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Original Research

Validation of Persian Version of Patient-Rated Wrist and Hand Evaluation: Confirmatory Factor Analysis and Rasch Analysis

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KEYWORDS
Factor analysis;
Rehabilitation

Abstract *Objectives:* To determine the factor structure and test the clinometric properties of wrist and hand version of the Patient-Rated Wrist Evaluation.
Design: Cross-sectional study using Rasch analysis and factor analysis. Confirmatory factor analysis was conducted to assess the factor structure. Higher-order factor analysis was used to explore the hierarchical structure of the items. The Rasch model was used to assess the overall fit, reliability, validity, and construct unidimensionality. Rasch analysis and factor analysis were conducted using RUMM2030 and LISREL software, respectively.
Setting: Outpatient hand rehabilitation clinic.
Participants: A convenience sample of patients (N = 206) with various hand injuries who completed the Persian version of the Patient-Rated Wrist and Hand Evaluation (PRWHE-P) at 2 months postinjury. The study included 66 men and 139 women, with a mean age of 40 years.
Intervention: Not applicable.

List of abbreviations: CFA, confirmatory factor analysis; CFI, comparative fit index; DIF, differential item functioning; FA, factor analysis; GFI, goodness of fit index; ICC, item characteristic curve; ICF, International Classification of Functioning, Disability and Health; PRWE, Patient-Rated Wrist Evaluation; PRWHE, Patient-Rated Wrist and Hand Evaluation; PRWHE-P, Persian version of the Patient-Rated Wrist and Hand Evaluation; PSI, person separation index; RMSEA, root means square error of approximation.

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Main Outcome Measures: The PRWHE-P was used as a patient-reported measure of pain and disability in wrist and hand conditions.
Results: Factor analysis confirmed 3-factor models of the PRWHE-P. Items fit well to the Rasch model in 3 subscales. The PRWHE-P had a good item reliability (0.82) and good internal consistency (0.8). No differential item functioning was detected for age, sex, dominant hand, or injured hand.
Conclusions: The results of this study indicated that the PRWHE-P with 3 sub scales is a reliable and valid measurement tool and could be used in patients with different wrist and hand disabilities.

The Patient-Rated Wrist Evaluation (PRWE)[1] is a commonly used patient-reported outcome measure that has undergone substantial evaluation for its psychometric properties using different approaches. The wrist and hand version is typically used for hand conditions.[2] For its application in a population with hand injuries, the word "wrist" was modified to "wrist and hand," and the name of the scale changed from PRWE to Patient-Rated Wrist and Hand Evaluation (PRWHE).[2]

This version refers to the wrist and hand instead of the wrist alone and has a supplemental and optional question regarding appearance. Several clinimetric studies have evaluated this version and confirm similar measurement properties to the original wording of the PRWE.[3-5] The psychometric properties of the PRWHE have been examined in many different languages, with acceptable validity and reliability.[6]

Establishing construct validity is an essential part of instrument validation, especially in intercultural research, when an outcome measure intends to measure the same construct across different cultures. There are 3 studies that have addressed the factor structure of the PRWE/PRHWE[7-9] using factor analysis (FA). Typically, when patient-reported outcome measures are translated cross-culturally, reliability and validity are reexamined in the new context and language, but the factor structure is rarely reexamined. This work is often completed in a separate study, such as the factor analyses reported for the PRWE in Turkish,[9] Chinese,[7] and Dutch.[8] The Turkish and Dutch versions suggested a 3-factor solution in PRWE, whereas the Chinese version reported a 2-factor structure in PRWHE. Although the PRWHE has the same items and instructions with the exception of replacement of "wrist" with "wrist and hand," it is still important to examine the structure in translated and alternative versions.

Rasch analysis allows for a more thorough investigation of measurement properties, including the extent to which the instrument or its subscales are unidimensional. Also, in this method, the estimation of parameters is independent of the sample.[10] Two studies have previously reported the clinical measurement properties of the PRWHE and PRWE using Rasch analysis.[5,11] They found no significant differential item functioning (DIF) or scale differences between individuals with injuries in the dominant hand when compared with injuries in the nondominant hand. They reported that 2 subscales (pain and function) were well targeted and had high reliability. The first Rasch analysis was based on the English version of the PRWHE in a sample of mixed hand pathologies.[11] The second was conducted on a distal radius fracture population using the PRWE version.[5] Concordance in Rasch findings between the PRWHE and PRWE can support the assumption that these measures can be used interchangeably. Rasch analysis can complement the findings obtained from FA, because it provides some overlapping information (ie, factor structure, unidimensionality) and some distinct measurement indicators such DIF and targeting.[12]

Concordance between findings on studies conducted in English and other languages enhances confidence in cross-cultural translations and provides more details on measurement properties in different clinical populations and contexts or when used to evaluate different treatments. Because different treatments can influence some items more than others and because different populations and contexts may influence the interpretation or importance of certain items, it is important to examine measurement properties across an array of circumstances. This is particularly true when the context and culture is quite different from that of the development context. Therefore, the purposes of this study were to describe the factor structure of the PRWHE-P and to assess age, dominant and affected hand, and sex-based DIF, unidimensionality of the subscales, targeting, and reliability of the PRWHE-P using Rasch analysis.

