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Research article

A bifactor structural model of the Hungarian Pain Catastrophizing Scale and latent classes of a clinical sample

Attila Galambos [a,b], Dániel Péter Stoll [c], Szabolcs Bolczár [c], Áron Lazáry [d], Róbert Urbán [b], Gyöngyi Kökönyei [b,e,f,*]

[a] Doctoral School of Psychology, ELTE Eötvös Loránd University, Izabella Street 46, H-1064, Budapest, Hungary
[b] Institute of Psychology, ELTE Eötvös Loránd University, Izabella Street 46, H-1064, Budapest, Hungary
[c] Department of Psychology, National Center for Spinal Disorders, Királyhágó street 1, H-1126, Budapest, Hungary
[d] Department of Research and Development, National Center for Spinal Disorders, Királyhágó street 1, H-1126, Budapest, Hungary
[e] SE-NAP2 Genetic Brain Imaging Migraine Research Group, Hungarian Brain Research Program, Semmelweis University, Nagyvárad square 4, H-1089, Budapest, Hungary
[f] Department of Pharmacodynamics, Faculty of Pharmacy, Semmelweis University, Nagyvárad square 4, H-1089, Budapest, Hungary

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ABSTRACT

Pain catastrophizing is an exaggerated cognitive-affective response to actual or anticipated pain, usually measured by the Pain Catastrophizing Scale (PCS). Our study aimed to test the bifactor measurement model of the Hungarian PCS and to identify a catastrophizing risk group with a clinically meaningful cut-off score.

The data of 404 chronic spine-related (neck, back and low-back) pain patients (mean age: 58.61 (SD = 14.34)) were used in our cross-sectional study. Besides pain-related and demographic data, pain catastrophizing and depressive symptoms were measured with questionnaires. Confirmatory factor analyses confirmed that the bifactor model outperformed the other tested measurement models, and the general catastrophizing factor was responsible for 81.5% of the explained variance. Using latent class analysis, we found that even moderately elevated pain catastrophizing score was related to more depressive symptoms and higher perceived pain intensity, and 22 score could be used as a cut-off score. Our results support the concept of global pain catastrophizing and the validity of the Hungarian PCS. Further studies are needed to evaluate the bifactor structure of this scale and the predictive value of the proposed cut-off score.

1. Introduction

Pain catastrophizing, defined as a tendency to magnify and ruminate about pain, and having a helpless feeling towards actual or anticipated pain (Sullivan et al., 1995), has often been found to be associated with pain intensity and severity in chronic pain patients (Buenaver et al., 2008; Edwards et al., 2006; George et al., 2011). Regarding low back pain, for instance, many studies have confirmed that pain catastrophizing is significantly associated with different pain-related outcomes not just in cross-sectional (Martel et al., 2014; Meyer et al., 2009), but in prospective studies as well (Besen et al., 2017; Wertli et al., 2014). Pain catastrophizing was also a risk factor for developing low back pain (along with fear of movement and fear of injury) in healthy individuals (i.e. those without low back pain at baseline) in a population-based cohort (Picavet, 2002). All these findings suggest that pain catastrophizing could have clinical relevance. Understanding the fine contribution of pain catastrophizing to the development, maintenance and correlates of chronic pain requires valid and reliable measures.

The most widely used questionnaire on pain-related catastrophic thinking is the Pain Catastrophizing Scale (PCS) developed by Sullivan (Sullivan et al., 1995) on a student sample (N = 439). Exploratory factor analysis was used in this study, which yielded 3 dimensions: magnification, rumination, and helplessness. The PCS has been translated and validated for several languages (Bansal et al., 2016; Cho et al., 2013; Fernandes et al., 2012; Kemani et al., 2019; Meyer et al., 2009; Monticone et al., 2013; Tremblay et al., 2008; Van Damme et al., 2002; Xu et al., 2015). Similar to the first study on PCS's factor structure (Osman et al., 1997), most of the studies using confirmatory factor analysis supported the original three-factor structure (Bansal et al., 2016; Meyer et al., 2009; Mohd Din et al., 2015; Morris et al., 2012; Pallegama et al.,

* Corresponding author.
E-mail address: kokonyei.gyongyi@ppk.elte.hu (G. Kökönyei).

