walking ability is evaluated.

Furthermore, in our data local dependency was only found among a few items in the Walk-12. This may be somewhat expected as the Walk-12 in itself covers the same latent variable, that is, various aspects of walking limitations. However, the local dependency that occurred in our analyses was judged to be of minor importance as boundaries for residual correlations could be up to 0.3-0.5.[32,46,47] A gender difference (DIF) was also revealed for one item (item 10, "support when walking outdoors"; Figure 2). Similar gender DIF for this item has recently been found for patients with MS.[48] Why the difference occurred for only this item is a bit unclear, as more women than men used walking aids in our sample (Table 1). Whether walking aids are more accepted among women than men with LEoP is not entirely clear and needs to be further investigated.

In our analysis we also found slightly disordered thresholds (response categories) for three items ("limited running," "need of support when walking indoors," and "need of support when walking outdoors"; Figure 3A-C). When these items were merged to three response categories the fit to the Rasch model improved (X^2 = 61.38; P = .093) and the PCA of the residuals indicated unidimensionality. A similar solution of rescoring these three items has previously been demonstrated by Bladh et al,[17] who revised the response categories to 1 = not at all, 2 = sometimes, and 3 = a lot, yielding a total score of Walk-12 ranging from 12 to 54.

The high Person Separation Index value (PSI = 0.94) in the present study suggests that the Walk-12 is reliable for a group of individuals with LEoP. Similarly, among patients with MS, high reliability (≥0.94) has been found for the MSWS-12.[48] In addition, the Walk-12 has been shown to be valid or moderately associated to other measures of physical function,[8,11,12,17] lower limb function, and social participation.[14] It has also been shown to be partly related to objective gait performance tests measuring walking speed, cadence, or walking distance.[3,11,13,14,16,17]

In clinical practice and in research, a summation of the 12 item scores of Walk-12 is warranted. We therefore transformed the raw (ordinal) scores into linearized scores (interval measurements) to be utilized in clinical settings and in future studies of self-perceived walking limitations in persons with LEoP (see Appendix). Interval scores are more appropriate than ordinal scores for use in parametric statistics and enable comparisons of changes in Walk-12 over time.[20] However, the transformed values can be obtained from the raw scores only if the person has responded to all items in Walk-12. Indeed, all participants in the present study responded to all items in the scale. Previous studies have also reported few or no missing item responses of the Walk-12.[3,8,14,16-18] This further supports the clinical utility of the scale in persons with LEoP.

Strength and Limitations

The participants were recruited from a postpolio outpatient clinic in southern Sweden and represented a fairly homogeneous sample of ambulatory persons with mild to moderate LEoP. Hence, further testing of the Walk-12 is needed in more heterogeneous groups. A strength of the study is the sample size of 325 persons, which is considered sufficiently large for a Rasch analysis; it is suggested that at least 250 persons, or 20 times the number of items, should be included in a Rasch analysis to enable a robust analysis.[49] Differential Item Functioning was assessed only in relation to gender and age and other factors that potentially may contribute to item bias need to be further examined. In addition, evaluation of other psychometric properties of the scale, such as test-retest reliability and responsiveness, is also warranted in persons with LEoP.

Conclusion

The Walk-12, in its current version, does not fully meet the rigorous psychometric Rasch measurement standards when used among persons with LEoP. Further development of the scale is warranted including merging response categories and complementing Walk-12 with objective measures of gait in order to improve targeting. However, as these limitations can be considered minor, the current version of the Walk-12 can still be useful for research and clinical practice.

Acknowledgment

The authors are grateful to the individuals who volunteered to participate. The study was supported by grants from the Skåne county council's research and development foundation and the Faculty of Medicine at Lund University.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

References

1. Lexell J. Postpoliomyelitis syndrome. In: Frontera WR, Silver JK, Rizzo TD, eds. *Essentials of Physical Medicine and Rehabilitation*. Fourth ed. Philadelphia, PA: Elsevier Saunders; 2019:834-840.
2. Jensen MP, Alschuler KN, Smith AE, Verrall AM, Goetz MC, Molton IR. Pain and fatigue in persons with Postpolio syndrome: independent effects on functioning. *Arch Phys Med Rehabil*. 2011;92(11):1796-1801.
3. Brogardh C, Flansbjer UB, Espelund C, Lexell J. Relationship between self-reported walking ability and objectively assessed gait performance in persons with late effects of polio. *Neuro Rehabil*. 2013;33(1):127-132.

