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Measurement properties of the Foot Function Index (FFI) questionnaire: A systematic review

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Abstract

Objective: Large numbers of people are subject to alterations and pathologies in the foot. To quantify how these problems of foot function affect the quality of life, clinicians and researchers have developed measures such as the Foot Function Index (FFI). Our aim is to determine the methodological quality of the FFI including adaptations to other languages.

Data sources: The studies considered in this review were extracted from the PubMed, Embase and CINAHL databases. The inclusion criteria were followed: (1) studies of patients with no previous foot or ankle pathology and aged over 18 years; (2) based on English-language patient-reported outcome measures that assess foot function; (3) the patient-reported outcome measures should present measurement properties based on COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) criteria.

Review methods: The systematic review was conducted following the COSMIN criteria to establish the methodological quality of the original FFI, together with its variants and adaptations. The last search was carried out in May 2024.

Results: Of the 1994 studies obtained in the preliminary search, 20 were eligible for inclusion in the final analysis. These results are the validations and cross-cultural adaptations to the following languages: the original FFI has cross-cultural adaptation in 13 languages and the FFI-Revised Short Form has been adapted and validated for use in 2 languages.

Conclusion: In terms of methodological quality, the FFI-Revised Short Form questionnaire is a valuable instrument for evaluating ankle and foot function and could usefully be expanded to be available in more languages.

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Introduction

The lower limb in general, and the foot and ankle in particular, is the anatomical structures responsible for human mobility and movement, for both walking and running, performing the functions of absorbing impact forces and adapting to the land surface.[1,2]

The continuous strains to which the foot and ankle are subjected can produce pathologies in these structures, which may be traumatic or non-traumatic. Such alterations include hallux valgus, plantar fasciopathy, ankle sprains, osteoarthritis and rheumatoid arthritis.[3] These foot problems have an overall prevalence of about 30% in the general population[4]; among adults, 24% of these problems are persistent.[5] Their appearance may be influenced by variables such as sex, age or pathologies affecting other areas of the body.[4,6]

Among the instruments developed to evaluate and monitor the treatment of problems in the foot and ankle, patient-reported outcome measures have proven very useful. These tools are very specific, valid and reliable, both in research and in clinical practice.[7,8] A wide range of patient-reported outcome measures have been created, but among the most common are the Self-reported Foot and Ankle Score,[9] Foot and Ankle Ability Measures,[10] the Foot and Ankle Outcome Score[11] and the Foot Function Index (FFI).[12]

The FFI in particular has good reliability and validity.[13] Many cross-cultural adaptations have been made of the FFI.[14–27] A revised short-form version, the FFI-Revised Short Form,[28] has been adapted for use in several languages other than English. The objective of the present study is to analyse these cross-cultural adaptations of the FFI and the Revised Short Form variant from a methodological standpoint to determine which presents the best quality and properties.

Methods

The protocol for this study is registered in the PROSPERO database for systematic reviews (CRD42023444657).

The measurement properties and methodological quality of the original FFI questionnaire and of all its cross-cultural adaptations and validations were analysed in accordance with the systematic review protocol presented in the COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist.[29] COSMIN criteria are used to select the most suitable measurement instrument for a population and a specific alteration through the analysis of reliability, validity, responsiveness and interpretability of the tools, following a reliable and systematic methodology.

The search was carried out using three databases, PubMed, Embase and CINAHL, with no time limitation and following the PRISMA statement for systematic reviews. The last search was carried out in May 2024, following the search strategy protocol for the PubMed database described by Terwee et al. This consists of a construct search (patient-reported outcomes specific to foot and ankle), a population search (non-pathological population) an instrument search (instruments, questionnaires, index, scales), the identification of measurement properties and the application of inclusion and exclusion filters. The aim is to critically evaluate, compare and summarize the measurement properties' quality of all self-administered questionnaires that assess foot and ankle function in patients with or without pathologies.

The following inclusion criteria were applied: studies carried out of patients with no previous foot or ankle pathology; patients aged over 18 years; studies based on patient-reported outcome measures assessing foot function; published in

English; studies obtaining measurement properties based on the COSMIN criteria (structural validity; internal consistency; reliability; measurement error; hypothesis testing for construct validity; cross-cultural validity/measurement invariance; criterion validity and responsiveness).

Any studies based on questionnaires that had not been validated with reliable criteria, or that were specific to other areas of the human body, or which had been carried out on animals, were excluded.