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2014; Tremblay et al., 2008; Van Damme et al., 2002) with some exceptions where the two-factor model (Chibnall and Tait, 2005; Huijer et al., 2017) was nearly as strong as the three-factor variant or in one case (Sehn et al., 2012) showed better fit. However, studies using the PCS usually applied only the sum score of the items reflecting the general factor (i.e. pain catastrophizing) and did not use the specific subscales in the analyses. From a psychometric point of view, to test general and specific factors simultaneously, the bifactor measurement model is suggested (Reise, 2012; Rodriguez et al., 2016) since it allows for all the items to load on a general factor (such as pain catastrophizing), and also to have specific factors (such as magnification, rumination and helplessness). Bifactor models can also help to clarify the dimensionality of the measurement model of a given construct and help to determine whether the subscales have any added value (at least at measurement level) and whether subscales can be considered as clinically meaningful theoretical distinctions. However, the bifactor model of PCS has not yet been tested extensively. A recent study by Cook and colleagues (2021) for instance found that bifactor model of PCS yielded a good fit, and the global factors explained the 96% of common variance, while the specific factors accounted for only a small proportion of the variance in a chronic pain sample, suggesting that the 3 components – at least on a measurement level – have no clinical relevance.

Given the clinical relevance of pain catastrophizing (i.e. that it has a strong role in shaping the emotional, physiological and functional responses to pain (Quartana et al., 2009)), it would be important to identify the group with high pain catastrophizing, as people with high pain catastrophizing scores are most likely at risk of pain related disability (Meyer et al., 2009; Picavet, 2002), losing work because of pain (Besen et al., 2017), taking more medications (Martel et al., 2014) and developing other illness behaviours (Quartana et al., 2009). However, determining the clinically relevant score is not easy as the cut-off values used in studies have varied greatly. Some studies (Chibnall and Tait, 2009; Sabo and Roy, 2019) have used 30 points suggested by the manual of PCS (Sullivan, n.d.) that was based on the distribution of PCS scores. The cut-off was established as the 75th percentile of the distribution among patients with soft tissue back injury. Later studies in chronic pain have used lower scores, also based on the distribution. For example, Sullivan and colleagues (Sullivan et al., 2005; Wideman et al., 2009) used 20 as the 50th percentile cut-off score. Using a different method, Scott and colleagues (Scott et al., 2014) determined 24 as pre-treatment PCS score that was best associated with the post-treatment outcomes. In the present study, we used latent class analysis that offers a statistically reliable method to identify groups of people according to their responses to certain variables. Persons with similar responses (scores) are classified in the same latent class, then allowing to identify the differences between the classes using other variables (Collins and Lanza, 2009). In this study we used this method to identify the group at risk (i.e. people with high pain catastrophizing scores), which can be validated with depressive symptoms and increased pain severity. Our goal was to determine what high pain catastrophizing means, thus to find a cut-off score that can help clinicians interpreting pain catastrophizing scores and plan treatment accordingly.

Therefore, the current study aimed to test the factor structure of the Hungarian PCS on a chronic pain patient population. We tested the one-, two- three- and bifactor model of the PCS to find the best structure and to confirm the existence of a general catastrophizing construct. To determine an optimal cut-off point for PCS, we used latent class analysis (LCA) and investigated whether latent classes differ in terms of demographic variables, depressive mood, and subjective ratings of pain.

2. Materials and methods

2.1. Participants

Participants with degenerative spinal disorders were recruited from the Hungarian National Center for Spinal Disorders. After hospital admission, patients undergo a complex diagnostic process, which contains physical examination, functional capacity assessment and also the mapping of psychological and psychosocial risk factors with multiple questionnaires.

In the present analysis, we used an inpatient sample, and included the data of patients who were above 18 years old, with local pain along the spine (either neck-, back- or low-back pain) and who reported reoccurring complaints and waited for conservative (non-surgical) treatment. All patients with radiating pain or neurological symptoms were excluded from the sample as we wanted to make our groups as homogenous as possible. We also excluded patient data where the reported pain was not yet chronic (i.e. existed for less than six months) (Boos and Aebi, 2008). The final sample consisted of 404 participants (136 males and 268 females; mean age = 58.61(SD = 14.34)).

The study was conducted according to the rules of the Declaration of Helsinki, ethical approval was provided by the Scientific and Research Ethics Committee of the Medical Research Council of Hungary. All the patients provided written informed consent.

2.2. Measures

2.2.1. Pain intensity and disease history

In this cross-sectional study, we gathered information about the type and location of pain and whether participants had experienced this pain previously (and if yes, for how long). We used a visual analogue scale (VAS) to measure current, experienced pain. The scale was a 100 mm long horizontal line with words at each end to describe the extreme

