Psicothema

Psicothema 2022, Vol. 34, No. 2, 323-331
doi: 10.7334/psicothema2021.21

ISSN 0214 - 9915 CODEN PSOTEG

www.psicothema.com

Article

Psychometric Properties of the PCS and the PCS-4 in Individuals With Musculoskeletal Pain

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Abstract

Background: The factor structure of the Pain Catastrophizing Scale (PCS) has rarely been adequately analyzed (e.g., performing principal component analyses rather than factorial approximations). We aimed to evaluate the psychometric properties of the PCS through a variety of exploratory and confirmatory factorial approaches. **Method:** Three hundred ninety-four Chilean patients with musculoskeletal pain were included (age, M = 49.61, SD = 18.00; 71.57% women). Eight factorial models were proposed to analyze the structure of the data. In addition, validity evidence of the PCS based on relationships with other variables were analyzed considering pain intensity and kinesiophobia. **Results:** The results suggest a unidimensional structure. Models with more than one dimension exhibited undesirable factor loadings or inadequate indices of fit. Based on these results, a short version of the scale composed of 4 items is proposed (PCS-4). The PCS-4 scores demonstrated high levels of invariance between sex, chronicity, and education groups and also were associated with pain and kinesiophobia. **Conclusions:** The results of the PCS-4 Spanish version showed evidence of reliability and validity for adequately measuring pain catastrophizing in Chileans who suffer from musculoskeletal pain. The PCS-4 is a short form that should be explored in future studies (e.g., in other Spanish-speaking populations).

Keywords: Musculoskeletal pain, pain catastrophizing, scale, validity, reliability, factor structure, PCS.

Resumen

Propiedades Psicométricas de la PCS y PCS-4 en Individuos con Dolor Musculoesquelético. **Antecedentes:** la estructura factorial de la Escala de Catastrofización del Dolor (PCS) rara vez se ha analizado adecuadamente. El objetivo de este estudio fue evaluar las propiedades psicométricas del PCS a través de diferentes enfoques factoriales exploratorios y confirmatorios. **Método:** se incluyeron trescientos noventa y cuatro pacientes chilenos con dolor musculoesquelético (edad, M=49,61; DE=18,00; 71,57% mujeres). Se propusieron ocho modelos factoriales. Asimismo, se analizó la evidencia de validez de la PCS basada en relaciones con otras variables considerando la intensidad del dolor y la kinesiofobia. **Resultados:** los resultados sugieren una estructura unidimensional. Los modelos con más de una dimensión mostraron cargas factoriales o índices de ajuste inadecuados. A partir de estos resultados se propone una versión corta de la escala compuesta por 4 ítems (PCS-4). Las puntuaciones de PCS-4 mostraron altos niveles de invarianza entre sexos, cronicidad del dolor y niveles educativos. La PCS-4 también se asoció con otras medias de dolor y kinesiofobia. **Conclusiones:** los resultados de la PCS-4 versión en español mostraron evidencia de fiabilidad y validez para medir adecuadamente el catastrofismo del dolor en chilenos con dolor musculoesquelético. El PCS-4 es una forma corta que debería explorarse en estudios futuros (por ejemplo, en otras poblaciones hispanoparlantes).

Palabras clave: dolor musculoesquelético, catastrofización del dolor, escala, validez, fiabilidad, estructura factorial, PCS.

Musculoskeletal pain is a significant clinical problem and is one of the main causes of medical care and reduced quality of life in those who suffer from it (Blyth et al., 2019). It must be considered that pain perception involves intricate sensory-discriminative, affective-motivational and evaluative-cognitive processes (Raja et al., 2020). This highlights its subjective nature and emphasizes the importance of psychosocial factors in the experience of pain [e.g., kinesiophobia and pain catastrophizing (PC)]. Therefore, assessing pain-related cognitive processes in individuals with musculoskeletal pain becomes important (Bascour-Sandoval et al., 2019). These can modulate the sensory-discriminative and affective-motivational processes, increasing our understanding of pain perception and its chronification mechanisms.

PC was defined as cognitive processing based on negative thoughts and expectations due to pain. This results in a negative evaluation of decision-making ability with pain. All this leads to the belief that an injury can escalate catastrophically (even with minimal stimuli) and that the situation is uncontrollable (Sullivan et al., 1995, 2001). Therefore, PC can be understood as a distortion of cognitive processing that magnifies the negative view of pain, acquiring a disproportionate idea of it (magnification), making it impossible to stop thinking about it (rumination) and limiting the ability to control it (helplessness; Sullivan et al., 2001). High levels

Received: January 19, 2021 • Accepted: January 24, 2022
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of PC have been associated with greater pain intensity (Day & Thorn, 2010), increased risk of developing chronic pain (Burns et al., 2015), greater kinesiophobia (Salvador et al., 2020), increased perception of disability (Wertli et al., 2014) and the loss of the improvement achieved in treatment (Moore et al., 2016).