Two members of the research team, experts in psiychometrics, clinimetrics and systematic reviews, analysed the obtained results. Each reviewer applied the COSMIN criteria separately, and then common points were discussed. In cases of discrepancies, the two reviewers reached an agreement and consensus with the rest of the team.

The data of each studio were extracted using a standardized template according COSMIN criteria: full title, year and country of publication, as well as information on the number of dimensions and items, type of population used for each study, published cross-cultural adaptations, and measurement properties and methodological quality of each study.

Results

Thousand nine hundred and ninety-four studies were identified in the first phase of the review. Of these, 532 were eliminated due to duplication among the databases. After reading the title and abstract of the remaining 1462 papers, another 1375 were found to be inappropriate and were discarded, leaving 87 to be read in full. This process showed that another 67 were not related to foot or ankle function, and were also discarded. Thus, 20 studies remained for the definitive analysis. This selection process was designed in accordance with the PRISMA statement for systematic reviews (Figure 1).

Study population

The total sample population, among the 20 studies analysed, was 1867 participants, of whom 42.7% were men and 57.3% were women. The average age of these participants was 47.85 years, ranging from 18 to 88 years.

Dimensions and items

In this study, we analyse studies based on the original version of the FFI,[12] the subsequent modification, the FFI-Revised Short Form[28] and are included 16 cross-cultural adaptations of the FFI and 2 cross-cultural adaptations of the FFI-Revised Short Form.

The FFI is a self-administered questionnaire containing 23 items divided into 3 subscales: pain (9 items), disability (9 items) and activity limitation (5 items). The respondent is instructed to complete the questionnaire according to his/her experience during the last week, using a Visual Analogue Scale that ranges from 0 (minimum item score) to 9 (maximum score).[12] In one adaptation of the FFI, this score was made on a scale ranging from 0 to 4.[22]

Two adaptations of the FFI-Revised Short Form[28] were analysed. This version includes 34 items grouped into 5 subscales: pain (7 items), stiffness (7 items), disability (11 items), limitation (3 items) and quality of life (6 items).

Cross-cultural adaptation

To date, 18 cross-cultural adaptations of the FFI questionnaire or the FFI-Revised Short Form variant have been made. The original The Foot Function has been adapted and validated for use in Dutch, German, Taiwan-Chinese, Danish, Italian (2 versions), Spanish, Brazilian (3 versions), French, Korean, Chinese, Thai, Turkish and Arab. The FFI-Revised Short Form has been adapted and validated for use in Polish and Norwegian (Table 1).

Methodological quality

In terms of methodological quality, the original The FFI questionnaire obtained the best results according to the COSMIN criteria, with positive values for the items Internal consistency, Reliability,