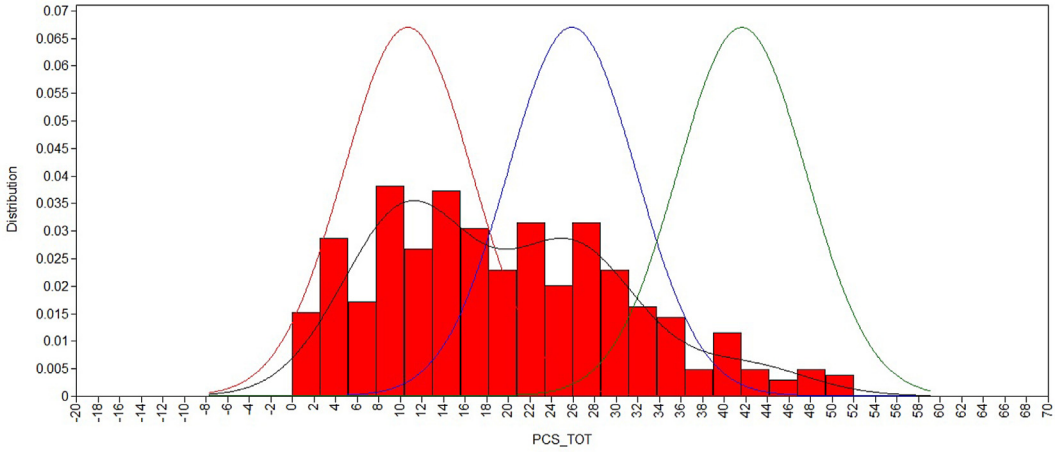

Figure 1. Overall distribution of the PCS total score, and the three latent classes (N = 404). Note: PCS TOT = Pain Catastrophizing Scale, Total score.

values from 0- no pain to 10- most intense pain (Thong et al., 2018). The line was divided into 10 parts for easier filling.

2.2.2. Pain Catastrophizing Scale (PCS)

In the focus of our study was the Hungarian PCS. The self-report questionnaire measures the three aspects of catastrophizing on 13 items divided into three subscales: Rumination, Magnification and Helplessness. Participants answer on a 5-point Likert scale (0- not at all to 4- all the time) with a maximum of 52 points. In previous studies the original PCS on a healthy sample (total score: $\alpha = .87$; Rumination $\alpha = 0.87$; Magnification $\alpha = .66$; Helplessness $\alpha = .78$; Sullivan et al., 1995) and the Hungarian PCS on a chronic pain sample (total score: $\alpha = .87$; Rumination $\alpha = 0.81$; Magnification $\alpha = .54$; Helplessness $\alpha = .80$; Kökönyei, 2008) demonstrated good internal consistency as well.

2.2.3. Beck Depression Inventory – short form (BDI-SF)

We used the 9-item short form of the Beck Depression Scale developed for the Hungarostudy, a representative survey of the Hungarian population over the age of 16 by age, sex, and place of residence (Kopp et al., 1990, 1995). From the original 21 items (Beck and Rush, 1979), the short form keeps nine: Social withdrawal, Indecisiveness, Insomnia, Fatigability, Somatic preoccupation, Retardation, Pessimism, Dissatisfaction, and Guilt. Unlike the original questionnaire, instead of the four, symptom-specific statements, in the short form there is only one statement which corresponds to the most severe one from the original (e.g. for Indecisiveness: *I can't make decisions at all anymore.*). Participants have to rate these statements on a 4-point Likert-scale from 1- not at all true to 4- definitely true. The questionnaire's psychometric properties in the Hungarian adaptation and in our sample as well showed excellent Cronbach's alpha (.83 and .84, respectively). Psychometric testing of the 9-item questionnaire showed that a cut-off score of 16 proved its diagnostic reliability (Rózsa et al., 2001).

2.3. Data analysis

Constructing our study, we did the following steps: 1) we presented the descriptive properties of our sample, then 2) we analysed the factor structure of the Hungarian PCS. After this, 3) we checked the factor loadings and 4) validity of the questionnaire. To determine groups based on the PCS scores 5) we used LCA then 6) compared the groups obtained. In the last step 7) we used an equation to determine a clinically meaningful cut-off score.

The factor structure of the PCS was tested with a series of confirmatory factor analyses. We treated the response options of the items as ordinal scale; therefore, we used the Weighted Least Squares Mean and Variance (WLSMV) adjusted estimation method in Mplus (version 7.4) (Muthén and Muthén, 1998). Different measurement models (the one-factor, two factor, three-factor models and the bifactor model with three uncorrelated factors) of PCS were compared. Different goodness of fit measures were applied to determine the best model: the $\chi 2$, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and the Root Mean Squared Error of Approximation (RMSEA). In the case of CFI and TLI, values above 0.95 indicate good fit of the measurement model. For the RMSEA, values lower than 0.05 show a good fit, while values between 0.05 and 0.08 reflect adequate fit and values between 0.08 and 0.10 show a mediocre fit (Schermelleh-Engel et al., 2003). In order to compare models using the WLSMV estimator, we used the DIFFTEST procedure within Mplus (Asparouhov and Muthen, 2006) to calculate the adjusted $\Delta\chi 2$ test.