Methods

Research design

This study was conducted as a cross-sectional study using Rasch analysis and FA.

Instruments and procedure

The PRWHE is a 15- item questionnaire (5 "pain" items; 10 "function" items), designed to measure pain and disability of the wrist and hand joints. It takes, on average, 6 minutes to complete. Items are scored on a scale of 0 to 10, where 10 is the worst possible score. The total score is calculated

Table 1 Frequency of participants

Variables	n (%)
Sex	
Male	67 (32)
Female	139 (67)
Injured hand	
Right	112 (55)
Left	93 (45)
Dominant hand	
Right	178 (87)
Left	27 (13)
Injuries	
Distal radius fractures	92 (44.5)
Other	114 (55.5)

by the sum of the pain items, plus half of the sum of the function items. The maximum score is 100, with higher scores indicating maximal (severe) pain and disability.[2,13] Lower scores denote better function and less pain. The Persian version of this scale (PRWHE-P), which has been validated and approved by the developer, was used in this study.[14]

Data collection

Sample size and characteristics

Between April 2017 and September 2018, all convenience patients with different hand conditions who were referred to an outpatient Hand Rehabilitation Clinic were recruited. Patients aged 18 years or older with the ability to complete the questionnaire in Persian, who had symptom duration of more than 2 months and absence of relevant motor co-morbidity were enrolled. Patients who had any neurologic cause for their hand function (eg, multiple sclerosis, stroke) were excluded. A suggested sample requirement for Rasch analysis is at least 10 endorsements for each potential response category for each item.[15] Because the questionnaire contains 15 items, a minimum sample of 150 patients is adequate. We included 210 to account for attrition.

Participants signed the informed consent that had been approved by the local ethics committee. The questionnaire was completed by the patients, and the data were analyzed using SPSS[a] for demographic examination and imported into the LISREL software[b] to compute FA.[16] RUMM2030[c] was used for Rasch analysis.

Statistical evaluation

The factor structure was evaluated using 2 methods. Confirmatory FA (CFA) was conducted to assess the fit and viability of the model developed based on the established structure and the construct validity of the PRWHE.[17] CFA was undertaken to assess a 2-factor (pain and function) or 3-factor (pain, specific activities, and usual activities) model of the PRWHE.

A higher order FA was done to explore the hierarchical structure of the items with applying a Varimax rotation to the results. This analysis was done to determine whether a more parsimonious explanation of the primary factor structures of instruments could be obtained.[18]

Several fit indices were used in interpret the results. The goodness of fit index (GFI) was used to measure the fit between the hypothesized model and the observed covariance matrix. The chi-square model was used to test the null hypothesis of fitting the model perfectly. Relative chi-square was calculated by dividing chi-square indices by the degree of freedom to test the goodness of fit. The acceptance level ranged from less than 2 to less than 5.[19]

The comparative fit index (CFI) was used to compare the target and null model. The CFI represents the extent to which the model of interest is better than the independence model. Values that approach 1 indicate an acceptable fit.[20]

The root means square error of approximation (RMSEA), as a measure of the average of the residual variance and covariance, is also used to determine model fit.[21] RMSEA values are required to be less than 0.08 to indicate good model fit. Values between 0.05 and 0.08 indicate reasonable model fit.[22]

Rasch analysis

The Rasch model was originally framed as a dichotomous model assuming the probability of an individual response to a given item is a logistic function of the discrepancy between a participant's ability of, for instance, hand and wrist function (θ) and the consequences of the pain and disability in hand condition (b) expressed by the given item.[11,23-26]

$$Pni = \frac{e^{(\theta n - bi)}}{1 + e^{(\theta n - bi)}}$$

The polytomous model was developed in addition to the original dichotomous model facilitating the analysis on those items containing multiple response options. Such a model requires a choice of rating scale or partial credit model for the further investigation. The basic assumption of the rating scale is the equidistance between thresholds across items, which is not required by the partial credit model. In RUMM2030, the software we used to conduct Rasch analysis, the selection of a partial credit model was based on the significant result from likelihood ratio test.[27]

Table 2 Fit indicators of models (2- and 3-factor models) for PRWHE

Model	χ^2	*Df*	χ^2/df	*P* Value	GFI	CFI	RMSEA
2 factors	661.99	90	7.35	.001	0.89	0.89	0.152
3 factors	406.21	107	0.79	.049	0.91	0.92	0.056

NOTE. $P<.05$.