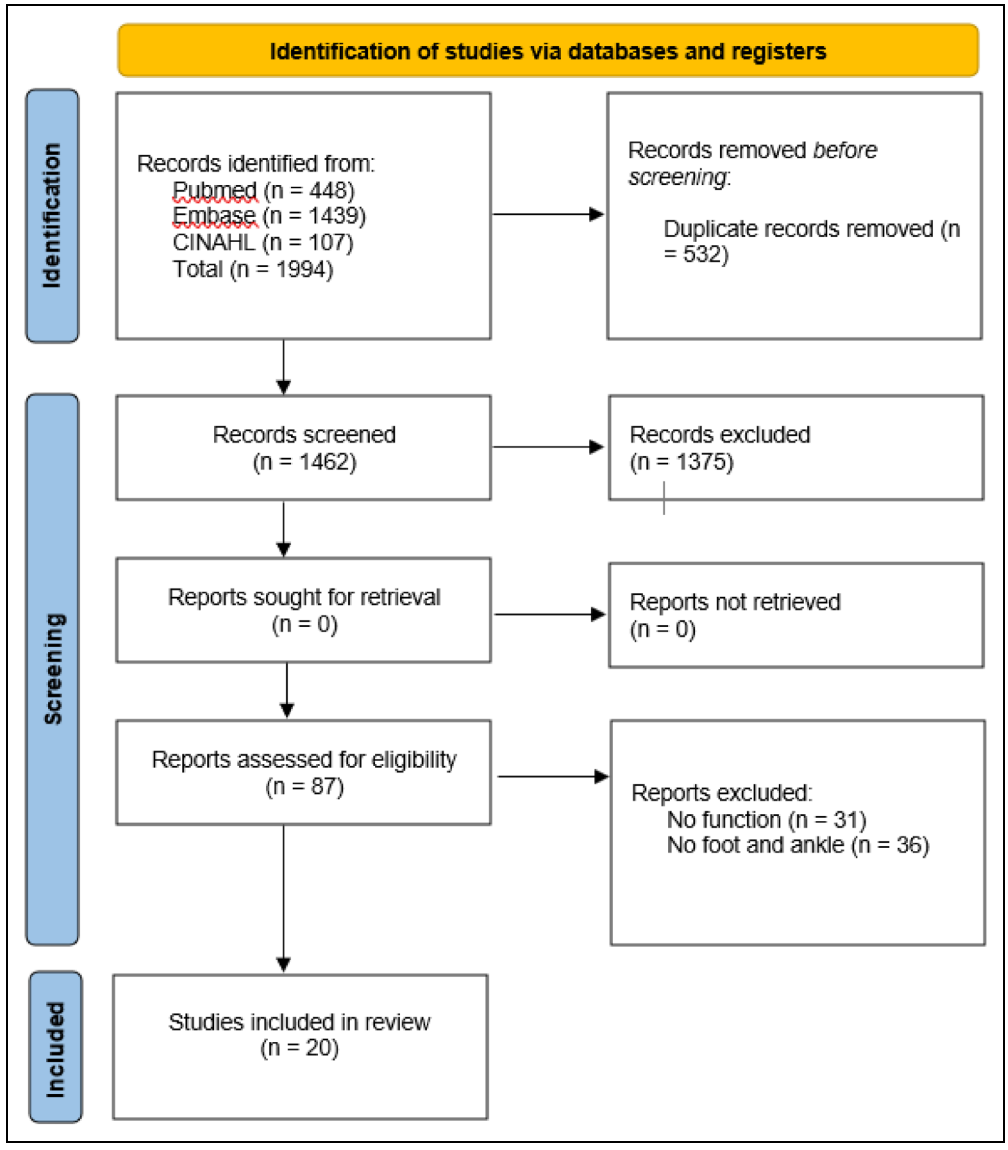

Figure 1. PRISMA flow diagram.

Hypothesis testing, Cross-cultural validity and Responsiveness, and a negative value for Criterion validity (Table 2).

The cross-cultural adaptations that obtained the best results was the French version, with four positive points, followed by the German, Italian (2014), Korean, Brazilian (2016) and Chinese versions, each with three positive points.

The original version of the FFI-Revised Short Form questionnaire obtained positive values for Internal consistency and Reliability and a negative value for Criterion validity. For the remaining measurement properties, no data were provided.

The cross-cultural adaptation of the FFI-Revised Short Form that obtained the best score was the Norwegian version, with 6 positive values and 2

Table 1. Instruments included.

Questionnaire title	Number of items	Dimensions	Cross-cultural adaptations
Foot Function Index (FFI) USA; 1991	23 items	1: Severity of pain 2: Degreee of difficulty 3: Frequency	Dutch (Netherlands), German (Switzerland), Taiwan-Chinese (Taiwan), Danish (Denmark), Italian (Italy), Spanish (Spain), French (France), Brazil (Brazil), Korean (Korea), Chinese (China), Turkish (Turkey), Thai (Thailand) and Arabic (Saudi Arabia)
Foot Function Index Revised Short Form (FFI-RSF) USA; 2006	34 items	1: Pain and stiffness 2: Social/emotional issues 3: Personal disability 4: Social activities limitation	Polish (Poland) and Norwegian (Norway)

negative ones (Criterion validity and Hypothesis testing).

Most of the studies examined did not report data for structural validity. The only exceptions were the Spanish adaptation of the FFI, which obtained a negative value in this respect, having performed a three-factor Confirmatory Factor Analysis, producing a Comparative Fit Index of 0.78 and a Root Mean Square Error of Approximation of 0.23. On the contrary, the Norwegian adaptation of the FFI-Revised Short Form obtained a positive value for a four-factor Confirmatory Factor Analysis, with a comparative fit index of 0.10 and a standardized Root Mean Square Error of Approximation of 0.07 (Table 3).