In testing the dimensionality of pain catastrophizing we estimated alternative reliability indices relevant to bifactor models therefore omega coefficients were also estimated. Unlike Cronbach-alpha - which is usually based on observed variances and assumes equal item loadings -, omega is based on the factor loadings of the model giving us a more accurate reliability value even if the item loadings vary (Rodriguez et al., 2016). We also calculated the coefficient hierarchical omega (omega H), which shows the percentage of variance associated with the given factor. The explained common variance (EVC) was used to determine unidimensionality and to check the strength of the general factor and to see the percentages of explained variance for both the general factor and the subscales (Rodriguez et al., 2016). The percent uncontaminated correlations (PUC) index was also calculated. It is the number of unique correlations in a correlation matrix that are influenced by a single factor divided by the total number of correlations (Rodriguez et al., 2016).

After establishing the one-dimensional measurement model, latent class analysis (LCA) was conducted to identify homogenous subgroups (latent classes) of participants based on their pain catastrophizing scores. LCA was performed with two to four classes with the full sample ($n = 404$) with MPLUS 7.4 (Muthén and Muthén, 1998). To determine the optimal number of classes and the relative goodness of our models, the following fit indices were used: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Sample Size Adjusted Bayesian Information Criterion (SSA-BIC), Lo-Mendel-Rubin Adjusted Likelihood Ratio Test (LMRT) and the index of Entropy. Lower values of AIC, BIC, SSA-BIC imply more sufficient model fit relative to models with a different number of latent classes. The index of Entropy with higher values (e.g. closer to 1) indicates a more accurate classification of the participants. Values at around 0.4, 0.6, and 0.8 represent low, medium, and high entropy, respectively (Clark and Muthén, 2009). If the Lo-Mendel-Rubin Adjusted Likelihood Ratio Test (LMRT) is significant ($p < 0.05$), it presents a more adequate model fit of the estimated model by involving an additional latent class compared to the previous model with a lower number of latent classes. If LMRT is non-significant, we did not assess further LCA models since it shows that the involvement of an additional latent class would have not increased the fit of the model. Then we used multinominal logistic regression analysis to explore the relationship between the most likely latent class membership and covariates (gender, age, pain duration, depressive mood and pain intensity measured with VAS) using the 3-step method.

Table 1. Descriptive statistics of the Study Sample (N = 404).

	Total sample
	N (%)
Spine related pain	
Neck pain	19 (4.7%)
Back pain	18 (4.5%)
Low-back pain	222 (54.9%)
Neck + back pain	12 (3.0%)
Neck + low back pain	40 (9.9%)
Low back + back pain	44 (10.9%)
All three areas	49 (12.1%)
Duration of spine-related pain symptoms	
More than half a year	37 (9.2%)
More than a year	47 (11.6%)
More than 2 years	72 (17.8%)
More than 5 years	84 (20.8%)
More than 10 years	104 (25.7%)
More than 20 years	60 (14.9%)

3. Results

3.1. Descriptive statistics

The descriptive data and clinical characteristics of participants are shown in Table 1. 222 from the 404 participants (54.9%) reported low-back pain, while 19 (4.7%) only had neck pain and 18 (4.5%) reported only back pain. 12 participants (3.0%) had neck and back pain, 40 (9.9%) had neck and low-back pain and 44 (10.9%) had back and low-back pain. 49 participants (12.1%) reported pain in all three areas. All

Table 2. Degree of model fit and comparison of the models.

		χ^2	df	RMSEA	CFI	TLI	Δχ2	Δdf	p
General model fit of the measured models									
Model 1	One factor	504.5	65	.129	.947	.936			
Model 2	Two factors*	377.7	64	.110	.962	.954			
Model 3	Three factors	357.2	62	.109	.964	.955			
Model 4	Bifactor with three factors	256.7	52	.099	.975	.963			
Comparison of the measurement models									
Model 2 versus Model 1							79.2	1	<.001
Model 3 versus Model 2							23.0	2	<.001
Model 4 versus Model 3							104.0	10	<.001

Note: *a combined helplessness-magnification factor and rumination; χ^2 = Chi Square test statistics; RMSEA = Root Mean Squared Error of Approximation; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; $\Delta\chi^2$ = Chi Square difference test. Chi Square test statistics and Chi Square difference test statistics are significant at least $p < .05$ level.

Table 3. Standardized factor loadings and reliability indices of the bifactor CFA model of PCS.

