



Original article

Confirmatory factor analysis of VISA-P scale and measurement invariance across sexes in athletes with patellar tendinopathy

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Abstract

Purpose: The Victorian Institute of Sport Assessment-Patella (VISA-P) scale is the most condition-specific patient-reported outcome measure used to assess symptom severity in athletes with patellar tendinopathy. Previous exploratory factor analyses have been conducted to evaluate the scale's dimensionality, with inconsistent results, and the factor structure of the scale remains unclear. The aims of the present study were to determine the factorial structure of the VISA-P scale using confirmatory factor analysis (CFA) and test measurement invariance across sexes.

Methods: The study included a convenience sample of 249 Spanish athletes with patellar tendinopathy. CFA was performed to assess factorial validity. Hypothesized 1- and 2-factor models were tested. Measurement invariance across sexes was evaluated via multi-group CFA with several fit indices using EQS 6.1 software.

Results: The internal consistency coefficient was 0.74. Several CFA models were examined and the 1-factor model in which errors for items 7 and 8 were correlated showed acceptable fit in terms of comparative fit index (CFI) and goodness-of-fit index (GFI) statistics (CFI = 0.93; GFI = 0.94; standardized root mean square residual = 0.06; root mean square error of approximation = 0.10; 90% confidence interval = 0.08–0.13). This model was invariant across sexes.

Conclusion: The 1-factor model of the Spanish version of the VISA-P scale (VISA-P-Sp) in which errors for items 7 and 8 were correlated demonstrated relative fit in CFA. Scores obtained via VISA-P-Sp can be compared between men and women without sex bias. Further studies should examine the VISA-P scale and other single-score patient-reported outcome measures concurrently.

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Keywords: Jumper's knee; Measurement invariance; Patient-reported outcome measure; Structural validity

1. Introduction

Patellar tendinopathy is a common overuse injury in sports, particularly in jumping athletes.¹ In addition to other means of objective measurement, the use of patient-reported outcome measures (PROMs) has become increasingly important in assessing patients' health status in recent years.² For example, structural changes in patellar tendinopathy can be studied using ultrasound or magnetic resonance imaging, but image findings and clinical symptoms are not always consistent.³ In order to

capture the patient experience, the use of PROMs in clinical practice and research is highly recommended.⁴

The Victorian Institute of Sport Assessment-Patella (VISA-P) scale is the only condition-specific scale for patellar tendinopathy.⁵ It has become the most widely used PROM in symptom severity assessment and the monitoring of changes related to injury over time.⁶ Nowadays, several versions of the VISA-P scale are available.^{7–14}

The Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) initiative established a set of standards, which are to be followed in studies assessing the psychometric properties of health-related patient-reported outcomes (PROs).¹⁵ One of these properties is the construct validity, defined as “the degree to which a health-related PRO instrument measures the construct(s) it purports to measure”.

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With respect to the validity of the VISA-P scale, the consensus among experts is that it is a good measure of symptom severity in patellar tendinopathy.⁶ The VISA-P scale can differentiate scores from various well-known groups (e.g., healthy individuals vs. those with tendinopathy) but is not a diagnostic tool. It has been found to be strongly correlated with other standardized instruments used to assess orthopedic knee disorders (Lysholm and Modified Blazina scales), in addition to the physical components of the Short Form-36 Health Survey; this indicates good construct validity.^{11,12}

However the factor structure of the VISA-P scale remains unclear. Factor structure can contribute strongly to the assessment of construct validity and is referred to as “the degree to which the scores of a health-related PRO instrument are an adequate reflection of the dimensionality of the construct to be measured.”¹⁵ In health and sports medicine, PROs are often measured indirectly through their manifestations, also called “latent variables” or “constructs”.⁴

Since its original publication, the scale has generated a single final score for patellar tendinopathy severity, measuring this phenomenon quantified by the set of 8 items. There are no subscales, suggesting a one-dimensional design and use for this instrument. However, there was no technical information regarding dimensionality provided in the original study.⁵ Controversy surrounds the scale’s underlying factors and item distribution by factor, due to the publication of various cross-cultural adaptations using exploratory factorial analysis (EFA).