Sullivan et al. (1995) developed the Pain Catastrophizing Scale (PCS) to evaluate PC. The PCS is one of the most commonly used instruments to measure PC in the clinical field and research. Theoretically, the PCS measures PC as a stable 'trait' variable (Darnall et al., 2017a).

The initial Sullivan analyses of PCS responses supported a three-component structure based only on the PCS's principal components analysis (PCA). Both PCA and exploratory factor analysis (EFA) are variable reduction techniques but are frequently mistaken in this case (Garrido et al., 2013). The surprising thing about this case is that only previous and recent work has accounted for this circumstance (Cook et al., 2021).

The three-component structure of the PCS has been improperly supported several times (García et al., 2008; Ikemoto et al., 2020; Olmedilla et al., 2013). The PCS never obtained robust empirical support for the three mentioned components in an exploratory factorial way (although it did show components or composites, which is different; Widaman, 2007). Later works directly assumed the three-factorial structure as the most suitable. On the one hand, this error is due to the abuse by some researchers of the default configuration of some software in the data reduction section (e.g., SPSS). On the other hand, this error is due to the misuse of the Confirmatory Factor Analysis (CFA), whose strict loading restrictions should be used to answer more specific hypotheses. However, this error is a classic one, and the editors or reviewers usually advise it of the manuscripts during the revision process (Hancock et al., 2010). Nevertheless, this is not the case, so one of the objectives of this study is to support an appropriate factorial structure as far as possible. A proper assessment of the data dimensionality is still lacking (e.g., using parallel analysis; Garrido et al., 2013), with an exploratory factorial strategy (e.g., EFA or ESEM). Then, if appropriate, carry out a confirmatory strategy (e.g., CFA).

In addition to the lack of adequate data structure support, the sociodemographic influences have still not been evaluated in Spanish-speaking samples. Differences in PC have been described according to sex (Sullivan et al., 2001), chronicity (acute pain vs. chronic pain; Sullivan et al., 2001) and education level (Shen et al., 2018). These differences could be related to language barriers (Sehn et al., 2012).

There is evidence that various territorial regions show disparities in economic, sociocultural factors and their healthcare system that differentiate pain-related conditions (Campbell & Edwards, 2012; Size et al., 2007). It has been suggested that cultural and social surroundings could contribute to variations in PC (Ikemoto et al., 2020). Thus, studies are needed in developing countries, such as the Latin American countries, particularly Chile. This contrasts with the fact that most of the evidence comes from developed countries with high GDPs, like the United States, which had a GDP of 21.374 trillion in 2019, or Spain with a GDP of 1.394 trillion in 2019 versus Chile, which had a GDP of 282.318 billion in 2019 (World Bank Group, 2020).

Given the limitations in generalizing the results from previous studies, the general aim of this study is to describe the psychometric properties (validity in terms of its structure and reliability as internal consistency) of the PCS in individuals with musculoskeletal pain. In addition, the validity evidence based on relations with other variables were analyzed considering pain intensity and kinesiophobia because these variables have been linked in behavioral cognitive theoretical models (i.e., fear-avoidance model; Leeuw et al., 2007). Considering previous studies, we anticipate the relation of PC with pain intensity (Monticone et al., 2012; Sullivan et al., 1995) and kinesiophobia (Monticone et al., 2012; Salvador et al., 2020) will be moderate and positive. As a secondary aim, sociodemographic influences in PC were analyzed.

Method

Participants

A sample of 394 individuals with musculoskeletal pain (mean age = 49.61, *SD* = 18.00 years old, 282 women, 71.57%) were recruited for this cross-sectional study by non-probabilistic and consecutive sampling. Participants were contacted at two Chilean university rehabilitation centers at the beginning of treatment. They were diagnosed with a musculoskeletal disorder in 2018-2019 (sociodemographic and clinical characteristics of the sample are presented in Table 1). For the adequate implementation of the confirmatory factor analysis (CFA), a number equal to or greater than 300 participants was needed (Moshagen & Musch, 2014). This number exceeds the recommendations of 10 or 20 participants per item (13 items = 260 participants; Muñiz & Fonseca-Pedrero, 2019). The inclusion criteria were as follows: people aged 18 years or over, permanent residence in Chile, and a medical diagnosis of pathologies of musculoskeletal origin. Individuals who presented a neurological and/or cognitive condition that did not allow for the assessment to be performed adequately were excluded, as well as individuals with a severe uncompensated visual or auditory disability were excluded (*N* = 23). This study had the approval of the Ethics Committee of the *Universidad Autónoma de Chile*, Chile, and was conducted in accordance with the declaration of Helsinki. All participants gave written informed consent. The collected data was anonymized. The responses were stored in a secure server under a unique number so that no participant could be personally identified from the dataset.