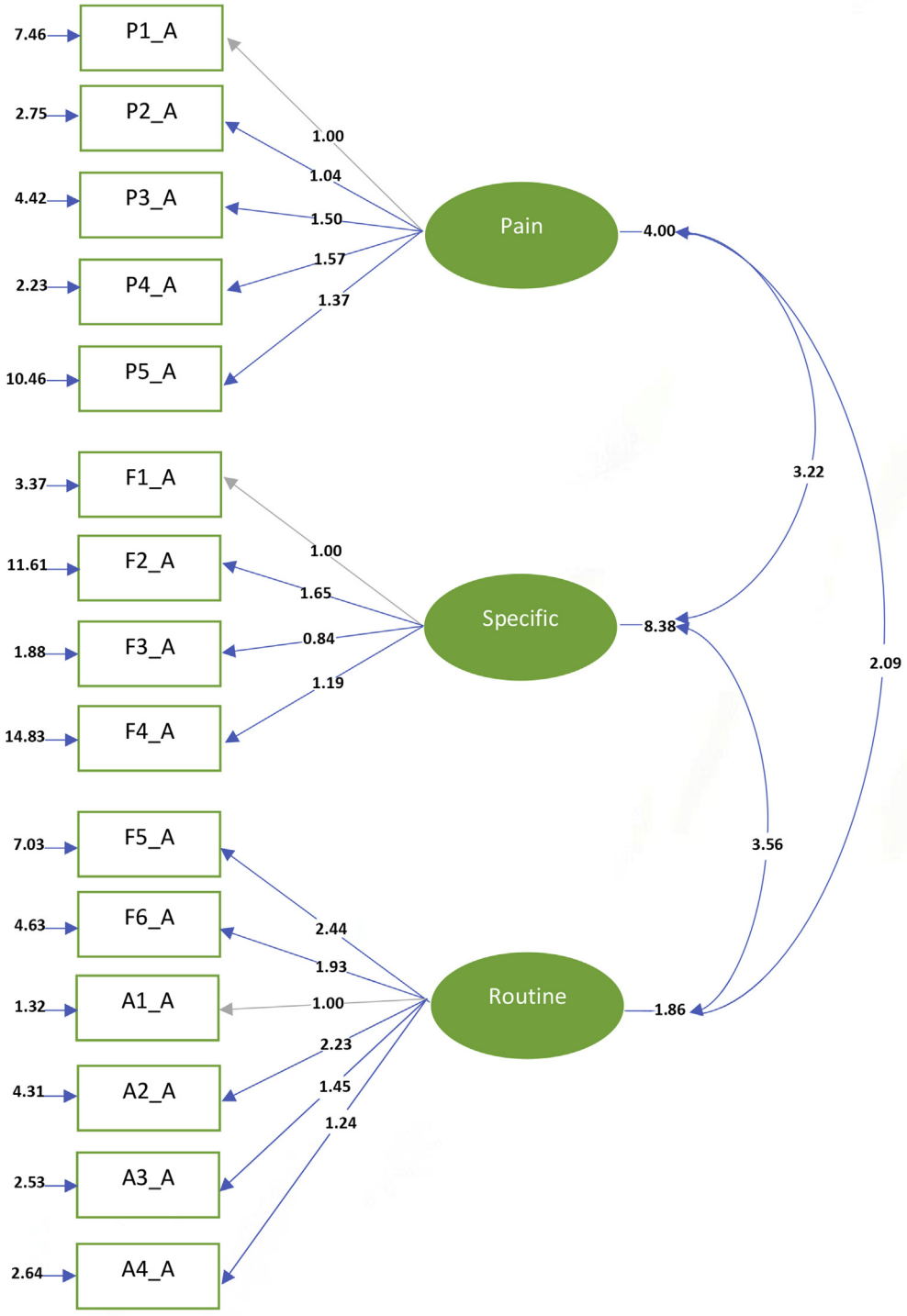

Fig 1 Three final structures of the PRWHE-P, confirmed by CFA, showing the item loading in factors. Items 2, 3, 4, and 5 from the pain domain were loaded in the pain factor, and items 5 and 6 from the function domains were loaded in usual activities. Abbreviations: A, usual activities; F, function; P, pain.

The process for Rasch analysis included tests of unidimensionality fit of residual, ordering of item thresholds, person separation index (PSI), DIF, and local independence of items. Analysis was performed using the RUMM 2030 professional software suite. The significance level was set at 0.05, with Bonferroni correction applied when multiple comparisons were made.

Test of fit

The fit statistic tested the PRWHE against the Rasch model and examined the degree of the agreement. Fit statistics were inspected from both overall and individual item levels. The overall fit was reviewed by item-trait interaction where a non-significant *P* value was required for the