Specifically, four cross-cultural adaptation studies have analyzed the factor structure of the VISA-P scale but their findings were inconsistent.^{7,9,11,12} In all cases, a 2-factor solution was drawn, allowing explanation of between 64.5% (Dutch) and 85.6% (Greek) of the variance. In Swedish and Dutch studies, factor loadings for the item 1 (no pain while sitting) were incongruent. Therefore, the authors forced a 3-factor solution, accounting for 74.6% and 85% of the variance in the Dutch and Swedish studies, respectively.

Factor descriptions and the assignment of items to factors are also controversial issues: a Spanish study reported that items 1–6 belong to the first factor (pain during activities), and items 7 and 8 belong to the second (sport participation). The distribution was very similar to that of the Dutch VISA-P scale adaptation, with the exception of item 1, which was assigned to an independent factor (pain while sitting). In the Swedish study, there were two factors with single items: sit pain free (item 1) and currently undertaking sports (item 7). The third factor included the six remaining items. In their discussion of the results, the Swedish authors suggested that item 1 may have been an artifact and should be considered in the first factor. In the Greek adaptation study, the first factor was pain/symptoms during functional load and sports participation and included 6 items (2 and 4–8). A second identified factor, symptoms during static loading, included items 1 and 3. However, they repeated the analysis excluding the other knee injury group from the analysis. In this case, only one factor, which explained 80.8% of the total variance, was identified, and in a forced 2-factor solution, the second factor included item 7 alone.

To date, there is no consensus with respect to the number of factors underlying the concept (or construct) of symptom severity in patellar tendinopathy, and assessment of VISA-P scale factor structure is required.

These studies employed EFA (principal components with varimax rotation), a statistical method that provides an initial, or exploratory, indication as to whether the items of a PROM are representative of single or multiple factors or constructs. This EFA process requires a smaller sample and indicates the direction for the more thorough confirmatory factor analysis (CFA), a statistical process that uses assumptions, modeling, and estimations to determine whether a questionnaire has a multifaceted or single unitary structure.¹⁶

This variability in the results of the analysis of VISA-P scale factor structure and the recommendations of the COSMIN initiative suggest that it is necessary to perform new analyses to clarify this attribute of validity. Therefore, the aim of the present study was to determine the factor structure of the VISA-P scale using CFA. As a secondary consideration, and due to the potential sex differences in pain perception and tolerance reported in the literature,^{17,18} we assessed measurement invariance in VISA-P scale scores across sexes using multi-group confirmatory factor analysis (MG-CFA).

2. Methods

2.1. Participants

A cross-sectional convenience sample was recruited. Between January 2012 and October 2014, data were collected from patients of 5 sports medicine clinics and members of 15 sports teams (volleyball, handball, and basketball) across various geographic zones in Spain.

Consecutive athletes with patellar tendinopathy who had undergone physiotherapy treatment were eligible if they were aged at least 18 years; had a history of continuous pain for at least 3 months or recurrent pain for at least 6 months at the inferior pole of the patella;¹⁹ were physically active at least three times a week prior to the tendinopathy episode; and were able to read and provide written informed consent. We restricted participation to patients who had been clinically diagnosed with patellar tendinopathy, and tendinosis was verified via ultrasound or magnetic resonance imaging. We focused on the more severely affected patella in athletes with bilateral patellar tendinopathy. Participants with inflammatory conditions, a history of previous knee surgery, or symptoms other than those of patellar tendinopathy were excluded.

2.2. Instrument

The VISA-P scale was developed in Australia by the Victorian Institute of Sport Assessment to quantify symptom severity in athletes with patellar tendinopathy.⁵ This brief, self-administered questionnaire consists of eight items; six are used to evaluate pain levels or disability in daily activities and specific functional tests and two provide information regarding ability to play sport. Response options for each item are provided on a numeric rating scale (from 0 to 10), with higher scores indicating lower levels of pain or disability for all items

other than 7 and 8, for which options have weighted scores. Item 7 has four possible rating levels (0, 4, 7, and 10). Item 8 is divided into three assumptions (A, B, and C), from which only one is chosen according to the impact of pain on engagement in sport; this holds greater weight in the final score range (0–30 on a Likert scale). The maximum score possible is 100 points and represents an asymptomatic athlete who can fully engage in sports. The theoretical minimum is 0 point.

