

Observational Studies

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Properties of pain catastrophizing scale amongst patients with carpal tunnel syndrome – Item response theory analysis

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Abstract

Objectives – To evaluate the psychometric properties of pain catastrophizing scale (PCS) using item response theory (IRT) amongst people with carpal tunnel syndrome (CTS).

Methods – Retrospective cross-sectional register-based study amongst 1,597 patients with CTS. Two-parameter IRT analysis with rating scale model.

Results – The average age was 55.3 (16.3) years and 896 (56%) were women. The average PCS total score was 15.1 (11.6) points. For all 13 items, the estimates of difficulty parameter indicated a shift towards higher PCS scores. This was also seen in item characteristic curves and item information function. Respectively, the entire composite score showed the same shift towards higher PCS scores. The discrimination of PCS was excellent 1.98 (95% CI 1.89–2.07).

Conclusions – Overall, the psychometric properties of the PCS were found to be sufficiently good to recommend this scale for clinical use in CTS. The PCS is well able to distinguish between people with different levels of pain catastrophizing, even if performing better in elevated levels of catastrophizing. Also, the respondents may have a slight tendency to underestimate the severity of their catastrophizing when responding to the PCS. The results may be of interest to both clinicians and researchers in planning and implementing conservative or operative treatment for CTS,

setting rehabilitation goals, and evaluating treatment or rehabilitation outcomes.

Keywords: pain management, carpal tunnel syndrome, catastrophization, psychometrics

1 Introduction

It has been suggested that emotional distress, depression, anxiety, and catastrophizing may play a significant role in the way people with carpal tunnel syndrome (CTS) perceive the severity of their symptoms and disability [1–4]. Pain catastrophizing can be understood as a propensity to amplify the perceived pain, to experience helplessness because of pain and to feel inability to deal with thoughts focused on pain. Despite the fact that different theories behind this phenomenon have been introduced without a commonly accepted one, pain catastrophizing is real and it may significantly affect the natural course of CTS as well as it should be taken into account when planning treatment or rehabilitation [5–8].

Since 1995, pain catastrophizing scale (PCS) has become the most widely used patient-reported outcome measure to detect the presence and to assess the severity of possible pain catastrophizing [9]. The PCS consists of 13 questions, which are grouped in three domains: rumination, magnification, and helplessness. This way, the PCS produces four scores: a total score and scores for each domain. The psychometrics of the PCS have been studied for different disorders that are associated with chronic pain [10–16]. The internal consistency and test–retest reproducibility of the PCS have usually been found to be good [9,14,17]. There have been inconsistent reports on the factor structure of the PCS with the number of retaining factors varying from one up to four [10–16]. Also, the reports on potential floor and ceiling effects have been inconsistent [18–22]. Despite these discrepancies, the PCS have been thought to have good enough psychometric properties to be used in clinical practice and research. Previous studies on the use of the PCS among people with CTS have been

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scarce and the knowledge on the psychometrics of the PCS in this population could mostly be described only indirectly based on the original research with primary focus on clinical results [1–4,6–8,23–25].

Item response theory (IRT) or Rasch analysis have been used to study the properties of the PCS in several studies [26–33]. The populations of interest in these studies have included general chronic pain [26,32], back pain [27,29,30], musculoskeletal chronic pain [28,31], or work-related pain [33]. Overall, the results have been promising – no substantial weaknesses have been reported. The PCS was found to have a tendency of better functioning at the higher level of catastrophizing among people with low back pain [27]. Differential item functioning (DIF) has been mentioned in previous studies on the PCS twice – one study did not observe DIF [31] and another reported of sex-related DIF for two items [32].

While the psychometrics of the PCS have been studied by numerous studies, the spectrum of disorders in studied populations have varied widely. Strictly speaking, the psychometric properties of the PCS concerning particularly CTS are mostly unknown. The objective of this study was to evaluate the psychometric properties of the PCS employing IRT amongst people with CTS.