Instruments

Pain Catastrophizing. The Spanish version of the PCS (Olmedilla et al., 2013) measured pain catastrophizing. The PCS has 13 questions. These have a response from 0 ("Not at all") to 4 ("All the time"), being expressed as a total score that varies between 0 and 52 points, where the higher score is related to a higher level of catastrophism.

It should be noted that a committee of researchers with expertise in the cultural adaptation of assessment instruments and the authors analyzed the instrument's content, concluding that it was adequate to be applied to the participants. Therefore, the PCS was applied without modifications. Likewise, a qualitative pilot study was carried out from three discussion groups (3-5 participants with musculoskeletal pain for each group) to test the instrument in terms of semantic or grammar errors and the degree of comprehensibility of the instructions and the items (Muñiz & Fonseca-Pedrero, 2019). None of the 12 participants (mean age = 46, *SD* = 15.39 years old) indicated difficulties in completing the scale; these participants were not included in the final sample of this study.

Pain Intensity. Pain intensity was assessed using a visual analog scale (VAS), given that it is a highly reproducible instrument, easy and quick to apply and frequently used in clinical practice (Treede et al., 2019). Pain intensity perceived at rest (VASr), pain intensity during movement (VASm) and average pain intensity in the last 7 days (VAS7d) were evaluated. To evaluate VASr, VASm and VAS7d, the patient was asked to score their pain while remaining still, while performing the movement that causes the most pain and the average of their pain in the last 7 days marking on a solid 100 mm line (0 = "No pain" and 100 = "Worst pain imaginable").

Pain-Related Interference. Pain-related interference, which describes how pain interferes with an individual's daily activities (Treede et al., 2019), was assessed through a VAS (VASi) that on the left end expressed the absence of interference ("Without interference") and on its right end the maximum interference ("Unable to perform my activities").

Pain Duration. Patients were categorized according to the duration of the pain in months as having acute pain (i.e., less than or equal to three months) and chronic pain (i.e., longer than three months).

Kinesiophobia. The Spanish version of the 11-item Tampa Scale for Kinesiophobia (TSK; Gómez-Pérez et al., 2011) was applied to evaluate this variable. Each item is valued on a Likert-type scale ranging from 1 ("Totally disagree") to 4 ("Totally agree"). The score is expressed on a scale of 11 to 44 points, with higher values reflecting greater fear of re-injury. The scale scores showed an adequate internal consistency (Cronbach's Alpha = 0.79 to 0.81; Gómez-Pérez et al., 2011).

Sociodemographic Data Questionnaire. A short questionnaire was used to record the participants' sociodemographic data (i.e., age, sex, years of formal education, type of musculoskeletal disorder and occupation).

Procedure

During the first session of treatment at the rehabilitation centers, the participants were informed of the purpose of the study and what their participation consisted of. The participants completed their sociodemographic, clinical, PCS and TSK data. To reduce the possible biases associated with self-report instruments, adequate time and space were set aside in the interviews. In addition, adequate training was given to the interviewing professional in the systematic application of the questionnaires (i.e., use of clear, direct and understandable language). Participants could choose to complete the surveys by themselves or with the assistance of an evaluator. The evaluator verified that each participant completed all the fields to avoid missing data. Study data were collected and managed using REDCap software.

Data Analysis

Internal Structure. Before evaluating the factorial models, the dimensionality of the data was assessed with a parallel analysis (Factor software10.8.04; Garrido et al., 2013, Lorenzo-Seva & Ferrando, 2013).

The data modeling strategy followed in this study aims to evaluate the indicated PCS factors of previous studies (in a confirmatory way) and then continue with more flexible factorial approaches (in an exploratory fashion). Eight factorial approaches were tested: First (M1), a simple unidimensional structure was evaluated. Second (M2 and M3), two CFA were performed to evaluate the original theoretical model (i.e., three factors correlated or three factors in a hierarchical structure). Then, a fourth exploratory structural equation model was proposed (ESEM; M4). The ESEM target approach has many advantages over the CFA (Martínez-Molina & Arias, 2018). Since exploratory models have rarely been performed and are necessary, two other EFAs were evaluated (M5 and M6) with two and three factors, respectively. A seventh model (M7) was also created to evaluate the bi-factor nature of the construct. In this structure, a general orthogonal factor was specified in all items (in addition to the seven specific factors, also orthogonal). Finally (M8), an eighth and last model was proposed considering all the previous factorial results (M1 to M7).

The weighted least squares and adjusted mean and variance estimator (WLSMV) was chosen in Mplus software (Muthén & Muthén, 2015) for all of these analyses (a robust estimator with ordinal data with relatively small samples; Shi et al., 2018). Goodness of fit was evaluated using the most widespread indices, and cutoff recommendations (Schreiber, 2017); χ^2, χ^2/df, comparative fit index (CFI), Tucker-Lewis Index (TLI) and root mean square error of approximation (RMSEA).