4. Flansbjer UB, Brogardh C, Lexell J. Muscle strength is only a weak to moderate predictor of gait performance in persons with late effects of polio. *Neuro Rehabil*. 2013;33(3):457-464.
5. Flansbjer UB, Brogardh C, Lexell J. Men with late effects of polio decline more than women in lower limb muscle strength: a 4-year longitudinal study. *PM&R*. 2015;7:1127-1136.
6. Lehmann K, Sunnerhagen KS, Willen C. Postural control in persons with late effects of polio. *Acta Neurol Scand*. 2006;113:55-61.
7. Bickerstaffe A, Beelen A, Nollet F. Change in physical mobility over 10 years in post-polio syndrome. *Neuromusc Disord*. 2015;25(3): 225-230.
8. Brogardh C, Lexell J. How various self-reported impairments influence walking ability in persons with late effects of polio. *Neuro Rehabil*. 2015;37(2):291-298.
9. Ploeger HE, Bus SA, Merel-Anne B, Frans N. Ankle-foot orthoses that restrict dorsiflexion improve walking in polio survivors with calf muscle weakness. *Gait Posture*. 2014;40(3):391-398.
10. Brogårdh C, Espelund C, Lexell J. The benefit of a flexible ankle-foot orthosis on balance and walking ability in persons with late effects of polio: a mixed-methods study. *J Prosthet Orthot*. 2019;31:1.
11. Holland A, O'Connor RJ, Thompson AJ, Playford ED, Hobart JC. Talking the talk on walking the walk: a 12-item generic walking scale suitable for neurological conditions? *J Neurol*. 2006;253(12):1594-1602.
12. Hobart JC, Riazi A, Lamping DL, Fitzpatrick R, Thompson AJ. Measuring the impact of MS on walking ability - the 12-item MS walking scale (MSWS-12). *Neurology*. 2003;60(1):31-36.
13. Strzok S, Cleanthous S, Pompilus F, et al. Development of a gait module to complement the 12-item Multiple Sclerosis Walking Scale: a mixed methods study. *Mult Scler J Exp Transl Clin*. 2018;4(2): 2055217318783766.
14. Graham RC, Hughes RA. Clinimetric properties of a walking scale in peripheral neuropathy. *J Neurol Neurosurg Psychiatry*. 2006;77(8): 977-979.
15. Nilsagård Y, Gunnarsson L-G, Denison E. Self-perceived limitations of gait in persons with multiple sclerosis. *Adv Physiother*. 2007;9 (3):136-143.
16. Brogardh C, Flansbjer UB, Lexell J. Self-reported walking ability in persons with chronic stroke and the relationship with gait performance tests. *PM&R*. 2012;4(10):734-738.
17. Bladh S, Nilsson MH, Hariz GM, Westergren A, Hobart J, Hagell P. Psychometric performance of a generic walking scale (walk-12G) in multiple sclerosis and Parkinson's disease. *J Neurol*. 2012;259(4): 729-738.
18. Winberg C, Brogardh C, Flansbjer UB, Carlsson G, Rimmer J, Lexell J. Physical activity and the association with self-reported impairments, walking limitations, fear of falling, and incidence of falls in persons with late effects of polio. *J Aging Phys Act*. 2015; 23(3):425-432.
19. Rasch G. *Probabilistic Models for some Intelligence and Attainment Tests*. Chicago, IL: University of Chicago Press; 1960.
20. Bond TG, Fox CM. *Applying the Rasch Model*. New York: Fundamental Measurement in the Human Sciences, Taylor and Francis; 2010.
21. Andrich D. *Rasch Models for Measurement*. Beverley Hills, CA: Sage Publications; 1988.
22. Mari L, Wilson M. An introduction to the Rasch measurement approach for metrologists. *Measurement*. 2014;51:315-327.
23. Smith EV Jr. Metric development and score reporting in Rasch measurement. *J Appl Meas*. 2000;1(3):303-326.
24. Stenner AJ, Stone MH, Fisher WP. The unreasonable effectiveness of theory based instrument calibration in the natural sciences: What can the social sciences learn? *J Phys*. 2018;1044 (1):012070.
25. McCarthy CM, Cano SJ, Klassen AF, et al. The magnitude of effect of cosmetic breast augmentation on patient satisfaction and health-related quality of life. *Plast Reconstr Surg*. 2012;130(1): 218-223.
26. Brogardh C, Lexell J. Falls, fear of falling, self-reported impairments, and walking limitations in persons with late effects of polio. *PM&R*. 2014;6(10):900-907.
27. Andrich D, Pedler P. A law of ordinal random error: the Rasch measurement model and random error distributions of ordinal assessments. *Measurement*. 2019;131:771-781.