2.3. Procedure

Participants completed a questionnaire, which recorded demographic and clinical data related to patellar tendinopathy, and the VISA-P scale during the first visit to medical staff members employed by the clinics and sports teams. Each patient was fully informed of the confidentiality of their responses and the voluntary nature of their participation. Written informed consent was obtained from the participants before data collection. Ethical approval for the study was granted by the Ethics and Experimental Research Committee at Miguel Hernandez University.

2.4. Statistics

The normality, or distribution, of the VISA-P scale item scores was examined by obtaining univariate skewness and kurtosis values. According to Finney and DiStefano,²⁰ univariate skewness of greater than 2 and kurtosis of greater than 7 indicate non-normal distribution. Moreover, Mardia's normalized multivariate kurtosis coefficient was calculated, whereby a value greater than 3 indicates non-normal distribution.²¹ In addition, Cronbach's α was used to estimate the internal consistency of the scale.

Subsequent to these analyses, CFA was performed to investigate the internal structure of VISA-P scale items in a Spanish sample; the maximum likelihood estimation method was used to evaluate the fit of two hypothesized models. The first was an original 1-factor model used in clinical practice to determine symptom severity via the VISA-P scale;⁵ this method was also used by Korakakis et al.¹² in their exploratory analysis. The second was an alternative 2-factor model that has been considered in other exploratory studies, with a second dimension, sport participation, containing items 7 and 8.^{11,12} MGCFA was used to examine the equivalence (measurement invariance) of the VISA-P scale across sexes. The present study adhered to the sequence recommended in other invariance studies^{22,23} as follows: (1) test the CFA model separately in each group, (2) conduct the simultaneous test of equal form (form invariance), (3) assess the equality of factor loadings, (4) assess the equality of intercepts, (5) assess the equality of errors, (6) assess the equality of factor variance, and (7) assess the equality of latent means.

The extent of factorial invariance was determined using χ^2 differences between two nested models, via a based likelihood ratio test. A nonsignificant result indicates that there is no difference in fit between the constrained and unconstrained models. However, the χ^2 test is fairly sensitive to sample size; therefore, the adequacy of the fit of the model was evaluated

using the following fit indices:^{24,25} relative chi-squared (χ^2/df), the comparative fit index (CFI), the goodness-of-fit index (GFI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA) including confidence interval. Further, when the CFI difference (ΔCFI) was larger than 0.01, model misfit was identified.²⁶ Conventional guidelines suggest that a good fit is indicated with CFI values between 0.90 and 0.95 and SRMR values of less than 0.08.²⁷ RMSEA values of less than 0.06 indicate a good fit, and those of 0.08 or more indicate a reasonable fit.²⁸ The criterion for acceptance of a model was a χ^2/df ratio of less than 3; however, this cutoff value varies across studies, ranging from greater than 2 to less than 5.^{28,29} In all cases, results were considered statistically significant when the probability value was less than or equal to 0.01. Statistical analyses were performed using EQS 6.1 (version 6.1; Structural Equation Modeling Software, Encino, CA, USA) for CFA and MGCFA and SPSS 17.0 (SPSS Inc., Chicago, IL, USA) for descriptive statistics.

There are no absolute guidelines regarding the minimum sample size required for CFA.³⁰ Some authors have reported sample sizes of approximately 100–150 or 10 participants per questionnaire item.³¹ Nevertheless, a sample size of at least 200 participants has also been recommended, and a considerably higher number of participants may be required for models involving many variables, latent factors, or estimated parameters.¹⁶ In this study, thresholds of at least 10 participants per VISA-P scale item and no fewer than 100 overall were applied for CFA, as suggested by Gorsuch.³²

3. Results

3.1. Descriptive statistics

The sample population was predominantly male (59.4%); the participants' mean ages were 30.2 ± 8.2 years for men and 27.5 ± 7.8 years for women. The majority of the participants (75.5%) were recruited from sports medicine clinics. Participants' ($n = 249$) descriptive and clinical characteristics are shown in Table 1. Cronbach's α was 0.74 for all VISA-P scale items.

3.2. Multivariate normality and assumptions

Table 2 shows the range of values for univariate skewness and kurtosis, as well as Mardia's normalized multivariate kurtosis values. Univariate skewness and kurtosis values indicated univariate normality. There was no evidence of multivariate non-normality.