Practically all versions of the FFI obtained a positive value for internal consistency, with a Cronbach's alpha value ≥ 0.70 for each subscale. The Chinese adaptation of the FFI obtained the highest value (0.99), followed by the Norwegian version of the FFI-Revised Short Form, with 0.97. Two Brazilian versions of the FFI (2015 and 2017) did not report data in this respect.

For reliability, an Intraclass Correlation Coefficient value ≥ 0.70 and a positive result were obtained in most of the versions included in our study. The Brazilian (2016) and Chinese versions obtained a value of 0.99, and the original version of the FFI-Revised Short Form obtained an average value of 0.945. The Spanish and Brazilian versions of the FFI (2015 and 2017) did not report data in this respect.

The Chinese and the Brazilian 2016 versions of the FFI and the Norwegian version of the FFI-Revised Short Form obtained a positive value for their results, with the smallest detectable change being greater than the minimal important change. In the other versions considered, minimal important change was not defined and/or data were not provided.

Most versions of the Index obtained an indeterminate score in the Hypothesis testing for construct validity item, because the hypothesis was not defined. The only exception to this was the original English FFI, which obtained a positive value in this respect.

Only six versions scored positively in the Cross-cultural validity; the original English, the Italian 2014, the Spanish, the French and the Korean versions of the FFI, and the Norwegian version of the FFI-Revised Short Form. No assessment could be made of the other versions, as the data provided were insufficient, non-homogeneous or dissimilar to the original version.

The vast majority of versions scored negatively for criterion validity, with <0.70 in their correlations with the different tools used. Only the German and French versions of the FFI reported positive values.

Only two versions reported positive values for Responsiveness: the original English FFI (because its results were in accordance with the study hypothesis) and the Norwegian FFI-Revised Short Form, which obtained an Area Under the Curve

Table 2. COSMIN methodological quality.

Methodological quality	Structural validity	Internal consistency	Reliability	Measurement error	Hypotheses testing	Cross-cultural validity	Criterion validity	Responsiveness
1991 Or English	?	+	+	?	+	+	-	+
2005 Dutch Short Version	?	+	+	?	?	-	?	?
2008 German	?	+	+	?	?	-	+	?
2008 Taiwan-Chinese	?	+	+	?	?	-	-	?
2014 Danish	?	+	+	?	?	-	?	?
2014 Italian	?	+	+	?	?	+	-	?
2014 Spanish	-	+	?	?	?	+	-	?
2015 French	?	+	+	?	?	+	+	?
2015 Italian modified	?	+	+	?	?	-	-	?
2015 Brazil	?	?	?	?	?	-	?	?
2016 Korean	?	+	+	?	?	+	-	?
2016 Brazil validity	?	+	+	+	?	-	-	?
2017 Chinese	?	+	+	+	?	-	-	?
2017 Brazil revised	?	?	?	?	?	-	?	?
2020 Turkish	?	+	+	?	?	-	-	?
2020 Thai	?	+	+	?	?	-	-	?
2022 Arabic	?	+	+	?	?	-	-	?
2006 Or FFI SF English	?	+	+	?	?	?	-	?
2017 Polish Short Form	?	+	+	?	?	-	-	?
2022 Norway Short Form	+	+	+	+	?	+	-	+

COSMIN: COnsensus-based Standards for the selection of health Measurement Instruments; FFI: Foot Function Index.

Table 3. Summary of measurement properties of all versions.

	Estructural validity			Internal Consistency	Reliability	Measurement error			Criterion validity	Responsiveness
Measurement property	Factor Structure	Variance %	CFA	Cronbach's alpha	ICC	SDC	LoA	MIC	Correlation	AUC
1991 Or English			-	0.95	0.87	-		-	R = 0.529	-
2005 Dutch Short Version			-	0.93	0.76	-		-	-	-
2008 German			-	0.97	0.98	-		-	SF36 −0.43/-0.8 VAS 0.81 VAS Function 0.77 UCLA -0.52	-
2008 Taiwan-Chinese			-	0.94	0.82	-		-	SF36 -0.66/0.44	-
2014 Danish			-	0.97	0.95	-		-	-	-
2014 Italian			-	0.95	0.94	-		-	SR36 -069/-0.31	-
2014 Spanish	3 factors		CFI 0.78 RMSEA 0.23	0.965	-	-		-	EuroQol -0.57 VAS 0.63 SF12 -0.49/-0.16 FSHQ -0.79/-0.18	-
2015 French			-	0.85/0.97	0.79/0.92	8.2		-	VAS 0.69/0.73 HAQ 0.73 MACTAR 0.71	-
2015 Italian modified			-	0.95	0.90/0.92	-		-	17 IFFI 0.732 LEFS 0.63	-
2015 Brazil			-	-	-	-		-	-	-
2016 Korean			-	0.943	0.814	-		-	VAS 0.81 SF36 -0.88	-
2016 Brazil validity			-	0.78	0.99	1.32/ 1.08		2.42	SF36 -0.36/-015 FAOS -0.58/-0.19	-
2017 Chinese			-	0.996/0.998	0.985/0.996	0.97		2.27	FFI Taiwan -0.866/ 0.619 SF12V2 -0.856/ 0.206 EuroQol -0.855/ 0.858	-
2017 Brazil revised			-	-	-	-		-		-