28. Masters GN. A rasch model for partial credit scoring. *Psychometrika*. 1982;47(2):149-174.
29. Marais I, Andrich D. Formalizing dimension and response violations of local independence in the unidimensional Rasch model. *J Appl Meas*. 2008;9(3):200-215.
30. Smith EV Jr. Detecting and evaluating the impact of multidimensionality using item fit statistics and principal component analysis of residuals. *J Appl Meas*. 2002;3(2):205-231.
31. Tennant A, Pallant J. Unidimensionality matters. *Rasch Measur Trans*. 2006;20:1048-1051.
32. Hobart J, Cano S. Improving the evaluation of therapeutic interventions in multiple sclerosis: the role of new psychometric methods. *Health Technol Assess*. 2009;13(12):iii, ix-x, 1-iii, ix-x, 177.
33. Christensen KB, Makransky G, Horton M. Critical values for Yen's Q3: identification of local dependence in the Rasch model using residual correlations. *Appl Psychol Measur*. 2017;41(3):178-194.
34. Marais I. Local Dependence. In: Christensen K, Kreiner S, Mesbah M, eds. *Rasch Models in Health*. London: John Wiley & Sons Inc.; 2013:111-130.
35. Hagquist C, Bruce M, Gustavsson JP. Using the Rasch model in nursing research: an introduction and illustrative example. *Int J Nurs Stud*. 2009;46(3):380-393.
36. Hudgens S, Dineen K, Webster K, Lai J, Cella D. Assessing statistically and clinically meaningful construct deficiency/saturation: recommended criteria for content coverage and item writing. *Rasch Measur Trans*. 2004;17:954-955.
37. Lai J, Eton D. Clinically meaningful gaps. *Rasch Measur Trans*. 2002; 15:850.
38. Tennant A, Conaghan PG. The Rasch measurement model in rheumatology: what is it and whu use it? When should it be applied, and what should one look for in a Rasch paper? *Arthritis Rheum*. 2007; 57:1358-1362.
39. Hagquist C, Andrich D. Recent advances in analysis of differential item functioning in health research using the Rasch model. *Health Qual Life Outcomes*. 2017;15(1):181.
40. Lundgren-Nilsson A, Tennant A, Grimby G, Sunnerhagen KS. Cross-diagnostic validity in a generic instrument: an example from the functional Independence measure in Scandinavia. *Health Qual Life Outcomes*. 2006;4:55.
41. Smith EV Jr. Evidence for the reliability of measures and validity of measure interpretation: a Rasch measurement perspective. *J Appl Meas*. 2001;2(3):281-311.
42. Wright B, Masters G. *Rating Scale Analysis*. Chicago, IL: MESA Press; 1982.
43. Schumacker R, Smith E. Reliability. A rasch perspective. *Educ Psych Meas*. 2007;67(3):394-409.
44. Brogardh C, Lexell J, Lundgren-Nilsson A. Construct validity of a new rating scale for self-reported impairments in persons with late effects of polio. *PM&R*. 2013;5(3):176-181.
45. Brogardh C, Lexell J. Test-retest reliability of the self-reported impairments in persons with late effects of polio (SIPP) rating scale. *PM&R*. 2016;8(5):399-404.
46. Roe C, Damsgard E, Fors T, Anke A. Psychometric properties of the pain stages of change questionnaire as evaluated by Rasch analysis in patients with chronic musculoskeletal pain. *BMC Musculoskelet Disord*. 2014;15:95.
47. Davidson M, Keating JL, Eyres S. A low back-specific version of the SF-36 physical functioning scale. *Spine*. 2004;29(5): 586-594.
48. Marengo D, Rosato R, Gamberini G, et al. Examining the validity of the multiple-sclerosis walking scale-12 with Rasch analysis:

results from an Italian study. *Mult Scler Relat Disord*. 2019;36: 101400.

49. Linacre JM. Sample size and item calibration stability. *Rasch Meas Trans*. 1994;7:328.

Disclosure

C.B. and J.L. Department of Health Sciences, Lund University, Lund, Sweden; and Department of Neurology, Rehabilitation Medicine, Memory Disorders and Geriatrics, Skåne University Hospital, Lund, Sweden. Address correspondence to: C.B.; e-mail: christina.brogardh@med.lu.se

A.W. Department of Health Sciences, Lund University, Lund, Sweden; and The Research Platform for Collaboration for Health, and The PRO-CARE Group, Faculty of Health Sciences, Kristianstad University, Kristianstad, Sweden

Disclosure: nothing to disclose

Submitted for publication February 6, 2020; accepted May 6, 2020.