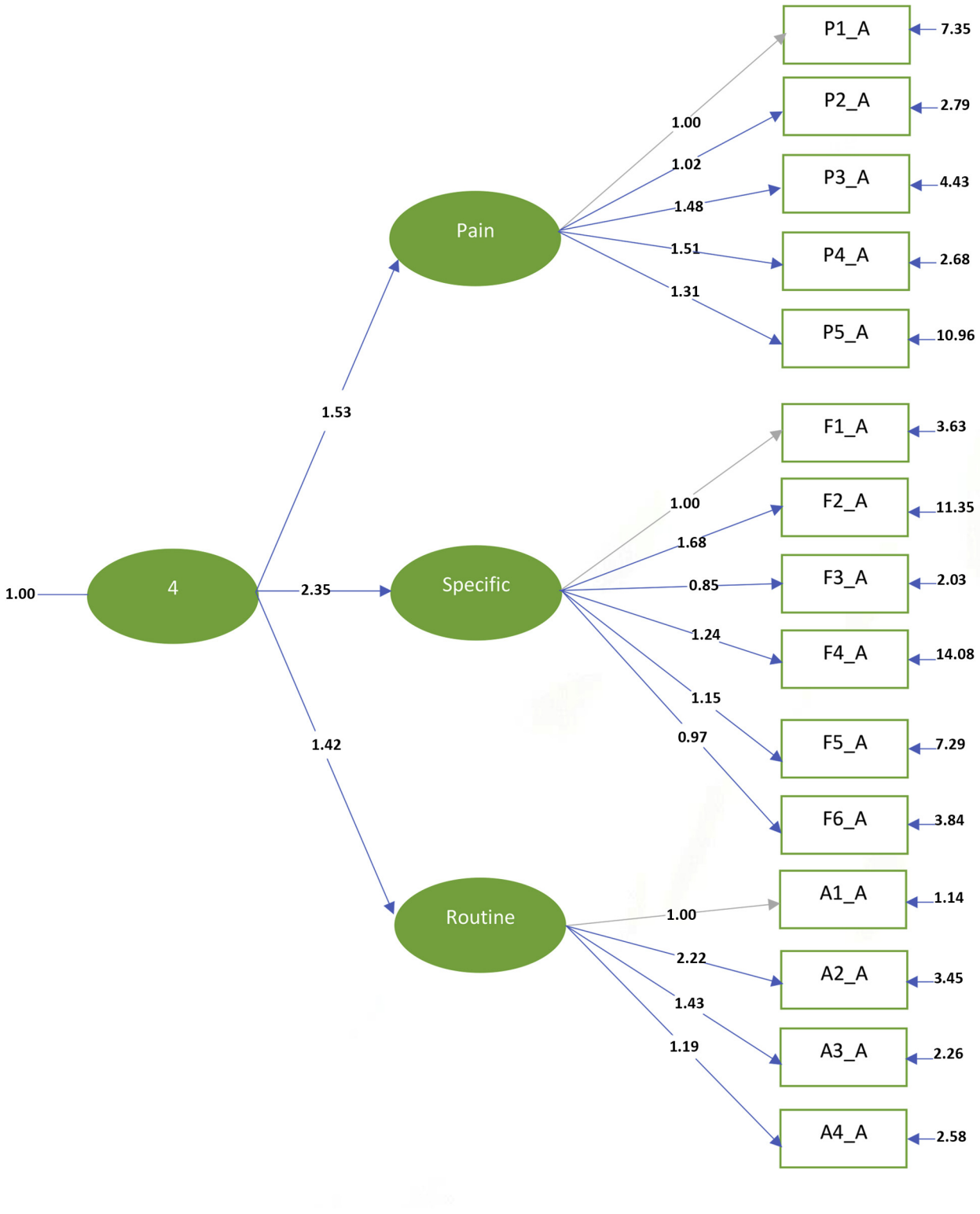

Fig 2 Higher Order FA of the PRWHE-P showing a higher order construct (disability), which encompasses the 3 lower order subscales of the PRHWE.

acceptable model fit.[25,28] The interaction statistics provided a summary of the deviations of all items and individuals from the Rasch model by transforming the residuals of individual items and person to an approximate z score and checking whether it followed standardized normal distribution with a mean of 0 and standard deviation of 1.[25,29] Fit residual localized within ±2.5 logits, representing an adequate level of the individual item fit. [11] Misfit items, which were outside the range of 2.5 logits, were removed to achieve the model fit.

Table 3 Overall summary of fit statistics

Subscale	Sample Size Without Missing Response	Fit Residual		Item-Interaction			Reliability		Unidimensionality	
		Item Fit	Person Fit							
		Mean ± SD	Mean ± SD	χ^2	*df*	*P* Value*	PSI	Alpha	Number, <5%	Percentage, <5%†
Pain (5 items)	184	0.28 ± 1.40	−0.46 ± 1.11	26.01	15	.04	0.81	0.83	10	4.90
Function (6 items)	188	−0.11 ± 1.40	−0.4 ± 1.07	33.18	18	.02	0.83	0.89	8	4.42
Usual activities (4 items)	191	−0.02 ± 0.82	−0.58 ± 1.15	14.48	12	.27	0.81	0.88	8	4.47

* Significant *P* values for χ^2 tests were set as 0.01 for the 3 subscales after Bonferroni correction.
† The number of significant *t* tests greater than 5% of the total comparisons raised concerns regarding unidimensionality.

Dimensionality

Dimensionality of the PRWHE was examined using the principal component analysis. This analysis was used to evaluate whether items within subscales and all subscales within the questionnaire measured a similar latent construct. We identified the positive and negative items loading on the primary factor using principal component analysis and then conducted an independent *t* test on these items. The number of significant *t* tests greater than 5% of the total comparisons raised concerns about unidimensionality. We examined the unidimensionality after each iteration of the rescoring and item reduction to ensure the revised measures were in compliance with the basic assumption.[30]

Targeting

Scale-to-sample targeting examined the extent to which the items on the PRWHE-P version measured all levels of impairments of the hand. The figure of person-item threshold distribution demonstrated the difficulty (item locations) and relative ability (person location) on the same ruler of logits. The better the match between, the greater the potential for precise person measurement. Poor targeting often results in floor or ceiling effects.[28]

DIF

DIF including both uniform and non-uniform types to examine the stability of items from the PRWHE across relevant subgroups within the sample. Uniform DIF occurs when divergences are consistent across individual subgroups and can be resolved through separate estimation by splitting the problematic item for subgroups (eg, for dominant and nondominant affected hands). Nonuniform DIF, caused by random differences of items, should be considered as a criterion of item removal.[28] The analysis of variance statistic and visual inspection of item characteristic curve (ICC) were examined and cross-referenced during the analysis.