3.3. Confirmatory factor analysis

3.3.1. Evaluating 1- and 2-factor solutions

CFA was conducted to evaluate the fit of two hypothesized models. The results obtained for these models are shown in Table 3. The data indicated that the 1-factor model obtained a relative fit, and the errors for items 7 and 8 were correlated (i.e., not independent). Therefore, an alternative 1-factor model that allowed for correlation of the errors for items 7 and 8 was tested (Fig. 1). The 1-model fit with errors correlated was adequate with respect to the GFI and CFI statistics, which was also the

Table 1
Descriptive characteristics of the study population ($n = 249$).

	Men ($n = 148$, 59.4%)	Women ($n = 101$, 40.6%)
Age (year) ^a	30.2 ± 8.2	27.5 ± 7.8
Height (cm) ^a	1.8 ± 0.1	1.7 ± 0.1
Weight (kg) ^a	80.0 ± 11.2	64.6 ± 9.4
Body mass index (kg/m ²) ^a	23.9 ± 2.4	21.9 ± 1.8
Chronicity (month) ^a	19.3 ± 22.1	17.6 ± 14.6
VISA-P scale baseline (point) ^a	46.0 ± 17.3	46.5 ± 17.1
Discipline ^b		
Volleyball	29 (19.6)	18 (17.8)
Basketball	14 (9.5)	20 (19.8)
Athletics	30 (20.3)	23 (22.8)
Soccer	32 (21.6)	6 (5.9)
Other	43 (29.0)	34 (33.7)
Training volume ^a		
Day/week	4.4 ± 1.3	4.1 ± 1.1
h/day	2.0 ± 0.9	1.8 ± 0.8
Side of injury ^b		
Right	85 (57.4)	61 (60.4)
Left	63 (42.6)	40 (39.6)
First episode ^b		
Yes	104 (70.3)	70 (69.3)
No	44 (29.7)	31 (30.7)

^a Data are presented as mean ± SD.

^b Data are presented as mean with range or frequency (%) in brackets.

Abbreviations: VISA-P scale = the Victorian Institute of Sport Assessment-Patella Scale.

case for the 2-factor model. The error, in terms of the RMSEA statistic, was within the upper accepted limits. However, χ^2 values for the model remained significant, suggesting some degree of misfit.

Table 2
Values for the normality tests of the Victorian Institute of Sport Assessment-Patella (VISA-P) scale scores.

	Total	Men	Women
Univariate			
Skewness	-0.26 to 0.53	-0.20 to 0.60	-0.39 to 0.49
Kurtosis	-0.35 to -0.69	-1.26 to -0.60	-1.10 to -0.39
Multivariate kurtosis	2.74	-0.36	2.81

Table 3
Goodness-of-fit indices in the confirmatory factor analysis of the VISA-P scale for all sample ($n = 249$).

	1-factor	1-factor*	2-factor
χ^2	157.38	67.94	67.94
df	20	19	19
p	<0.01	<0.01	<0.01
χ^2/df	7.86	3.57	3.57
CFI	0.80	0.93	0.93
GFI	0.87	0.94	0.94
RMSEA (95%CI)	0.17 (0.14–0.19)	0.10 (0.08–0.13)	0.10 (0.08–0.13)
SRMR	0.10	0.06	0.06

* 1-factor model with errors for items 7 and 8 correlated.

Abbreviations: VISA-P scale = the Victorian Institute of Sport Assessment-Patella Scale; CFI = comparative fit index; GFI = goodness-of-fit index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual.