2 Methods

This was a retrospective cross-sectional register-based study. The study sample was derived from a register kept by the Wellbeing Services County of Southwest Finland. The study has been approved by the research department of Wellbeing Services County of Southwest Finland (2024-1208-TL). According to the Finnish legislation, a retrospective register-based study does not require a formal informed consent from a participant. The data were provided to the research group in an anonymous form without any individually identifiable information. Before every visit at the department of hand surgery of a university clinic all the patients had received a link to a survey, which contains questions regarding demographics, pain, and functioning. At the beginning of June 2024, the entire register contained data on 14,095 patients. Of them, 1,609 had the diagnosis of CTS (G56.0) as the main reason for visiting the clinic. Of them, 1,597 (99%) have answered to the PCS questionnaire between February 14, 2019 and June 3, 2024.

Sex was defined in a binary form as men vs women. Dominant hand was defined as right vs left vs ambidextrous. Educational level was defined as no high school vs high school. Physical activity was defined as none, 3 h/week, 4 h/week, or >4 h/week. Age was defined in full

years at the time of response. Body mass index was defined as body weight divided by height and expressed in kg/m². The total score of QuickDASH questionnaire was reported in points ranging from 0 (no disability) to 100 (most severe disability) points.

The PCS is a 13-item scale, with each item rated on a five-point Likert-like scale from zero (not at all) to four (all the time). Additionally to a composite score, the PCS produces scores for its three subscales: magnification, rumination, and helplessness. The sub-scores were the sums of responses to items 8, 9, 10, and 11 (rumination), 6, 7, and 13 (magnification), and 1, 2, 3, 4, 5, and 12 (helplessness). The overall score is a sum all 13 item responses ranging from 0 to 52, higher scores indicating a greater degree of pain catastrophizing. A total score of >30 is usually considered a clinically significant level of pain catastrophizing.

2.1 Statistical analysis

Two-parameter IRT analysis was applied. “Difficulty” describes the perceived severity of catastrophizing needed to obtain a particular score. The second parameter was “discrimination.” Discrimination is the ability of scale to differentiate people with different levels or measurable entity (here the level of catastrophizing). Discrimination of 0.01–0.24 was considered “none” (a totally level regression curve), 0.25–0.64 was considered “low,” 0.65–1.34 was considered “moderate,” 1.35–1.69 was considered “high,” and a discrimination >1.7 was considered “perfect” (a regression curve approaching a vertical line) [34]. Item characteristic and item information (inverse variance) function curves were built for each item. The corresponding item information function was evaluated for the total score as well. All the analyses were conducted using Stata/IC Statistical Software: Release 18. College Station (StataCorp LP, Texas, USA).

3 Results

The average age of 1,597 patients was 55.3 (16.3) years and 896 (56%) were women (Table 1). The average PCS total score was 15.1 (11.6) points.

3.1 Difficulty parameter

The intervals between the estimates of scores’ difficulty (from zero to four) were not even for all 13 items (Table 2).

Table 1: Descriptive characteristics of sample

Characteristics	<i>n</i> (%) / mean (SD)
<i>n</i>	1,597
Sex	
Men	701 (43.9%)
Women	896 (56.1%)
Dominant hand	
Right	533 (91.6%)
Left	37 (6.4%)
Ambidextrous	12 (2.1%)
Educational status	
No high school	377 (67.1%)
High school	185 (32.9%)
Physical activity	
None	149 (25.7%)
3 h/week	96 (16.6%)
4 h/week	319 (55.1%)
>4 h/week	15 (2.6%)
Age, years	55.3 (16.3)
Body mass index, kg/m ²	28.6 (6.2)
Hand pain, points (0–10)	5.7 (2.8)
QuickDASH, points (0–100)	32.5 (23.6)
PCS, points (0–52)	
Total score	15.1 (11.6)
Rumination	5.6 (4.2)
Magnification	2.8 (2.5)
Helplessness	6.7 (5.6)