Reliability

RUMM2030 provides 2 types of reliability statistics, the PSI and the internal consistency represented by the traditional Cronbach's alpha. The acceptable value of PSI was set as 0.7 as a criterion to confirm whether the PRWHE was reliable in distinguishing impairments between at least 2 groups.[24,30-33] Cronbach's alpha of 0.8 or greater indicated satisfactory internal consistency.[34]

Results

Four patients did not complete the questionnaire and were excluded; 206 patients were included in this study. Most of the patients had a fracture in their wrist or forearm (distal radius fracture; 66 [32%]). The mean age of the participants was 40±15 years (table 1).

Table 4 Summary of individual item fit statistics

Item	Location	SE	Fit Residual	*df*	χ^2	*df*	*P* Value*
Pain							
I0001	0.66	0.04	1.79	139.40	4.39	3.00	.22
I0002	0.02	0.04	0.20	139.40	5.71	3.00	.13
I0003	−0.22	0.04	−0.62	139.40	3.87	3.00	.28
I0004	−0.57	0.05	−1.51	139.40	10.49	3.00	.01
I0005	0.11	0.04	1.54	139.40	1.54	3.00	.67
Function							
I0006	0.03	0.03	−0.36	147.00	3.00	3.00	.39
I0007	−0.10	0.03	−0.63	147.00	6.12	3.00	.11
I0008	0.34	0.04	−1.43	147.00	8.91	3.00	.03
I0009	−0.18	0.03	2.56†	147.00	9.28	3.00	.03
I0010	−0.51	0.04	−0.89	147.00	3.65	3.00	.30
I0011	0.43	0.04	0.08	147.00	1.29	3.00	.73
Usual Activity							
I0012	0.16	0.04	0.17	130.50	6.25	3.00	.10
I0013	−0.20	0.04	−1.15	130.50	5.10	3.00	.16
I0014	−0.23	0.04	0.07	130.50	2.07	3.00	.56
I0015	0.27	0.04	0.82	130.50	1.06	3.00	.79

* Significant *P* value was set as .01 after Bonferroni correction.
† Fit residual localized within ±2.5 logits representing adequate level of the individual item fit.

FAs

The CFA supported the presence of 3 subscales in which items fit the 3 described subscales of the PRWHE: pain, specific activities, and usual activities. The fit indices are provided in table 2. A nonsignificant item−trait interaction (chi-square, 442.43), relative chi-square more than 2 (chi-square index divided by the degree of freedom, 0.79), and RMSEA less than 0.08 (0.056) empirically confirmed verification of the 3-factor structure solution. GFI and CFI indices more than 0.9 in 3-factor structure model indicted better fit to data than the 2-factor structure (see table 2; fig 1).

Higher order FA with GFIs (GFI, 0.91;CFI, 0.94; RMSEA, 0.053) indicated a higher order construct overarch the subscales (fig 2). This confirmed that PRWHE was evaluating a single higher order construct (disability), which encompasses the 3 lower order subscales (pain, specific activities, usual activities).