Items	Catastrophizing	Helplessness	Magnification	Rumination
1	.678	.338		
2	.671	.524		
3	.837	.186		
4	.876	.129		
5	.843	.193		
6	.793		$.159^{ns}$	
7	.719		$.162^{ns}$	
8	.514			.492
9	.806			.247
10	.831			.344
11	.636			.527
12	.773	-.286*		
13	.682		$.657^{ns}$	
ECV	81.5%	10.1%	0.6%	7.8%
Omega	.961	.942	.815	.889
Omega hierarchical	.896	.154	.016	.222
Relative Omega	.932	.163	.019	.250
H	.952	.576	.050	.475
PUC	.692			

Note: ns = non-significant, other factor loadings are significant on a $p < .001$ level, EVC = Explained Common Variance; Relative Omega = Omega hierarchical/Omega; H = H-index; PUC = Percentage of uncontaminated correlations. *In the omega analysis, we set the factor loading of this item to helplessness to zero.

in all, 355 (87.9%) participants suffered from low-back pain. More than half of the participants reported that the pain existed for more than 5 years (61.4% of the sample). Half of our sample (49.75%) was more than 60 years old.

Table 5. Fit indices for the latent class analysis of pain catastrophizing.

	AIC	BIC	SSA-BIC	Entropy	LMRT	p
2 class model	3109.8	3125.8	3113.1	.603	20.2	.0011
3 class model	3098.0	3122.0	3103.0	.723	14.6	.0045
4 class model	3096.3	3128.3	3102.9	.709	5.3	.2087

Note. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; SSA-BIC = Sample Size Adjusted Bayesian Information Criteria; LRT = Lo-Mendel-Rubin Adjusted Likelihood Ratio Test.

3.2. Factor structure of the Pain Catastrophizing Scale

The model fit indices of the one-, two-, three- and bifactor models of the PCS are presented in Table 2. Each of the tested models showed adequate fit to the data. To select the best fitting model, we compared the models, and found that the bifactor model (Model 4) outperformed the three-factor model, thus it was selected for further analyses.

In the bifactor model, all the items had large loadings (range: 0.51–0.88) on the general catastrophizing factor (Table 3), while the loadings relating to the three subscales were mainly low (<0.40). This general pain catastrophizing factor explained 81.5% of common variance supporting the presence of a strong general factor. In addition, the factor loadings of items relating to the Magnification subscale were not significant once the general factor was in the model, and it had very low proportion of variance (only 0.6 %).

We also calculated the omega hierarchical coefficients to reveal how specific and general constructs contribute to the PCS' score. The results showed that Rumination and Helplessness explained more than 15% variance of pain catastrophizing score (22.2% and 15.4%, respectively), while Magnification contribution to the variance was negligible (1.6%).

The internal consistency of the questionnaire was good to excellent, indexing both Cronbach's alphas (Rumination: .82; Magnification: .77; Helplessness: .88; Total: .93) and omega coefficients (range between 0.82-0.96, Table 3).

Table 4. Correlations between pain catastrophizing, depressive mood and pain intensity, along with means and standard deviations.

	Mean (SD)	1	2	3	4	5	6
1. Rumination (PCS)	8.03 (4.03)						
2. Magnification (PCS)	3.39 (2.92)	.66***					
3. Helplessness (PCS)	8.06 (5.81)	.74***	.75***				
4. Pain Catastrophizing (PCS total)	19.48 (11.57)	.88***	.86***	.95***			
5. Depressive symptoms	14.09 (4.36)	.50***	.55***	.60***	.61***		
6. Pain intensity (VAS)	50.17 (25.31)	.24***	.23***	.30***	.30***	.19***	
7. Age	58.61 (14.34)	.08	.12*	.10*	.11*	.14**	.26**

Note: PCS = Pain Catastrophizing Scale; VAS = Visual Analogue Scale; ***p < .001; **p < .01; *p < .05.

Table 6. Descriptive statistics and group comparison for pain catastrophizing total score: a three-class solution.

	No pain catastrophizing group N = 203 (50.3%)	Moderate pain catastrophizing group N = 171 (42.3%)	High pain catastrophizing group N = 30 (7.4%)	Wald statistics
Women (%)	58.2%[a]	74.4%[b]	77.0%[b,c+]	8.8*
Age, Mean (SE)	57.38 (1.12)[a]	58.77 (1.42)[ab]	65.17 (12.33)[c]	9.3**
Pain duration – more than 5 years %	55.4%[a]	64.6%[ab]	82.5%[b]	9.2**
Perceived pain intensity (VAS), Mean (SE)	44.40 (1.95)[a]	51.56 (2.39)[b]	78.32 (2.98)[c]	93.8***
Depressive mood, Mean (SE)	11.50 (0.20)[a]	16.04 (0.43)[b]	20.63 (1.17)[c]	147.5***

Note: Different letters in the same row represent significant differences between mean scores, whereas the same letter in the same row represent non-significant differences according to the paired post-hoc tests. *p < 0.05, **p < 0.01, ***p < 0.001; SE: standard error; +the difference between the first and the third group was marginally significant: p < 0.1.