Figure 1 supports these results – the intervals between difficulty levels were not equal. The distances between scores “1” and “2” and between “3” and “4” were approximately twice as big comparing with the distance between “2” and “3”. Except for the item #8 “I anxiously want the pain to go away”, all the other items showed slight shift towards higher scores. This can be seen in Table 2 – the difficulty estimates switched from positive to negative at the lowest possible response, except for items #4 “It’s awful and I feel that it overwhelms me” and #7 “I keep thinking of other painful events,” where the estimates remained positive even at the smallest scores. Also, the same shift towards higher scores was seen graphically. This phenomenon suggested that the respondents tended to underestimate their severity of catastrophizing when responding to the PCS. Even when the severity is more severe than the average level, the respondents might mark the low score like “1” or even zero.

3.2 Discrimination parameter

The discrimination of the PCS was perfect 1.98 (SE 0.04, z-score 44.35, *p* < 0.001, 95% CI 1.89–2.07). The item

Table 2: Difficulty parameter (probability of achieving a particular score) of PCS items

Score	Difficulty	95% CI	Score	Difficulty	95% CI
PCS #1 I worry all the time about whether the pain will end			PCS #8 I anxiously want the pain to go away		
1 vs 0	-0.78	-0.85 -0.71	1 vs 0	-1.06	-1.14 -0.99
2 vs 1	0.22	0.15 0.28	2 vs 1	-0.06	-0.13 0.00
3 vs 2	0.78	0.71 0.85	3 vs 2	0.50	0.43 0.57
4 vs 3	1.68	1.58 1.78	4 vs 3	1.40	1.31 1.49
PCS #2 I feel I can't go on			PCS #9 I can't seem to keep it out of my mind		
1 vs 0	-0.46	-0.53 -0.40	1 vs 0	-0.55	-0.61 -0.48
2 vs 1	0.54	0.47 0.60	2 vs 1	0.45	0.39 0.52
3 vs 2	1.10	1.02 1.17	3 vs 2	1.01	0.94 1.09
4 vs 3	2.00	1.89 2.10	4 vs 3	1.91	1.81 2.02
PCS #3 It's terrible and I think it's never going to get any better			PCS #10 I keep thinking about how much it hurts		
1 vs 0	-0.28	-0.34 -0.21	1 vs 0	-0.25	-0.32 -0.19
2 vs 1	0.72	0.65 0.80	2 vs 1	0.75	0.68 0.82
3 vs 2	1.28	1.20 1.37	3 vs 2	1.31	1.22 1.39
4 vs 3	2.18	2.07 2.30	4 vs 3	2.21	2.09 2.32
PCS #4 It's awful and I feel that it overwhelms me			PCS #11 I keep thinking about how badly I want the pain to stop		
1 vs 0	0.03	-0.04 0.09	1 vs 0	-0.81	0.88 -0.74
2 vs 1	1.03	0.95 1.11	2 vs 1	0.19	0.13 0.26
3 vs 2	1.59	1.50 1.68	3 vs 2	0.75	0.68 0.82
4 vs 3	2.49	2.37 2.61	4 vs 3	1.65	1.55 1.75
PCS #5 I feel I can't stand it anymore			PCS #12 There's nothing I can do to reduce the intensity of the pain		
1 vs 0	-0.08	-0.15 0.02	1 vs 0	-0.45	-0.52 -0.39
2 vs 1	0.92	0.84 0.99	2 vs 1	0.55	0.48 0.61
3 vs 2	1.48	1.39 1.57	3 vs 2	1.10	1.03 1.18
4 vs 3	2.38	2.26 2.49	4 vs 3	2.00	1.90 2.11
PCS #6 I become afraid that the pain will get worse			PCS #13 I wonder whether something serious may happen		
1 vs 0	-0.58	-0.64 -0.51	1 vs 0	-0.20	-0.27 -0.14
2 vs 1	0.42	0.36 0.49	2 vs 1	0.80	0.72 0.87
3 vs 2	0.98	0.91 1.06	3 vs 2	1.36	1.27 1.44
4 vs 3	1.88	1.78 1.99	4 vs 3	2.26	2.14 2.37
PCS #7 I keep thinking of other painful events					
1 vs 0	0.51	0.44 0.58			
2 vs 1	1.51	1.42 1.60			
3 vs 2	2.07	1.96 2.18			
4 vs 3	2.97	2.83 3.11			