Measurement Invariance. Assuming the factorial model that best suits the data (i.e., according to the parallel analysis, appropriate factor loadings and parsimony), a series of nested models were performed to test the invariance of their parameters at different levels between groups of participants. First, the *configural* level of invariance was tested, then *strong* invariance level, and finally *strict* invariance level: the *configural* test assumes the dimensionality equivalence in terms of the number of dimensions and the configuration of factor loadings; the *strong* invariance propose that the factorial loadings, as well as the intercepts of the items (the thresholds, in this case), be equal in magnitude between groups; and the *strict* test the reliability equivalence of the scores (i.e., residual variances of the items) must be equivalent between groups (Martínez-Molina & Arias, 2018). In this study, invariance tests were executed between (1) sexes (women vs. men), (2) chronicity of the pain (acute vs. chronic) and (3) education level (≤12 years vs. >12 years). Twelve years (i.e., secondary education) was considered the cutoff point given that they are the years of mandatory education in Chile.

Descriptive Statistics and Internal Consistency of the scale scores. Jamovi program was used to obtain basic descriptives, mean comparisons and reliability coefficients (The Jamovi project, 2021). Cronbach's Alpha (α) and McDonald's Omega (ω) coefficients were computed to estimate the internal consistency of the scale scores. In addition, the item-rest correlation was also analyzed.

Validity Evidence Based on Relations With Other Variables. In order to add validity evidence based on relations with other variables to de data from this study, Spearman's rho correlations were executed between the PCS, VASr, VASm, VAS7d, VASi and TSK (considering weak for 0.1, moderate for 0.3 and strong for 0.5; Cohen, 1988).

Results

The sociodemographic and clinical characteristics of the sample are presented in Table 1. No missing values were present in the dataset.

Table 1
Sociodemographic and clinical characteristics

Variables	n (%)	Mdn (p25-p75)
Age		52 (33-64)
Sex		
Women	282 (71.6)	
Men	112 (28.4)	
Years of formal education		12 (12-15)
Education level		
≤12 years	226 (57.4)	
>12 years	168 (42.6)	
Occupation		
Students	61 (15.5)	
Housewife	121 (30.7)	
Retired	30 (7.6)	
Healthcare services	21 (5.3)	
Service occupations	61 (15.5)	
Office and administrative support	40 (10.2)	
Transportation occupations	10 (2.5)	
Education and library occupations	19 (4.8)	
Others	31 (7.9)	
Months with pain		6 (2-12)
Chronicity		
Acute	147 (37.3)	
Chronic	247 (62.7)	
Type of musculoskeletal disorder		
Cervical	26 (6.6)	
Dorsal-lumbar	72 (18.3)	
UL No-Trauma	124 (31.5)	
UL Trauma	20 (5.1)	
LL No-Trauma	112 (28.4)	
LL Trauma	40 (10.2)	

Note: *p25-p75* = 25th and 75th percentiles. UL = Upper limb, LL = lower limb

Internal Structure

A parallel analysis was carried out, checking the data dimensionality. This analysis identified only one dimension for the 13 items of the PCS. Factor loadings, correlations and regressions of the proposed models are showed in Table 2. The fit indices for each of the models can be seen in Table 3.

All the proposed models have RMSEA greater magnitudes than the recommended criteria (< .05). Models that allow relations between factors show high or very high correlations or regressions magnitudes. Some items (e.g., 1, 5, 8, 10) showed inappropriate factor loadings in various models (> 1). However, the CFI and the TLI showed adequate or good values. In general, the models (including the bifactor) support a single interpretable factor.

After these factorial results, we opted to select those items that (a) mainly and adequately loaded into the first factor and (b) whose content was congruent with the theoretical definition of its dimension. This is the case of the eighth model proposed (M8, PCS-4). Note that the first of the proposed theoretical dimensions (Helplessness) was composed of 6 items. Of these, items 1 and 5 were problematic in the different factorial approaches (inappropriate factorial loadings). This is consistent with its content, which we understand does not fit the definition of "Helplessness" (see the content of these items in the Table 4). For all these reasons, we propose a single factor of 4 items (i.e., 2, 3, 4 and 12). The rest of the items are not theoretically related enough, nor are they sufficient to compose a second factor.