3.3. Convergent validity of the Hungarian PCS

To examine the convergent validity of the PCS, we tested its correlations with the BDI-SF measuring depressive symptoms and the VAS indexing pain intensity. We found moderate correlation between pain catastrophizing and depression, and a weak relationship with pain intensity (see Table 4).

3.4. Latent class analysis (LCA)

We decided to use the PCS total score in the latent class analysis since we found that the general catastrophizing factor explained 81.5% of the common variance, supporting that the general factor is a strong one. Based on the fit indices of LCA, the 3-class model solution proved to be the best model (see Table 5). Figure 1 shows the overall distribution of the PCS total score and the three latent classes.

Table 6 reports the descriptive statistics for these 3 classes: a group whose members do not catastrophize their pain (N = 203, 50.3%, Mean (SD): 10.17 (5.96)), a group with moderate level of pain catastrophizing (N = 171, 42.3%, Mean (SD): 25.93 (5.96)) and a group with high pain catastrophizing score (N = 30, 7.4%, Mean (SD): 41.88 (5.96)).

In the next step, we performed a multinomial logistic regression analysis (see Table 7), in which auxiliary variables, such as gender (male or female), age, pain duration (less than 5 years or more than 5 years), depressive symptoms and perceived pain intensity (VAS), predicted class membership. Compared to the no pain catastrophizing group, increased depressive symptoms was associated with being in moderate and high catastrophizing groups. Also, compared to the non-catastrophizing group, higher perceived pain intensity was associated with high pain catastrophizing membership. It is worth mentioning that pain intensity was a marginally significant (p < 0.1) predictor of moderate pain catastrophizing group membership. Neither demographic variables, such as gender or age, nor pain duration was a predictor of moderate or high pain catastrophizing membership, compared to the no pain catastrophizing group.

Both the group comparison (see Table 6) and the multinominal regression analysis (Table 7) highlighted that not only the high but also the moderate pain catastrophizing group can be characterized by elevated depressive mood and perceived pain intensity. Accordingly, we assume that even moderately elevated pain catastrophizing is associated with more depressive symptoms and increased pain-intensity.

Table 7. Multinomial logistic regression analysis to predict moderate and high pain catastrophizing group (N = 400*).

Covariate	OR	95% CI	p
Moderate pain catastrophizing group vs. No pain catastrophizing group			
gender	1.42	0.59-3.42	.420
age	0.98	0.95-1.01	.243
pain duration**	1.47	0.65-3.33	.366
depressive symptoms	1.68	1.36-2.08	<.001
perceived pain intensity (VAS)	1.02	1.00–1.05	.075
High pain catastrophizing group vs. No pain catastrophizing group			
gender	0.83	0.14-4.97	.835
age	1.01	0.95-1.06	.861
pain duration	2.10	0.36-12.13	.397
depressive symptoms	2.22	1.69-2.94	<.001
perceived pain intensity (VAS)	1.10	1.06-1.14	<.001

Note: OR: odds ratio, CI: confidence interval, p: significance level, VAS: Visual Analogue Scale. * four participants did not answer the items of Beck Depression Inventory-Short Form, ** pain duration is a binary variable: having pain for more than 5 years versus 5 years or less.

3.5. Cut-off score

In order to establish a cut-off score, we first calculated the standard error (SE) of the mean score (25.93) of the moderate pain catastrophizing group by using the Cronbach's alpha of the total score (0.93) and the standard deviation (5.96). Using the following equation: SE = SD * sqrt (1-Cronbach's alpha) we found that SE = 1.58. Then, by subtracting the confidence interval of SE (2*1.58) from the mean score of the moderate pain catastrophizing group (25.93), we found that the clinically relevant or meaningful cut-off score should be 22.

4. Discussion

In this study, our main goal was to test the measurement models for the Hungarian PCS and to find a clinically meaningful cut off point using latent class analysis to differentiate a group at risk based on their elevated pain catastrophizing scores and its correlates (increased pain intensity and more depressive symptoms). To achieve these goals, we tested the mentioned properties of the PCS on a chronic pain sample (90% of them had low back pain with or without other pain along the spine (neck, back)).

We tested the most commonly used one-, two-, three-factor models and also the bi-factor model of PCS and found that all the models adequately fitted the present data, but the bi-factor structure showed the strongest fit. Further analysing this model, we found a strong general catastrophizing factor and weak specific factors, which is in line with Cook and colleagues' (2021) results. In our study the general catastrophizing factor was responsible for 81.5% of the explained variance, meaning that the questionnaire indeed measures pain catastrophizing, thus the use of the total score is reasonable which is in line with the original conceptualization of pain catastrophizing by Sullivan and co-workers (1995). From the original three subscales, rumination and helplessness had reasonable but small contribution in explaining the variance (with 7.8% and 10.1% parts of the total variance), while, in the bi-factor model, the magnification subscale “disappeared”, with only 0.6% of explained variance and non-significant item loadings, meaning that its items loaded only on the general factor. This latter result might give an explanation for why the internal consistency of this subscale in some studies was found to be low (Cronbach's alpha: between .5-.7),

while the other two subscales and the total score usually show good or excellent reliability values (alphas above .8) (Bansal et al., 2016; Monticone et al., 2013; Osman et al., 2000; Tremblay et al., 2008; Van Damme et al., 2002).