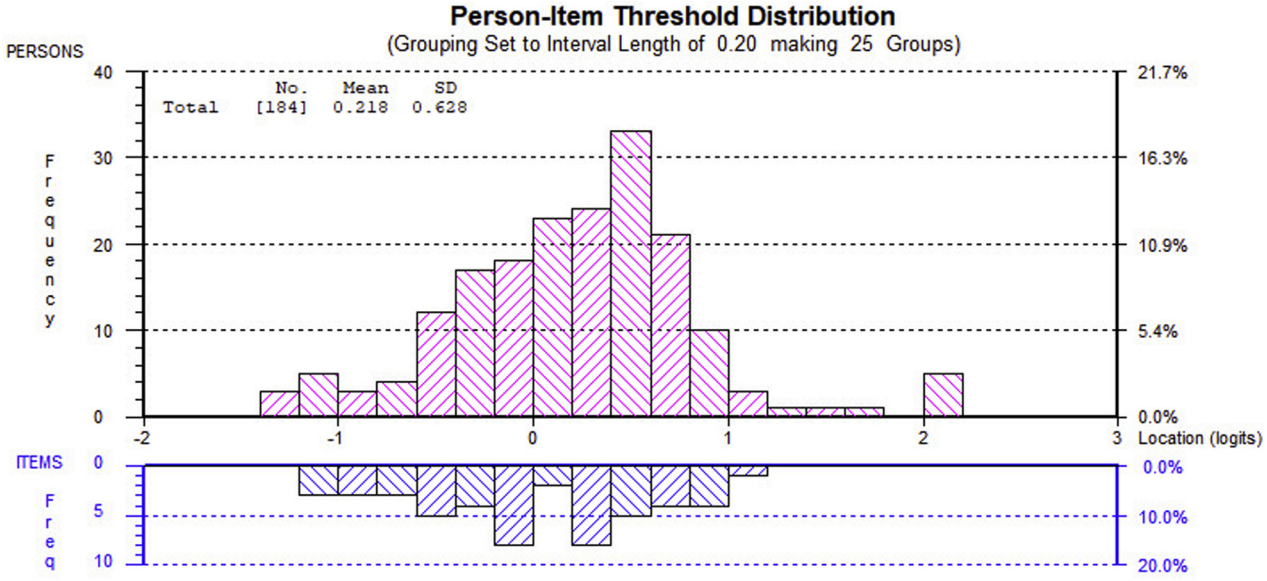

Fig 3 Person-item distribution map for the pain subscale of the PRWHE-P showing the distributions of person (top) and item thresholds (bottom) for the pain subscale. The average mean person location value of 0.202 suggested that the pain subscale was reasonably well-targeted for use with this group, with patients averaging at a slightly higher level of pain than the average of the scale items (0 logits). The thresholds positioned at the extreme right of the graph are those hardiest to endorse.

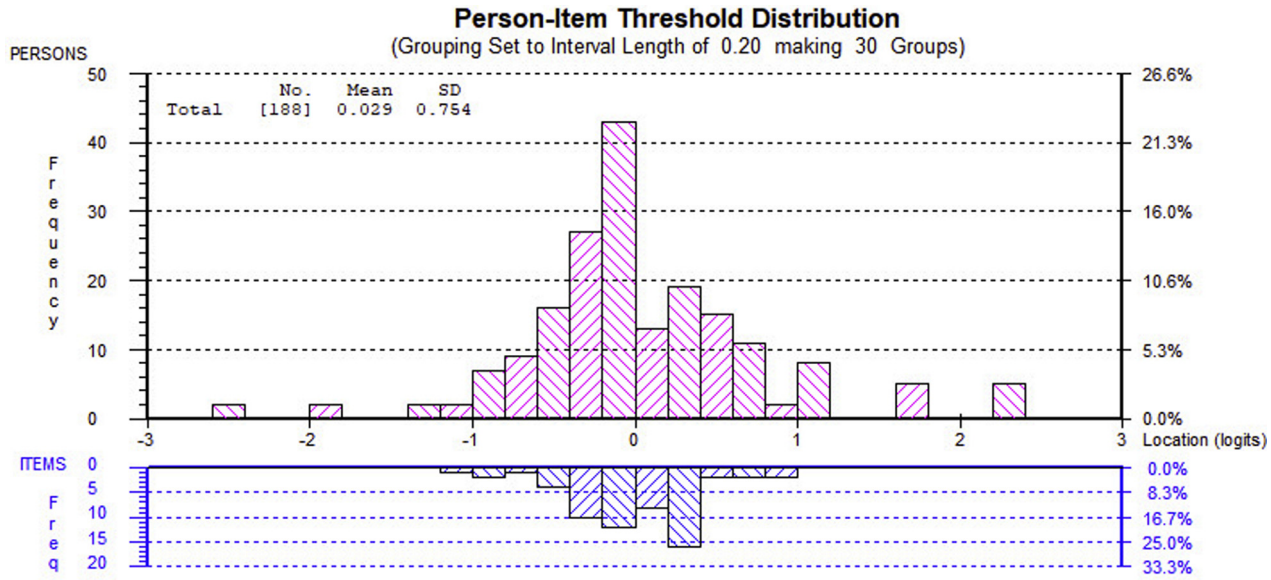

Fig 4 Person-item distribution map for the function subscale of the PRWHE-P showing the distributions of person (top) and item thresholds (bottom) for the function subscale. The average mean person location value of 0.024 suggested that the function subscale was reasonably well-targeted for use with this group.

Test of fit

The current analysis was performed under the partial credit model because the likelihood ratio test was significant ($P<.001$). Table 3 shows the overall summary of fit statistics. Owing to the nature of the Rasch model, responses with missing values were removed during the analysis. Therefore, the actual sample size for Rasch analysis was 184 complete responses for the pain subscale, 188 complete responses for the function subscale, and 191 complete responses for the usual activity subscale. Because the 3-factor model was identified through FA, Rasch analysis was performed on the subscale level instead of the whole questionnaire. Investigation on 3 subscales including pain, function, and usual activity showed an acceptable level of overall fit with mean values ranging from −0.02 to 0.28, and SD values from 0.82 to 1.40. The chi-square tests were not statistically significant after Bonferroni correction ($P<.01$).

The individual fit statistics of each item are listed in table 4. The results indicated that all individual items in each subscale showed good fit with fit residuals within ±2.5 logits except for item 9 in the function scale. However,