Measurement Invariance

As we have described, all the irregularities found in the different factorial approximations have their origin in having proposed confirmatory factors that were never supported by an

Table 2
Factor loadings. correlations and regressions of the proposed models

	M1: Un	M2. M3: CFA			M4: ESEM			M5: EFA		M6: EFA			M7: Bifactor CFA				M8: Un PCS-4
i	F1	F1	F2	F3	F1	F2	F3	F1	F2	F1	F2	F3	FG	F1	F2	F3	F1
1	**.508**	**.523**			**1.170**	.149	**.455**	.084	**.505**	.057	**.352**	.295	**.557**	-.087			
2	**.789**	**.809**			**.779**	.010	.040	**.761**	.072	**.750**	.054	.053	**.696**	**.409**			**.789**
3	**.779**	**.801**			**.735**	-.050	.153	**.718**	.117	**.742**	.009	.161	**.714**	**.349**			**.779**
4	**.875**	**.892**			**.921**	-.019	-.030	**.893**	.001	**.891**	-.002	.015	**.738**	**.496**			**.875**
5	**.860**	**.872**			**1.089**	-.159	-.141	**1.033**	-.182	**1.093**	-.221	-.011	**.667**	**.677**			
6	**.782**		**.889**		**.464**	.259	.103	**.438**	**.448**	**.338**	**.438**	.165	**.812**		.227		
7	**.486**		**.535**		**.409**	.239	**.315**	.257	.290	.148	**.373**	.013	**.491**		.149		
8	**.597**			**.646**	.233	.241	.127	-.004	**.694**	.208	-.001	**.872**	**.604**			**1.142**	
9	**.789**			**.856**	.089	**.477**	.270	**.302**	**.600**	.004	**.912**	-.109	**.832**			-.112	
10	**.772**			**.840**	.011	-.250	**1.012**	**.325**	**.558**	.120	**.749**	-.068	**.816**			-.140	
11	**.659**			**.716**	.231	**.635**	.163	-.035	**.800**	-.014	**.491**	**.454**	**.657**			.240	
12	**.697**	**.720**			**.305**	**.514**	.152	**.477**	**.300**	**.362**	**.398**	-.004	**.688**	.163			**.697**
13	**.624**		**.691**		-.013	.197	**.690**	.153	**.568**	-.063	**.730**	.029	**.621**		**.549**		
FG		.897	.910	.905													
F1																	
F2		.816			.557			.627		.758							
F3		.812	.823		.593	.390				.266	.391						

Note: At the top of the table factor loadings are shown. The lower part of the table shows factor correlations or regression weights (M3). Bold values denote loadings ≥ 0.3. GF = General factor; UN = Unidimensional

Table 3
Fit indices of the estimated models

	Model	Analysis	Structure	d	i	χ2	df	χ2/df	RMSEA(CI)	CFI	TLI	ΔRMSEA	ΔCFI	ΔTLI	Δχ2/df
Measurement	M1	CFA	Un	1	13	564.678	65	8.687	.140 (.129 .150)	.933	.919				
	M2	CFA	Cf	3	13	371.565	62	5.993	.113 (.102 .124)	.958	.948				
	M3	CFA	Hi	3	13	371.565	62	5.993	.113 (.102 .124)	.958	.948				
	M4	ESEM	Cf	3	13	162.672	42	3.867	.085 (.072 .099)	.984	.970				
	M5	EFA	Cf	2	13	269.672	53	5.088	.102 (.090 .114)	.971	.957				
	M6	EFA	Cf	3	13	162.417	42	3.867	.085 (.072 .099)	.984	.970				
	M7	B-CFA	Uf	3	13	173.417	52	3.335	.077 (.064 .090)	.984	.975				
	PCS-4	**EFA**	**Un**	**1**	**4**	**1.542**	**2**	**.771**	**.000 (.000 .092)**	**1.000**	**1.001**				
Invariance	*Sex*														
	PCS-4	Configural	Un	1	4	7.396	4	1.849	.066 (.000 .139)	.998	.994				
	PCS-4	Strong	Un	1	4	27.196	18	1.511	.051 (.000 .088)	.995	.997	-.015	-.003	.003	-.338
	PCS-4	**Strict**	**Un**	**1**	**4**	**31.551**	**22**	**1.434**	**.047 (.000 .081)**	**.995**	**.997**	**-.004**	**.000**	**.000**	**-.077**
	Edu														
	PCS-4	Configural	Un	1	4	1.363	4	.341	.000(.000 .059)	1.000	1.004				
	PCS-4	**Strong**	**Un**	**1**	**4**	**2.505**	**18**	**1.139**	**.027 (.000 .071)**	**.999**	**.999**	**.027**	**-.001**	**-.005**	**.798**
	PCS-4	Strict	Un	1	4	49.867	22	2.267	.080 (.051 .110)	.998	.992	.053	-.001	-.007	1.128
	Pain														
	PCS-4	Configural	Un	1	4	1.455	4	.364	.000 (.000 .062)	1.000	1.004				
	PCS-4	**Strong**	**Un**	**1**	**4**	**12.766**	**18**	**.709**	**.000 (.000 .041)**	**1.000**	**1.002**	**.000**	**.000**	**-.002**	**.345**
	PCS-4	Strict	Un	1	4	31.262	22	1.421	.046 (.000 .081)	.995	.997	.046	-.005	-.005	.712