In order to support the validity of the Hungarian PCS we tested its correlation with depression and with perceived pain intensity. In line with the literature (Feinstein et al., 2017; Leung, 2012; Quartana et al., 2009), we found that pain catastrophizing showed moderate to weak positive correlations with depression and perceived pain intensity, respectively.

Another goal was to find a clinically relevant cut-off point which might help us identify a risk group in terms of pain catastrophizing. Previously in the literature, researchers used the 50th (20 points) (Sullivan et al., 2005; Wideman et al., 2009) or 75th (30 points) (Chibnall and Tait, 2009; Sabo and Roy, 2019; Sullivan et al.,1995, 2001) percentiles of the PCS. Scott (Scott et al., 2014) used a receiver operating characteristic (ROC) curve analyses and identified 24 as the clinically meaningful score on the PCS. We used latent class analyses (LCA) to identify groups based on their catastrophizing scores and found that three groups emerged: a no pain catastrophizing group, a group which showed moderate catastrophizing and a high pain catastrophizing group. We found that the high pain catastrophizing group compared to the no pain catastrophizing group showed significant differences in depression scores and in the perceived pain intensity. What is more interesting, however, is that these differences were also present when we compared the moderate pain catastrophizing group to the no pain catastrophizing group. This might indicate that not only the high, but this moderate pain catastrophizing group can also be an at-risk group.

Based on our calculations, we suggest 22 points as a cut-off score which is in line with Scott and co-workers' results (Scott et al., 2014). They reported that 24 points on the Pain Catastrophizing Scale are clinically meaningful and indicate a risk group of pain catastrophizers. As pain catastrophizing has a significant effect on different pain-related outcomes (Besen et al., 2017; Martel et al., 2014; Meyer et al., 2009; Picavet, 2002), pre-treatment use of the PCS should be considered to identify this risk group and plan treatment accordingly.

The half of our chronic pain patient sample (50.3%) belonged to the no pain catastrophizing group with mean PCS scores at around 11 (SD = 5.96). This group – compared to the other two groups in univariate analyses – had lower perceived pain intensity and depression scores as well. For instance, the mean of perceived pain intensity in the high catastrophizing group was almost the twice than it was in the no pain catastrophizing group. Though pain catastrophizing is usually treated as a risk, i.e. an antecedent factor in the development of chronic pain (Marcuzzi et al., 2018), pain intensity could also affect pain catastrophizing. For instance, Racine and colleagues (Racine et al., 2016) found a reciprocal association between pain catastrophizing and pain intensity in fibromyalgia: reduction in pain catastrophizing early in treatment subsequently reduced pain intensity, and vice versa, early reduction in pain intensity predicted a decrease in pain catastrophizing. Thus, it is plausible to hypothesize that once chronic pain has developed it is "easier" not to catastrophize low-intensity pain than high-intensity pain, pointing out the need for effective pain reduction treatments.

Our LCA result also highlights that chronic pain samples are heterogeneous groups, and although pain catastrophizing is an important psychological factor, there could be other psychological (e.g. kinesiophobia, Picavet, 2002; and anxiety, Tran et al., 2015)) and non-psychological risk factors that should be considered. For instance, according to some results obtained in fMRI studies, structural and functional connectivity in the medial prefrontal cortex–nucleus accumbens and medial prefrontal cortex–amygdala connections appear to predict the risk for developing persistent pain from sub-acute back pain (Baliki et al., 2012; Mansour et al., 2013; Vachon-Presseau et al., 2016), though in these studies pain catastrophizing was not measured, thus potential interaction between biological and psychological risk factors should be investigated in future prospective studies.

Another specialty of our study is that half of our sample (49.75%) was above 60 years of age. This gave us the advantage of being able to better examine the effects of age. In the multinominal regression analysis, neither age, nor gender predicted group membership, however univariate analysis showed that more women were in the moderate and the high pain catastrophizing group, and the mean age of the high pain catastrophizing group was a slightly higher compared to the no pain catastrophizing group. In a review about pain catastrophizing, Leung (2012) found that there is a lack of consensus about the effect of age in connection with pain processing or pain catastrophizing, however Feinstein and coworkers (2017) while comparing adolescents (aged 18–23) with young adults (24–29 years old) found that age moderated the association between catastrophizing and pain interference, but with a declining tendency with age. More studies on older age groups with chronic pain are needed.