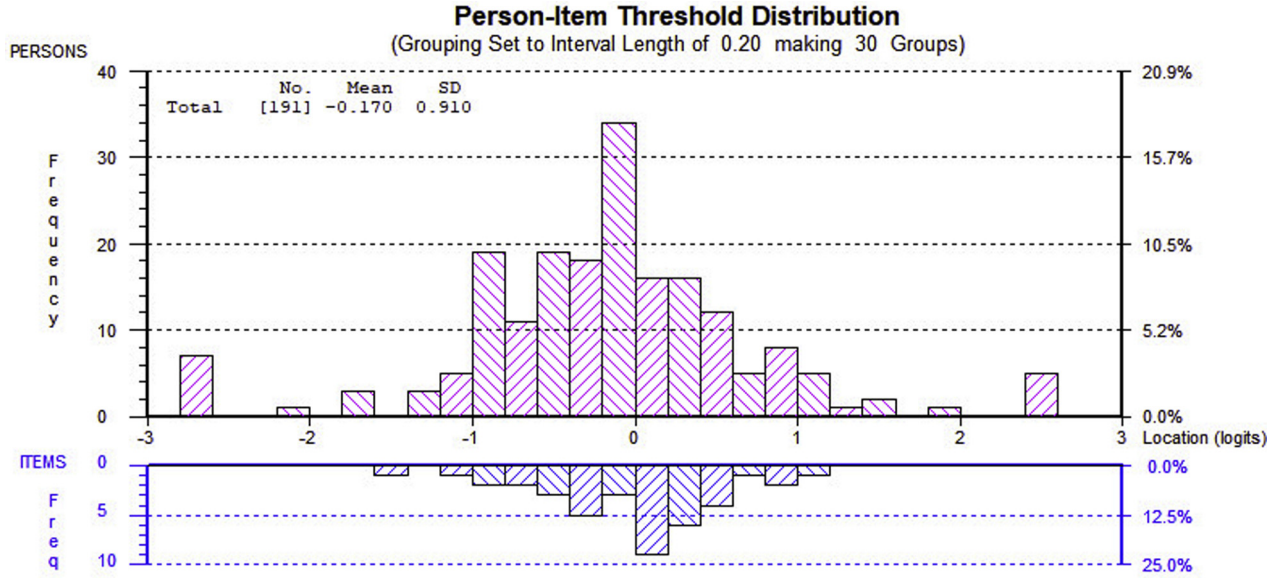

Fig 5 Person-item distribution map for usual activity subscale of the PRWHE-Persian showing the distributions of person (top) and item thresholds (bottom) for the usual activity subscale. The average mean person location value of −0.152 suggested that the function subscale was reasonably well-targeted for use with this group, with patients averaging at a slightly lower level of performing usual activities than the average of the scale items (0 logits).

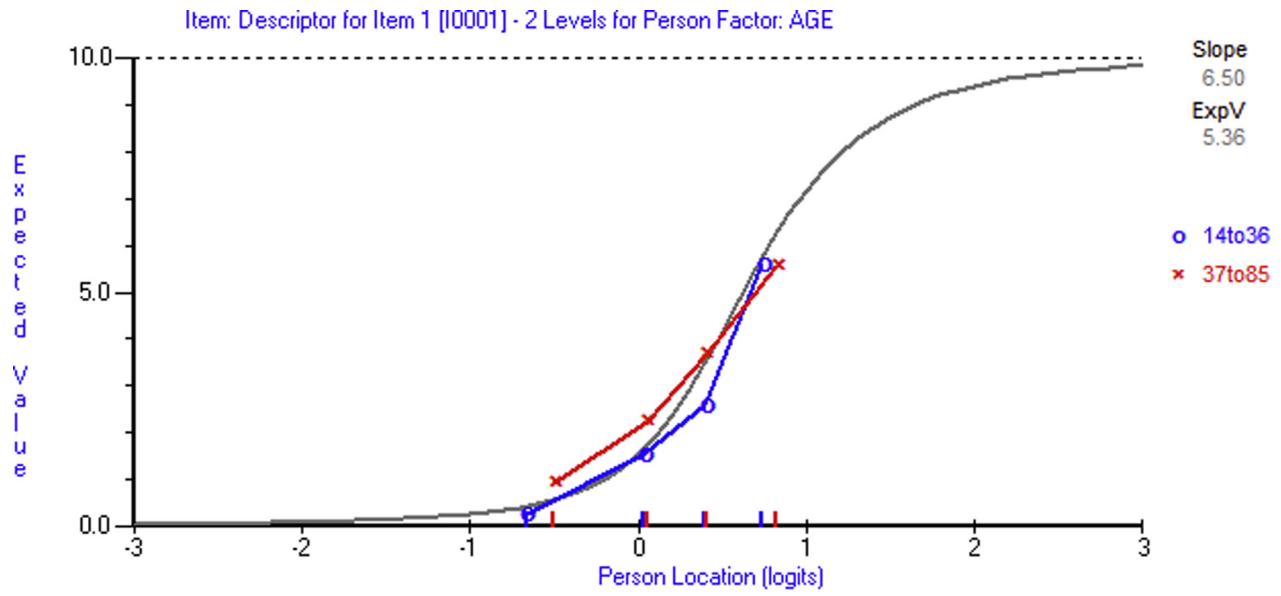

Fig 6 DIF for item 1 of the PRWHE-P for 2 age groups (14-36y and 36-85y). Groups of responders (2 age groups) across the trait were plotted against the expected model curve (ICC). Inspection of the graph suggests that the 2 age groups are equal in endorsing this item at equal levels of the overall attribute. There were no differences detected.

because the *P* value was not significant after Bonferroni correction, item 9 was kept in the questionnaire without further modification. Consequently, no further strategies were required at this stage.