information curves, respectively, the item information functions of the items showed that the best precision of responses could be found at the levels of catastrophizing that were higher than the average level estimated for this sample (Figure 2). The test characteristic curve of the PCS as a whole showed an asymptotic curve of classical shape (Figure 3). The steepest interval of this curve was shifted towards higher level of catastrophizing.

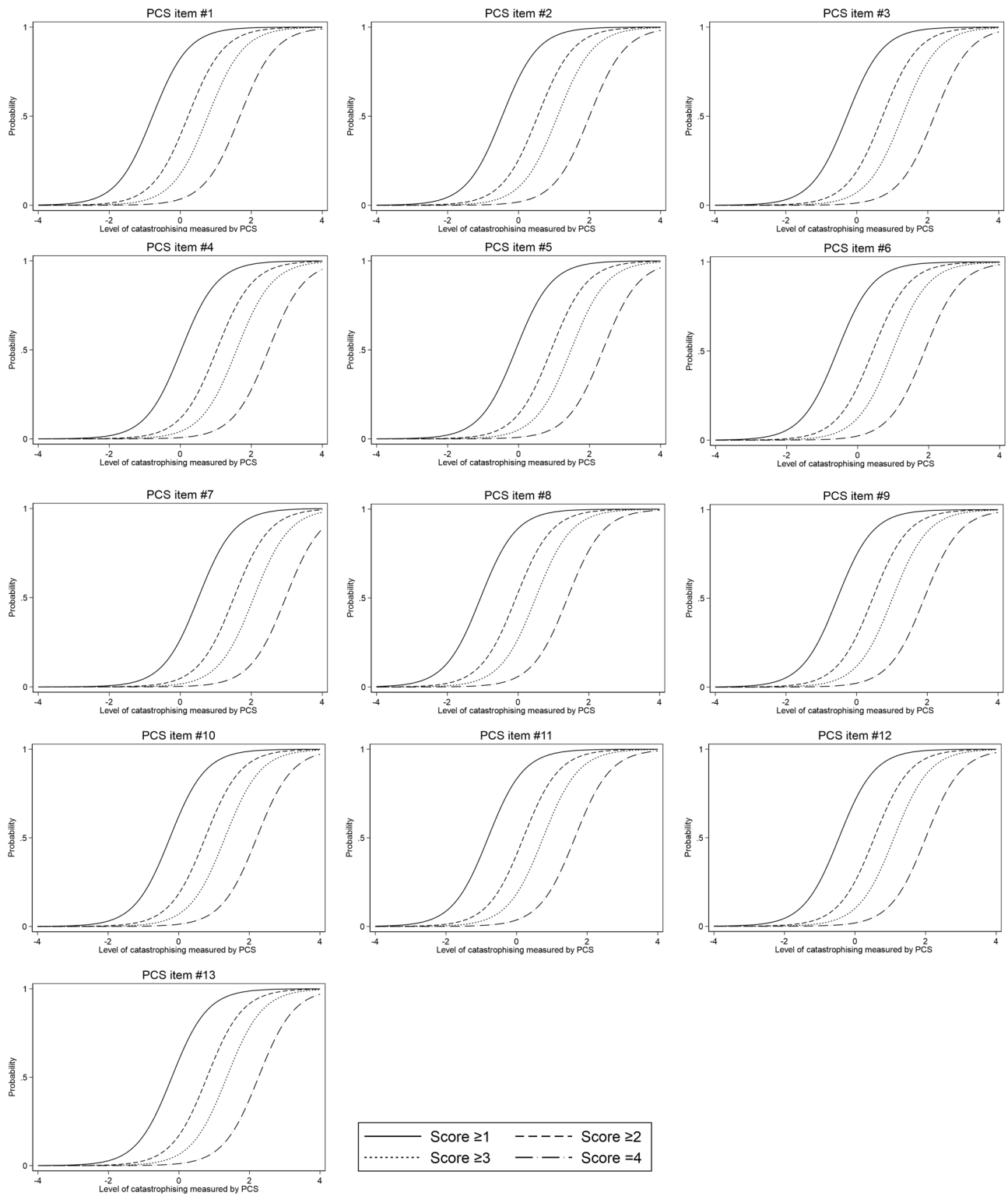


Figure 1: Item characteristic curves for each PCS item.