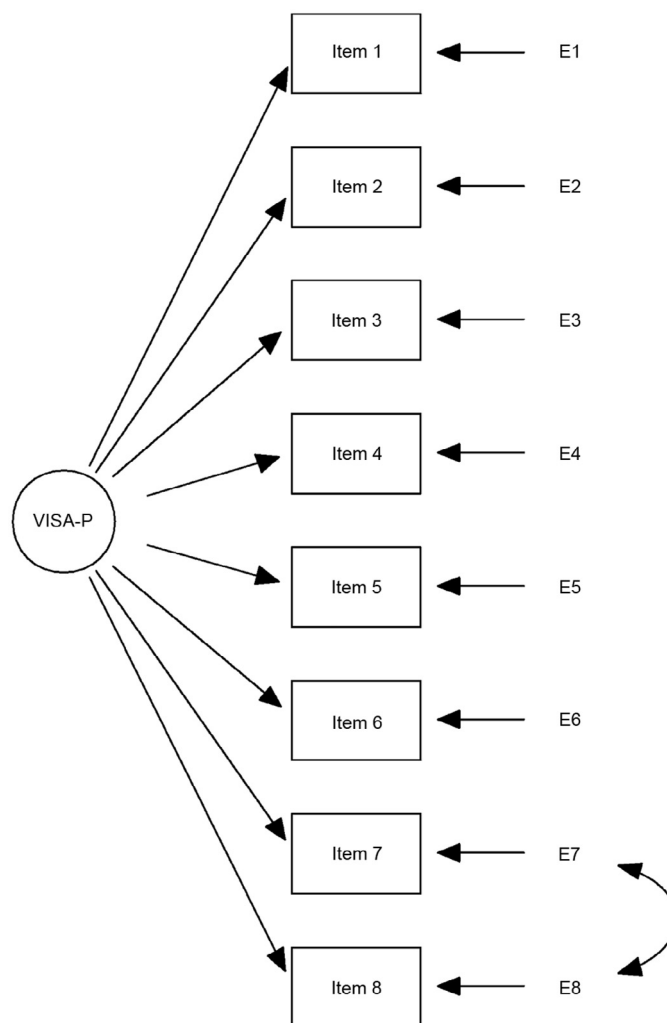


Fig. 1. The 1-factor model with errors of items 7 and 8 correlated (final model). VISA-P scale = the Victorian Institute of Sport Assessment-Patella Scale.

This indicates that items 7 and 8 are closely interrelated (i.e., they share more with each other than they do with the remaining six items), which suggests that the items may not all measure the same construct. This could be the reason why the 1-factor model with correlation of the errors for items 7 and 8 fits equally as well as the 2-factor model. Nevertheless, a factor with only two indicators appears weak, as it is generally accepted that definition of a factor requires at least three variables.^{31,33}

Factor loadings for 1-factor model modified related to the VISA-P scale scores for the total sample are shown in Table 4.

3.3.2. Measurement invariance across sexes

Subsequent to identification of the VISA-P scale model with the best fit, and considering the parsimony model principle, measurement invariance was assessed across sexes for the 1-factor adjusted model (with correlation of the errors for items 7 and 8), using the sequential strategy described by Meredith and Teresi.²³

One-factor theoretical model was assessed separately for each level of the sex variable. Initial testing of the hypothesized

Table 4
Factor loadings for the latent variables of the Victorian Institute of Sport Assessment-Patella Scale for all samples and across sexes.

Item	Statement	Loading		
		Total	Men	Women
1	For how long can you sit pain free?	0.47	0.50	0.43
2	Do you have pain walking downstairs with normal gait cycle?	0.71	0.67	0.71
3	Do you have pain at the knee with full active non-weight bearing knee extension?	0.54	0.55	0.52
4	Do you have pain when doing a full weight-bearing lunge?	0.73	0.68	0.76
5	Do you have problems squatting?	0.73	0.56	0.82
6	Do you have pain during or immediately after doing 10 single leg hops?	0.85	0.87	0.84
7	Are you currently undertaking sport or other physical activity?	0.25	0.34	0.25
8	For how long can you manage being train/physically active?	0.41	0.32	0.44

model for both men and women indicated a marginally good fit to the data. A review of the Lagrange Multiplier (LM) test results (i.e., indices of model misfit) revealed that the error covariance between items 7 and 8 was markedly misspecified.

Given the obvious relationship between items 7 and 8, the model was respecified and re-estimated with the error covariance included. This reparametrization resulted in an improvement in the fit of the model (Table 5). Factor loadings across sexes are shown in Table 4.

Configural or factorial invariance analysis was conducted across sexes to determine whether the factor structure of the VISA-P scale was the same for both men and women.

A baseline model (M1) with no equality constraints across sex subsamples was tested, revealing that the model fit the data reasonably well, with a CFI value of almost 0.95, an SRMR value of almost 0.07, and an RMSEA value of less than 0.10 (Table 6). Thereafter, all free factor loadings were constrained to be equal across groups (M2). The fit of this model was also reasonable. Therefore, the χ^2 difference test ($\Delta\chi^2$) indicated a nonsignificant difference between the model with factor loadings constrained and the modified baseline model ($p > 0.01$). The factor loadings and intercepts were both constrained to be equal across groups (M3). The $\Delta\chi^2$ test for M3 and M2 indicated that the factor loadings and intercepts were equivalent across groups ($p > 0.01$). The model with factor loadings, intercept, and error variance constrained (M4) was fit to the data; the $\Delta\chi^2$ test indicated a nonsignificant difference between this model and M3. The models with factor variance (M5) and factor means (M6) constrained were then fit to the data;

Table 5
Goodness-of-fit indices in the confirmatory factor analyses of the VISA-P scale across sexes.