Note: d = dimensions; i = number of items; EFA= Exploratory Factor Analysis; CFA = Confirmatory FactorAnalysis; ESEM = exploratory structural equation model; B-CFA = Bifactor CFA; Edu = Level of education (≤ 12 years vs. > 12); Pain = Pain chronicity (Acute vs. Chronic); CI= 90% Confidence Interval; bold measurement and invariance models showed the best test results; Un = Unidimensional, Cf = Correlated factors; Hi = Hierarchical structure

Table 4
(PSC and PSC-4 items)

i	Helplessness / *Indefensión* (English / *Spanish*)	
1	I worry all the time about whether the pain will end	*Me preocupo sobre si el dolor se acabará*
2	**I feel I can't go on**	***Siento que ya no puedo continuar debido al dolor***
3	**It's terrible and I think it's never going to get any better**	***El dolor es muy fuerte y creo que nunca va a mejorar***
4	**It's awful and I feel that it overwhelms me**	***El dolor es muy desagradable y siento que me supera***
5	I feel I can't stand it anymore	*Siento que no aguanto más el dolor*
12	**There's nothing I can do to reduce the intensity of the pain**	***No puedo hacer nada para disminuir la intensidad del dolor***
i	Magnification / Magnificación (English / Spanish)	
6	I become afraid that the pain will get worse	*Tengo miedo de que el dolor pueda ir en aumento*
7	I keep thinking of other painful events	*Me vienen a la memoria experiencias dolorosas anteriores*
13	I wonder whether something serious may happen	*Me pregunto si me podría pasar algo grave*
i	Rumination / *Rumiación* (English / *Spanish*)	
8	I anxiously want the pain to go away	*Deseo con muchas ganas que el dolor desaparezca*
9	I can't seem to keep it out of my mind	*No paro de pensar en el dolor*
10	I keep thinking about how much it hurts	*Estoy centrado en cuánto me duele*
11	I keep thinking about how badly I want the pain to stop	*Pienso en que lo quiero es que me deje de doler*

Note: Bold items are the final reduced scale version (PCS-4)

EFA (including a parallel analysis). That is why we propose the PCS-4 for the following invariance analysis.

Tests of *configural*, *strong* and *strict* invariance (see Table 5) were executed between sexes (female and male), chronicity (acute and chronic) and education level (≤ 12 years vs. > 12 years). All mentioned fit indices met the criteria for a strong level between education and chronicity groups and a strict invariance level between sexes. This means that considering PCS-4 with regard to the collected data, at least factor structure and factor loading magnitudes were equivalent between these groups.

Descriptive Analysis, Internal Consistency and Mean Comparisons

The scores obtained by the participants on the PCS and PCS-4 are provided in Tables 5 and 6. Comparisons of means (see Table

6) concur with the analysis of invariance; that is, the differences between groups are generally not significant or small in magnitude (Cohen's $d < 0.5$).

As shown in Table 7, the PCS-4 item scores presented good internal consistency (α = .84, ω = .84). In general the PCS scales scores is adecuate or high: helplessness, α = .86, ω = .87; magnification, α = .69, ω = .71; rumination, α = .77, ω = .77. Discrimination indices (item-rest correlation) were shown to be adequate in all cases (i.e., > 0.20).

*Validity Evidence Based on Relations With Other Variable*s

The Spearman's rho correlation coefficient was pointed a positive relation between PCS/PCS-4 and VASr, VASm, VAS7d, VASi and TSK. This is, a higher level of catastrophism was associated with greater pain intensity (at rest, during movement, on average over the last 7 days), greater pain-related interference, and greater kinesiophobia (see details in Table 8). We also want to point out that the PCS and the PCS-4 scores were strongly correlated (r_s = .91, 95% CI [.88, .93], p <. 001).

Table 5
Descriptive statistics of the study scales

Variables	M	SD	Mdn	p25	p75
PCS					
Total	27.1	10.7	27.5	20	35
Helplessness	11.5	5.5	11.5	8.0	15.0
Magnification	5.6	3.1	5.0	3.0	8.0
Rumination	10.1	3.4	10.0	8.0	12.0
PCS-4	**7.0**	**3.9**	**7.0**	**4.0**	**10.0**
TSK	31.7	6.9	33.0	27.0	37.0
VASr	31.0	30.0	28.5	6.0	50.0
VASm	65.2	25.7	70.0	50.0	85.0
VAS7d	54.9	26.6	59.0	35.0	74.0
VASi	59.1	27.2	62.5	44.0	80.0

Note: *p25-p75* = 25th and 75th percentiles. Bold values highlight the PCS-4 short form