(Continued)

Table 3. (Continued)

	Estructural validity			Internal Consistency	Reliability	Measurement error			Criterion validity	Responsiveness
Measurement property	Factor Structure	Variance %	CFA	Cronbach's alpha	ICC	SDC	LoA	MIC	Correlation	AUC
									-	
2020 Turkish			-	0.969	0.969	-		-	FAOS -0.69/0.33 MOX FQ 0.35/0.75 SF36 -0.73/-0.02	-
2020 Thai			-	0.974	0.946	-		-	VAS 0.695 EQ-5D5L -0.712 EQ VAS -0.508	-
2022 Arabic			-	0.76	0.89	-		-	SF36 -0.65/-0.57	
2006 Or English FFI Short Form			-	0.95	0.93/0.96	-		-	50 ft Walking Time 0.306	-
2017 Polish Short Form			-	0.95	0.78/0.84	-		-	VAS 0.54 HAQ 0.61 HAQ Walking 0.51 PAS28 0.26	-
2022 Norway Short Form	4 factors		CFI/TLI 0.10 SRMR 0.07	0.97	0.91	-		-	Rand-12 PCS12 -074 Rand-12 MCS12 -058 NRS pain activity 0.60	AUC 0.78

FFI: Foot Function Index.

<0.70. The remaining versions either did not correctly define their hypothesis or failed to report the variance data.

Methodological quality score per patient-reported outcome measures

Table 2 shows the scores obtained for the methodological quality of the four validations analysed, of the 20 studies in total. These four patient-reported outcome measures in particular were chosen because they met the greatest number of COSMIN criteria with a positive score. Thus, the Norwegian FFI-Revised Short Form obtained six positive items, the English FFI, five, the French FFI, four and the English FFI-Revised Short Form, two (Table 4).

Our analysis of the patient-reported outcome measures showed that none were of excellent methodological quality, and that they failed to meet most of the criteria considered. The above four versions met the criteria of *Internal consistency* and *Criterion validity* but were rated as insufficient or doubtful for the remaining criteria. The FFI-Revised Short Form Norwegian version, with three ratings of Very Good (in *Structural validity*, *Internal consistency* and *Criterion validity*), was the best measure in this regard.

Discussion

The FFI is widely used to analyse foot function. In this systematic review, we analyse the methodological quality of the original FFI and that of the numerous cross-cultural adaptations that have been proposed. In addition, we consider the FFI-Revised Short Form questionnaire, which was first published in 2006 as the basis for a theoretical model of foot function based on the World Health Organization International Classification of Function (28), and several of its adaptations.

In total, we examined 20 patient-reported outcome measures: the original FFI, the original FFI-Revised Short Form and all of their cross-cultural adaptations. Of these instruments, the

Table 4. Methodological quality scores per PROMs on a measurement property.

	BOX 1 PROM development	BOX 2 Content validity	BOX 3 Structural validity	BOX 4 Internal Consistency	BOX 5 Cross-cultural validity	BOX 6 Reliability	BOX 7 Measurement error	BOX 8 Criterion Validity	BOX 9 Hypothesis testing	BOX 10 Responsiveness
FFI Or. English	Inadequate	Doubtful	Inadequate	Very good	Inadequate	Doubtful	Inadequate	Very good	Adequate	Inadequate
FFI French	Inadequate	Doubtful	Inadequate	Very good	Inadequate	Adequate	Adequate	Very good	Adequate	Inadequate
FFI-RSF Or. English	Doubtful	Doubtful	Doubtful	Very good	Inadequate	Adequate	Inadequate	Very good	Adequate	Inadequate
FFI-RSF Norwegian	Inadequate	Doubtful	Very good	Very good	Doubtful	Adequate	Adequate	Very good	Very good	Adequate