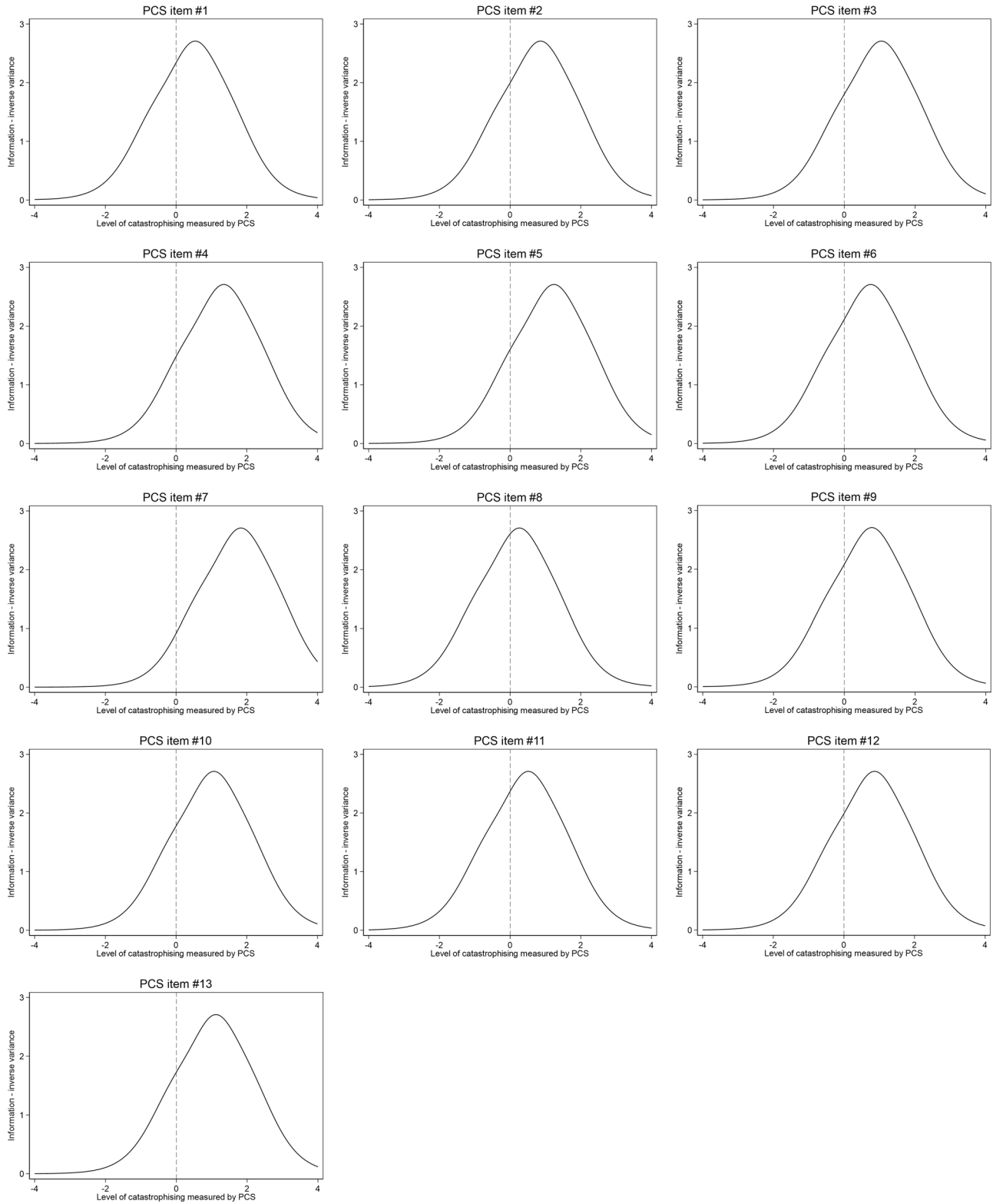


Figure 2: Item information (inverse variance) functions of PCS items.

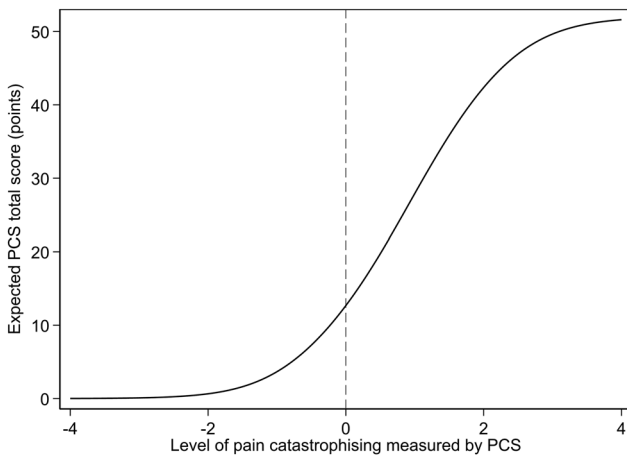


Figure 3: Test characteristic curve of PCS.

4 Discussion

The responses to the PCS by 1,597 patients with CTS were analyzed employing two-parameter IRT. A shift towards higher levels of catastrophizing was seen for most of the items as well as for the entire scale suggesting that the respondents might tend to underestimate their severity of catastrophizing. Also, the precision of the PCS was at its best at the levels of catastrophizing that were above the average level in the studied sample. The discrimination ability of the PCS was perfect, meaning that the PCS is well able to differentiate people with different levels of pain catastrophizing. The intervals between the estimates of scores' difficulty (from zero to four) were not even. The distances between scores "1" and "2" and between "3" and "4" were approximately twice as big comparing with the distance between "2" and "3."

The generalizability of the results might be compromised by some factors. The proportion of respondents with clinically significant catastrophizing (PCS total score >30 points) was as low as 12% (less than 200 respondents). In this way, the results described CTS patients, the overwhelming majority of which did not show pathological pain behavior. In order to study the characteristics of CTS specifically in the group where there is a lot of catastrophizing, data that is larger than the sample of this study is required. This retrospective study was based on a register containing only a few background variables. For example, emphasizing the physical or psychological load in the respondent's work might affect the characteristics of PCS. The PCS translation used in this study has not been properly validated as for COSMIN guidelines. However, the version employed here is what has been used by all hospital districts in this particular country for many years. Thus, this register-based retrospective analysis was unable to affect the version used to gather the data. The results

might be slightly different if a more appropriately validated translation has been used, like suggested by a recent study by Mikkonen *et al.* [35].