Dimensionality

The 3 subscales (pain, function, usual activity) all demonstrated unidimensionality, as nearly 4% to 5% of the independent *t* tests were found to be significant at the 5% level (see table 3). However, the overall PRWHE failed to meet the unidimensional assumption, indicating that the PRWHE should be considered as 3 separate subscales.

Targeting

The targeting of 3 subscales of the PRWHE-P is illustrated in the figure of person-item threshold distribution (figs 3-5). The mean person measure was 0.22±0.63 and 0.03±0.75 logits, indicating that the total scores of the pain and function scales from participants were slightly higher than the target of the scale. This suggested that the pain and function scores overestimated person traits. However, we also identified that the usual activity subscale underestimated person traits given a negative mean value as −0.17±0.91. The range of item difficulty as shown on the bottom was not able to cover the entire range of the respondents' ability, indicating that the PRWHE-P needs both more difficult and easier items to capture the full extent of wrist and hand functioning.

DIF

The person factors were set as 2 age groups (14-36y and 37-85y for equal distribution of the study sample), sex (male and female), the affected side (left and right), and dominant hand (left and right). The DIF was examined using both critical statistical values (0.003 after Bonferroni correction) and visual inspection. The visual inspection was facilitated by plotting the ICC along with the person trait for given person factors. An example of ICC is shown in figure 6, which illustrates the DIF of item 1 with age as the person factor. Neither uniform nor nonuniform DIF existed in the PRWHE-P for the factors examined.

Reliability

Both PSI and Cronbach's alpha values exceeded 0.8, suggesting that all subscales of the PRWHE-P were internally consistent and reliable (see table 4 for details).

Discussion

This study provides new information on factor structure and dimensionality of factors of the PRWHE. The FA demonstrated that a 3-factor solution aligned with the individual subscale structure provided the best fit. Although the usual and specific activities can be summed into a function score, our results suggest it is better to interpret the subscales separately. Similarly, although many authors prefer to report the total score, from a measurement perspective this is not as valid as presenting the 3 subscales.

Our findings of a 3-factor structure have been reported in other versions, including the English,[11] Turkish,[9] and Dutch[8] versions. Despite the agreement regarding a 3-factor structure, it may be difficult to convince researchers to avoid the use of a single score in statistical analyses in which 1 outcome score is often preferable. This might be justified when considering the need for a primary outcome and the fact that our higher order FA indicated the presence of a higher order construct that encompassed the 3 subscales.

Separating the subscales as separate constructs might be more important in clinical applications, because pain, ability to perform specific activities, and ability to perform one's usual activities may differ for important reasons.

One of the benefits of the 3-structure model of the PRWHE is that the subscales are aligned with the International Classification of Functioning, Disability and Health (ICF) conceptual framework. The ICF considers disability an interaction of impairment, activity limitation, and participation restriction.[35] The specific activities subscale focuses on tasks and activities, and the usual activity, which is consistent with participation domains of the ICF. Although there is no hand outcome measure that captures all the items from the ICF Hand Core Set,[36] the PRWHE covers all 3 domains of function based on the ICF.[35] Because participation is an overarching goal related to the level of impairment and activity and is highly influenced by personal and environmental factors,[37,38] it is appropriate to be evaluated as a different subscale. Therefore, when considering the CFA and theoretical models, the structure of the PRWHE is supported. For example, when placing the 3 subscales in an ICF conceptual model, pain is considered impairment, specific activities would fall under activity, and usual activities reflect more of a participation level. This provides a conceptual basis for the separation of these 3 factors in our CFA.

Our Rasch analysis provided some confirmation of the structural validity findings in that it also confirmed a 3-factor structure. Additional information about the measurement properties found from including a Rasch analysis were the strong reliability, internal consistency, and lack of DIF. Our results of satisfactory reliability (item reliability, 0.82; person reliability, 0.83) corroborate the findings of Packham and MacDermid, who conducted a Rasch analysis on the PRWHE using 264 patient records representing a mixture of wrist and hand injuries and found good to excellent reliability of the scale.[11]

The result of Rasch analysis did not confirm the targeting of the PRWHE in our sample. The results suggested that the pain scores overestimated person traits. However, the usual activity subscale underestimated person traits. This can be the result of evaluation time, which was more than 2 months after injury. The patients will recover and adapt with the activities, so the activities embedded in items are not challenging for the patients. This is the opposite of pain, as persistent pain and pain with movement is a potential sequel of hand injuries. Thus, overall, the PRWHE with 3 subscales demonstrated good measurement properties, including reliability, construct validity, and dimensionality, that are consistent with that proposed in the original development of the scale and the validation of the Persian version.[39,40]

Study limitations

This study represents the initial data analysis of a convenience sample. However, it may be influenced by selection bias. The questionnaire was not given to all patients who presented in the study period. Therefore, the data may not represent an accurate cross-sectional study. Because of the limited variations of diagnosis, DIF could not be evaluated for different wrist and hand conditions.

Conclusions

The PRWHE-P is a reliable and valid assessment tool and can be used in patients with different wrist and hand disabilities. Also, it is better to define disability using 3 separate subscales (pain, specific activities, usual activities) rather than summarizing the scale into pain and function.

Suppliers

a. SPSS, version 26; IBM Corp.
b. LISREL; Scientific Software International, Inc.
c. RUMM2030; RUMM Laboratory Pty Ltd.

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