FFI: Foot Function Index.

original FFI presented the best measurement properties, with five positive scores, followed by the French version of the FFI, with four. The original version of the FFI-Revised Short Form questionnaire obtained two positive scores for measurement properties, and the best adaptation was that made into Norwegian, with six positive results. The other adaptations of the FFI and the FFI-Revised Short Form presented very few positive items, either due to an absence of data or because the results obtained did not meet the minimum criteria for methodological quality.

The COSMIN criteria were determined from the measurement properties observed, for each of the patient-reported outcome measures considered. Those of *Internal consistency* (represented by Cronbach's alpha) and *Reliability* were met in almost every case. All the studies that reported results for *Internal consistency* achieved a Cronbach's alpha of well over 0.7. Moreover, none reported negative results; the Chinese version of the FFI obtained an Intraclass Correlation Coefficient of 0.99, with a time interval of 4 days between repetition of questionnaires, while the Brazilian version was found to be valid for a maximum interval of 1 week in this respect.

On the other hand, for *Criterion validity*, the vast majority of studies that provided results produced correlations with a negative rating. In this respect, the German and French versions of the FFI were the only ones to obtain positive ratings in the COSMIN criteria. In most cases, the correlations were obtained using the Visual Analogue Scale or the Short Form-36 questionnaire. Among the latter, the German and Korean versions of the FFI obtained the best correlation results (0.81 in both cases), while the Spanish FFI scored lowest, with 0.63. All of the studies that used the Short-Form-36 questionnaire to establish correlations obtained a negative result.

Only two studies provided data regarding the *Structural validity* criterion, the Spanish version of the FFI and the Norwegian version of the FFI-Revised Short Form. In both cases, a negative score was obtained in this respect. Moreover, these two studies were the only ones that performed a confirmatory factor analysis of their questionnaires, but the data obtained did not reflect a fit to the proposed model.

Finally, only two studies provided data on the *Responsiveness* item. The original English version confirmed the study hypothesis in this respect, but only the Norwegian version of the FFI-Revised Short Form provided Area Under the Curve data (0.78); the latter, moreover, was the only adaptation to score positively for this item.

Our analysis shows the FFI-Revised Short Form (both the original version and the adaptations) has better measurement properties than the FFI and its adaptations. In terms of methodological quality, the Norwegian version of the FFI-Revised Short Form presented the best cross-cultural adaptation and validation, and therefore is considered most useful for the analysis of foot and ankle function. However, since this patient-reported outcome measure has fewer adaptations than the FFI and has been subjected to less critical analysis, further validation is required, both of the original instrument and of its different versions.

After analysing the methodological quality of different transcultural adaptations of the FFI questionnaire, a deficit in positive scores related to COSMIN criteria becomes evident. It is possible that many of these adaptations are influenced by the time when they were developed, although there are also cases of much more recent adaptations that exhibit poor quality. For better practice and utilization of these adaptations, they should be updated to enhance their methodological quality, thereby making their use more reliable.

The greatest strength of our systematic review is the rigorous methodology and analysis made of the patient-reported outcome measures considered and of their measurement properties. On the other hand, it is also subject to some limitations, especially the lack of specific instruments for the analysis of foot and ankle function, validated in a population with specific pathologies. Furthermore, several of the studies examined did not report all of the data obtained in their statistical analyses.

In conclusion, the FFI-Revised Short Form questionnaire can be a useful instrument for assessing foot and ankle function in a given population, with or without related pathologies, and merits

further analysis. Healthcare personnel should choose, according to the study population, the most appropriate version of this questionnaire, namely one that has been cross-culturally adapted and validated and which meets the minimum criteria for methodological quality.

Clinical messages

- The self-administered FFI questionnaire and its modified version, the FFI-Revised Short Form, are appropriate tools for evaluating the functional status of the foot and ankle.
- In general, the majority of patient-reported outcome measures for foot and ankle function present little evidence of their measurement properties.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by AMR, ELR, SDM and MOR. *The first draft of the manuscript was written by* PCG *and* ABOA*, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.*

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Institutional review board that approved the protocol for the study: PROSPERO (CRD42023444657).

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