CFA	Men		Women	
	1-factor	1-factor*	1-factor	1-factor*
χ^2	85.54	37.63	68.42	31.93
<i>n</i>	101		101	
<i>df</i>	20	19	20	19
χ^2/df	3.43	1.78	3.42	1.66
<i>p</i>	<0.01	0.01	<0.01	0.03
CFI	0.74	0.92	0.84	0.96
GFI	0.84	0.91	0.86	0.93
RMSEA (95%CI)	0.18 (0.14–0.22)	0.10 (0.05–0.15)	0.16 (0.12–0.20)	0.08 (0.02–0.13)
SRMR	0.11	0.07	0.10	0.06

* 1-factor model with errors for items 7 and 8 correlated.

Abbreviations: VISA-P scale = the Victorian Institute of Sport Assessment-Patella Scale; CFA = confirmatory factor analysis; CFI = comparative fit index; GFI = goodness-of-fit index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual.

Table 6
Invariance constraints across sexes.

Invariance level	Model	χ^2	<i>df</i>	<i>p</i>	CFI	GFI	RMSEA (90%CI)	SRMR	$\Delta\chi^2$	Δdf	<i>p</i>	ΔCFI
Configural	M1: free model (baseline) with E7/E8 correlated	69.55	38	<0.01	0.94	0.92	0.091 (0.06–0.12)	0.07	NA	NA		
Metric	M2: M1 with factor loadings constrained	77.22	45	<0.01	0.94	0.91	0.087 (0.05–0.12)	0.09	7.67	7	0.36	<0.01
Scalar	M3: M1 with factor loadings and intercepts constrained	82.92	52	<0.01	0.94	0.91	0.085 (0.05–0.12)	0.08	5.70	7	0.58	<0.01
Equal error variances	M4: M1 with factor loadings, intercept and error variances constrained	99.77	60	<0.01	0.92	0.89	0.088 (0.06–0.12)	0.09	16.85	8	0.03	0.016
Equal factor variances	M5: M4 with factor variances invariance constrained	99.83	61	<0.01	0.93	0.89	0.086 (0.06–0.11)	0.09	0.06	1	0.81	<0.01
Equal latent means	M6: M5 with factor means constrained	99.95	62	<0.01	0.93	0.89	0.084 (0.05–0.11)	0.09	0.12	1	0.73	<0.01

Abbreviations: CFI = comparative fit index; GFI = goodness-of-fit index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual; ΔCFI = comparative fit index difference.

nonsignificant differences between M4 and M5 and M5 and M6 were observed. All goodness-of-fit indices indicated that all of the tested models that assumed different degrees of invariance were acceptable. None of the factor loading differences between sexes were statistically significant. Moreover, nonsignificant differences in latent means between men and women were observed. Therefore, formal and measurement invariance across sex was evidenced for the VISA-P scale.

4. Discussion

The VISA-P scale is a condition-specific questionnaire that is used as a one-dimensional tool.⁵ In clinical practice, the final VISA-P scale is used to monitor clinical severity and the progress of symptoms in athletes with patellar tendinopathy³⁴ and is even used as a criterion for return to play sport.³⁵ Results of previous EFA^{7,9,11,12} of the VISA-P scale have not reached consensus with respect to the dimensions underlying the severity of symptoms quantified by the scale.

This study represents a first attempt to examine the factor structure of the VISA-P scale using CFA, which is a multivariate statistical method that contributes to robust determination of the latent factors underlying clinical concepts.²⁴

Our findings support the one-dimensional model of the VISA-P scale. This result is congruent with that of a study conducted by Korakakis et al.,¹² in which a 1-factor solution was obtained when participants with other knee injuries were excluded from EFA. This single-factor solution explained a very high proportion of the variance. As suggested by the authors, the existence of different symptom/severity constructs in the other knee injury group may have affected factorial validity. For this reason, the current sample consisted solely of athletes with patellar tendinopathy.