Table 6
PCS and PCS-4 scores according to sex, pain chronicity and education level

PCS	M (SD)	Mdn (p25-p75)	*p*	Effect size, 95% CI
Sex				
Women	28.2 (10.4)	29.0 (22-36)	*p* < .001	*d* = 0.38, [0.15, 0.6]
Men	24.3 (10.8)	24.5 (17-32)		
Edu				
≤12	28.8 (10.5)	30.0 (22-36)	*p* < .001	*d* = 0.36, [0.16, 0.57]
>12	24.9 (10.6)	24.0 (17-32)		
Pain				
Acute	26.7 (10.4)	27.0 (20-34)	*p* = .523	*d* = -0.07, [-0.27, 0.14]
Chronic	27.4 (10.8)	28.0 (21-35)		
PCS-4				
Sex				
Women	7.5 (3.9)	7.0 (5-10)	*p* < .001	*d* = 0.49, [0.26, 0.72]
Men	5.6 (3.8)	5.0 (3-8)		
Edu				
≤12	7.6 (3.9)	7.0 (5-10)	*p* < .001	*d* = 0.36, [0.16, 0.56]
>12	6.2 (3.8)	6.0 (3-9)		
Pain				
Acute	6.5 (3.8)	6.0 (4-9)	*p* = .057	*d* = -0.20, [-0.40, 0.07]
Chronic	7.3 (4.0)	7.0 (4-10)		

Note: *p25-p75* = 25th and 75th percentiles; Edu = Level of education (≤ 12 years vs. > 12); Pain = Pain chronicity (Acute vs. Chronic); *p* = Student's *t* test probability; *d* = Cohen's d

Table 7
Internal consistency and item-rest correlationof the PCS subscales and PCS-4

Scale (α, ω)	i	M	SD	Sk	K	r_{ix}	If item dropped	
							α	ω
Helplessness (.858, .867)	1	2.8	1.2	-0.7	-0.4	.370	.881	.885
	2	1.7	1.2	0.0	-0.8	.710	.822	.836
	3	1.7	1.2	0.3	-0.8	.719	.820	.835
	4	1.9	1.2	0.0	-0.8	.777	.809	.820
	5	1.7	1.2	0.1	-0.9	.748	.815	.824
	12	1.7	1.2	0.3	-0.8	.582	.846	.858
Magnification (.692, .705)	6	2.3	1.3	-0.3	-1.0	.578	.505	.505
	7	1.5	1.3	0.4	-0.9	.407	.719	.719
	13	1.8	1.3	0.2	-1.0	.543	.552	.553
Rumination (.770, .774)	8	3.6	0.9	-2.2	4.8	.448	.774	.785
	9	1.7	1.2	0.2	-0.8	.636	.679	.733
	10	1.7	1.2	0.3	-0.7	.620	.689	.723
	11	3.1	1.1	-1.1	0.4	.602	.699	.731
PCS-4 (.838, .841)	2	1.7	1.2	0.0	-0.8	.663	.797	.803
	3	1.7	1.2	0.3	-0.8	.712	.776	.783
	4	1.9	1.2	0.0	-0.8	.728	.769	.774
	12	1.7	1.2	0.3	-0.8	.581	.834	.835

Note: Sk = Skewnees; K = Kurtosis; r_{ix} = item-rest correlation; α = Cronbach's α; ω = McDonald's ω

Table 8
Spearman's rho correlation between PCS (and its subscales),VASr, VASm, VAS7d, VASi and TSK

Outcome measurement	PCS total	PCS Helplessness	PCS Magnification	PCS Rumination	PCS-4
VASr	.36 [.27, .44]	.39 [.31, .47]	.23 [.13, .33]	.28 [.19, .38]	.37 [.28, .46]
VASm	.35 [.26, .44]	.39 [.30, .49]	.20 [.10, .30]	.32 [.23, .41]	.37 [.28, .47]
VAS7d	.40 [.30, .49]	.44 [.35, .53]	.25 [.15, .34]	.33 [.24, .42]	.42 [.33, .50]
VASi	.44 [.35, .53]	.47 [.38, .56]	.31 [.22, .41]	.34 [.26, .43]	.46 [.37, .55]
TSK	.49 [.41, .58]	.42 [.33, .51]	.46 [.38, .55]	.45 [.37, .53]	.42 [.33, .51]

Note: In square brackets 95% confidence interval. All *p* values were <.001

Discussion

This study aimed to analyze the psychometric properties of the Spanish PCS in Chilean individuals with musculoskeletal pain. The initial Sullivan analyses of PCS responses supported a three-component structure based on a PCA. However, as we mentioned before, the PCS has never shown robust empirical support for the three mentioned factors in an exploratory factorial way (although it has shown components or composites, which is different; Widaman, 2007). This three-component structure was not supported by parallel analysis or exploratory factor approximations; our results indicated that the Spanish version of the PCS has a unidimensional structure. Despite the original proposal of a three-component structure, the scale's total score is usually used both in clinical practice and research. In addition, a short form of the PCS, the PCS-4, was well supported in terms of reliability and validity by four items. The PCS and the PCS-4 were highly correlated (r_s = .91).