As there have been only scarce research on the psychometrics of PCS in CTS, the direct comparison with previous reports was hardly possible. However, some conclusions can be interpolated from previous studies in other health conditions. Several earlier studies have applied the IRT, or comparable to IRT Rasch analysis, to the research on the PCS scale [26–33]. In line with previous report, the present results showed the presence of shift in PCS functionality towards higher levels of pain catastrophizing. This is true at least for a population of people with low back pain [27]. Also, similarly to previous studies the overall performance of PCS was considered to be satisfactory. This consistency was not surprising considering that previous research has been conducted amongst people with chronic pain – general pain [26,32], back pain [27,29,30], musculoskeletal chronic pain [28,31], and work-related pain [33]. It is reasonable to assume that chronic pain may cause pain catastrophizing or vice versa catastrophizing may intensify pain complaints disregarding of the anatomical site of initial pain.

For all 13 items, the intervals between scores on a Likert-like scale from zero to four were not evenly distributed in term of their difficulty. The findings imply that this phenomenon may be important to consider when measuring change in the scores of individual PCS items. Uneven distances between different choices suggest that a direct comparison between two changed scores may lack a sufficient preciseness, at least in some situations. The change between two and three points was half the change between all other points. In other words, if we compare changes in individual PCS item scores for two groups of respondents, a change from one point to two points is likely to represent only half the change in the direction of milder or more severe catastrophizing compared to other possible combinations of points.

IRT analysis is clearly one of the most difficult concepts in psychometrics. From a clinical practice perspective, the main results can be explained as follows. In general, the PCS items were able to reliably describe different aspects of catastrophizing among CTS patients. Increased levels of catastrophizing resulted in higher scores for all 13 items. On the other hand, it has been seen that respondents may slightly underestimate the level of catastrophizing they experienced. It was also seen that the PCS had excellent discrimination across all items – the PCS scale was accurate enough to distinguish respondents who experienced varying degrees of catastrophizing. However, it was seen that for almost all items the PCS performed better at slightly higher levels of catastrophizing compared to situations where respondents experienced milder catastrophizing. For an

individual person, this shift would hardly be clinically significant. However, it may be important when statistical analysis is conducted on larger samples or when considering including the PCS in comprehensive patient surveys. For the sake of simplicity, it can be stated that, at least based on the IRT, the PCS can be recommended as reliable for the clinical evaluation of catastrophizing experienced by CTS patients.

Further research may reveal other important issues in the psychometric functionality of the PCS. For example, DIF in PCS has been mentioned by only a few previous studies [31]. Different factors that may potentially cause the DIF in PCS should be studied. Among such factors may be age, sex, and occupational and educational status. Another direction for further assessment may be confirming the stability of the psychometrics of PCS over time, for example before and after carpal tunnel release.

5 Conclusions

Overall, the psychometric properties of the PCS were found to be sufficiently good to recommend this scale for clinical use in CTS. The PCS is well able to distinguish between people with different levels of pain catastrophizing, even if performing better in elevated levels of catastrophizing. Also, the respondents may have a slight tendency to underestimate the severity of their catastrophizing when responding to the PCS. The results may be of interest to both clinicians and researchers in planning and implementing conservative or operative treatment for CTS, setting rehabilitation goals, and evaluating treatment or rehabilitation outcomes.

Research ethics: The work described has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involved. The privacy rights of human subjects have been observed according to the EU general data protection regulation (GDPR). The study sample was derived from a register kept by the Wellbeing Services County of Southwest Finland. The study has been approved by the research department of Wellbeing Services County of Southwest Finland (2024-1208-TL). The data were provided to the research group in an anonymous form without any individually identifiable information.

Informed consent: According to the Finnish legislation, a retrospective register-based study does not require a formal informed consent from a participant.

Author contributions: All three authors substantially contributed to the conception, design, analysis, and interpretation of the work. M.S. and H.T. were responsible for the acquisition of data for the work. M.S. was responsible for the statistical analysis and the drafting the work. All the authors substantially contributed to the reviewing the draft critically for important intellectual content and to the final approval of the version to be published. All the authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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