Some of the results about dimensionality study require attention. In the adjusted one-dimensional model, the factor loading for item 7 appeared to indicate different behavior from that of the other items. Korakakis et al.¹² considered this possibility when they forced a 2-factor solution in their exploratory analysis. It appears that item 7 was the main indicator in the scale for reporting "sports participation". The conflicting CFA results for this item may have occurred as a result of the scoring formula. Four values (0, 4, 7, or 10) are used to rate item 7, and this could affect the variability of the scores, in that the item is unable to reflect variability in athletes' responses or situations. Future validity studies could focus on different ways to rate this item or test various response formats to clarify this issue.

With respect to the choice of the resultant model with correlated errors in CFA, considering the statistical principle of parsimony, when two models have similar fit indices, the model with fewer free parameters is preferred.³⁶ Therefore, the results of this study support a single-factor model for the VISA-P scale and suggest that it should be considered a one-dimensional instrument. However, as the scale reports on pain and disability as well as sports participation and the limitation thereof, it may reflect the impact of patellar tendinopathy on athletes' activity (disability) more realistically. Given these results, it would be interesting, as well as consistent with the International Classification of Functioning, Disability and Health (ICF), to explore

more indicators of sports participation⁶ and resubmit the scale to new analyses. Some recently published PROMs, such as the Lower Limb Functional Index, have already addressed this aspect of participation.³⁷

Previous research has reported sex differences in pain intensity, tolerance, duration, and thresholds.^{17,18} In addition, Knobloch et al.³⁸ observed a gender-specific differential response to 12 weeks of eccentric training in patients with Achilles tendinopathy: VISA-Achilles scores revealed that, relative to men, symptomatic women reported lower pain reduction and less improvement. Taking these sex differences and their potential influence on VISA-P scale pain item scores into account, the second aim of the present study was to examine measurement invariance in the model with the best fit. According to Cheung and Rensvold,²⁶ a difference of <0.01 in CFI values indicates that the invariance hypothesis should not be rejected, and definite differences exist when differences in CFI values are >0.02 . Considering this rule, manifest mean levels, latent mean comparisons, and results indicating that VISA-P scale items have the same meanings across sexes suggest that comparison across sexes is meaningful. This is an important finding, as differences in observed scores between men and women may not be directly comparable without evidence of measurement invariance across sexes.³⁹

There is a possibility that the sex differences in pain reported in the literature are less pronounced in athletes.⁴⁰ The physical effort, coping strategies, greater motivation, and increased pain tolerance and thresholds inherent in athletes may contribute to homogeneous behavior in men and women.⁴¹ Nevertheless, VISA-P scales were not affected by sex in our study.

The following limitations should be considered when interpreting these results. We employed a convenience sample of Spanish injured athletes, which may not have been representative of all athletes with patellar tendinopathy. It is unclear whether these results could be generalized to other populations in terms of ethnicity, sport discipline, or geographical area. With a larger sample size, it would be interesting to examine the factorial invariance of the VISA-P scale across ages (e.g., adolescents, adults, and older adults) and severity subgroups (e.g., competitive and recreational athletes) to identify potential differences in latent variables. In addition, the lack of assessment of different subgroups according to clinical characteristics and psychological and socio-demographic status is another potential limitation. Accordingly, such measurement of invariance would be desirable to avoid misinterpretation of differences in VISA-P scale between athletes from different countries and cultures.

5. Conclusion

The results of the present study indicated that the original 1-factor model of the VISA-P scale showed relative fit in a sample of Spanish athletes with chronic patellar tendinopathy. However some data suggested that additional factors could represent the underlying structure of the scale more accurately; therefore, further research is required. In addition, the 1-factor VISA-P scale structure with correlation of the errors for items 7 and 8 was invariant across sexes, which indicates that men and

women share a uniform structure of symptom severity, and their VISA-P scale can be compared while avoiding sex bias. Further larger studies are required to examine the VISA-P scale and other PRO measures with a single score concurrently.

Authors' contributions

MDH and SHS conceived the study and wrote the first draft of the manuscript; MDH and ACV carried out the statistical analyses; SHS, FA, JSI, and VS contributed to the acquisition of data from sports medicine and physiotherapy clinics; AGC helped to draft and revised the manuscript critically. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

None of the authors declare competing financial interests.

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