4.1. Limitations

Our study has some limitations that warrant discussion. In this study, we have a special chronic pain sample (originated from degenerative spinal disorders), thus, our results might only be interpreted on similar chronic pain patients. In connection with this another limitation might be that we recruited our participants from a single specialized centre that might affected our results. In a meta-analysis, Wheeler and colleagues (2019) for instance found that mean PCS score differed as a function of the pain type: participants with upper or upper and lower limb pain achieved lower points on the PCS than healthy participants while participants with trunk pain or generalized pain experienced the highest pain catastrophizing score. We used the short form Hungarian version of Beck Depression Inventory, however it is a valid scale (Rózsa et al., 2001), and it showed good reliability in our study.

We used the standard instruction when measuring pain catastrophizing, so we do not know how our participant interpreted it exactly. In other words, items of the PCS can be answered either using general (past) painful experience as a reference (that is the standard instruction, aiming to assess dispositional pain catastrophizing), or using specific (actual or past) pain as a reference. Participants with chronic pain likely think of their ongoing pain. This idea is supported by a recent study (Kapoor et al., 2015), in which participants were asked to report what type of pain they were recalling when filling out the PCS. Almost half of the sample (44.5 %, N = 81) in that study had chronic pain, and more than half of this subsample (58%) used this chronic pain as a primary pain referent when completing the general trait pain catastrophizing questionnaire. While 23.5% thought of their worst pain unrelated to their actual disease when completing the PCS, and only a minority of this subsample used disease unrelated pain as a primary referent (Kapoor et al., 2015). In addition, further studies would need to check whether pain, other than chronic pain, is catastrophized among people living with chronic pain while also checking what type of pain (general or specific) the participants had in mind while filling out the questionnaire. For instance, in a study when different explicit instructions were used, there was only a weak association between dispositional pain catastrophizing and catastrophizing of actual clinical pain ($r = 0.27$, $p > 0.05$, $N = 34$) (Grosen et al., 2016).

From a methodological point of view, it is an important question how the bi-factor model would fit to data and what proportion of variance would be explained by general and specific factors in pain-free samples. Comparing groups (e.g. people with chronic pain vs. pain-free controls) on pain catastrophizing is meaningful only if both groups attribute the same meaning to the questionnaire items and the latent construct. However, there are only some studies in which the invariance of PCS structure was tested.

From a clinical point of view, our result suggest that 22 points on the PCS requires special attention in medical settings, since in this group pain intensity and depressive symptoms are also elevated. However, prospective studies are needed to see whether the proposed cut-off score has

any predictive/prognostic value. It is also important that a cut-off score may depend on the sample collected according to specific eligibility criteria in a study and, thus the score may not be directly applicable to other studies with different eligibility criteria (e.g. different countries). It is worth mentioning that pain catastrophizing thoughts can be influenced by different methods (Darnall et al., 2014; Schütze et al., 2018). Findings corroborate the notion that these maladaptive pain-related cognitions can be changed, however it is unclear whether these changes are stabile in time. Although it seems that the most effective methods in changing catastrophic thoughts (Cognitive Behaviour Therapy, multimodal interventions and Acceptance and Commitment Therapy) maintained their positive effects in the long run. Notably, these methods work best aimed at people with higher catastrophizing (Schütze et al., 2018).

From a theoretical point of view our results questioned the magnification component of pain catastrophizing, which is in line with a recent psychometric study by Cook and colleagues (2021). Identifying the key elements of pain catastrophizing is not just a methodological question but a more basic conceptual one (Petrini and Arendt-Nielsen, 2020), pointing out the need for a more cohesive understanding of pain catastrophizing.

5. Conclusion

Based on the results of the present study, we can conclude that on a chronic spine-related (neck, back and low-back) pain sample, the bifactor model of the Hungarian PCS showed the best fit to the data, proving the existence of a general pain catastrophizing factor and the viability of two subscales (Rumination and Helplessness). Using LCA, we found that 22 points on the PCS separates non-catastrophizers from those who at least moderately catastrophize pain, have depressive symptoms and evaluate their pain as more intense, thus it can be considered a clinically meaningful cut-off point, which is almost identical with the score (24) that was suggested by Scott and colleagues (Scott et al., 2014). The cut-off score could be used in screening or pre-treatment to identify a risk group for interventions targeting pain catastrophizing could be fruitful. However, further prospective studies are needed to evaluate the usefulness of the proposed (or any) cut-off score.

Declarations

Author contribution statement

Attila Galambos and Róbert Urbán: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Dániel Péter Stoll: Conceived and designed the experiments; Wrote the paper.

Szabolcs Bolczár: Performed the experiments; Wrote the paper.

Áron Lazáry: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Gyöngyi Kökönyei: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at https://osf.io/8aqdf/

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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