PCS and PCS-4 scores showed good internal consistency and adequate relations with other variables (i.e., VASr, VASm, VAS7d, VASi and TSK). These relationships are similar in magnitude to previous studies with pain intensity (Monticone et al., 2012; Sullivan et al., 1995) and kinesiophobia (Monticone et al., 2012; Salvador et al., 2020).

PC, pain, and kinesiophobia are variables that form part of the Fear-Avoidance Model of Musculoskeletal Pain (Leeuw et al., 2007). This suggests that individuals catastrophically misinterpret their pain and these dysfunctional interpretations give rise to a fear of movement (Leeuw et al., 2007). Thus, our results support the link between these variables.

In line with previous studies (Sullivan et al., 2001), women presented higher levels of catastrophism than men in our study. This difference is not due to an inadequate fit to the structural model of the measurement, given that the scale demonstrates measurement invariance between women and men. In addition, individuals with ≤ 12 (vs. > 12) years of formal education presented higher levels of catastrophism. This is consistent with Shen et al. (2018), who found a negative association between the level of catastrophism and the education level of individuals with chronic musculoskeletal pain.

Our study represents a useful resource for the vast corpus of studies that include individuals with musculoskeletal pain. This is because individuals with chronic and acute pain were included, in contrast to other studies that have assessed specific populations. In addition, a suitable number of individuals adapted for the statistical analysis was considered. In this same vein, the use of rigorous statistical analysis is a noteworthy point of this study.

Although the validation of PCS and PCS-4 presented here are promising, this study is not without weaknesses. The Spanish version of the PCS used in this study was the one developed by Olmedilla et al. (2013), not undertaking a translation process of Sullivan's original survey (Sullivan et al., 1995). However, the analysis by a committee of experts agreed that the survey was understandable for the Chilean population and that, therefore, it fulfilled the conditions of applicability. Another limitation is the sample composition: the disproportion of sex (smaller proportion of men). However, this is common in musculoskeletal pain studies (Schütze et al., 2018). These results are representative of individuals with musculoskeletal pain, and extrapolation to other clinical populations (e.g., individuals with oncological pain) should be done with caution. It would also be desirable to generalize these results to other languages where the psychometric properties of the instrument have not been tested yet. Finally, it should be noted that in recent years instruments that allow evaluating the daily fluctuation of PC (i.e., daily PCS; Darnall et al., 2017) have ben developed, marking a difference with the instruments that evaluate PC as a trait variable (i.e., PCS), opening new and exciting lines of research highlighting the importance of this construct in people's health. In addition, our promising results with PCS-4 support the literature (e.g., Kruyen et al., 2014), that emphasizes that short administration time in change assessment is very desirable to decrease the fatigue and burden of individuals, who often do not feel well, especially when they are in pain as the participants of the present investigation. Moreover, it should be kept in mind that most tests are part of protocols or batteries that are often time-consuming. In this vein, it should be noted that one disadvantage of short versions of the tests is their accuracy (Mellenbergh, 1996). However, the PCS-4 has demonstrated high reliability and validity to measure PCS adequately.

Conclusions

This study shows that the Spanish version PCS-4 is adequate to measure PC in Chileans who suffer from musculoskeletal pain, potentially being used in both clinical practice and research in other Spanish-speaking countries.

In future studies, we strongly suggest that researchers make a more exhaustive analysis of the PCS (of all its items) with an appropriate factorial approach. We support using the short version of the PCS (PSC-4) instead of the original one until a more precise definition, and a proper analysis of its dimensions is made (even starting from the data already published).

The PCS-4 can benefit research and care in clinical contexts of Spanish-speaking communities, the second most-spoken language globally by many native speakers (Eberhard et al., 2020). This is because PC has been consistently associated with various health-related outcomes (i.e., pain intensity, physical disability, mental well-being, development of chronic pain; Khan et al., 2011; Suso-Ribera et al., 2017), and is considered a key target of intervention. Furthermore, from the scope of the study, having a valid and reliable instrument makes it possible to develop studies that assess the effectiveness of therapies aiming to reduce PC and studies aiming to increase our knowledge regarding the perception of pain and chronification.

Acknowledgments

We thank the *Dirección de Investigación de la Universidad de La Frontera*. We also thank Helen M. Lowry for proofreading the article.

Funding

This research was funded by DIUFRO (project code DI20-0046) and by ANID-Chile (FONIS, project code SA19I0003).

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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