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Identification and characterization of pain processing patterns among patients with chronic primary pain: A replication

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Abstract

Objectives: To develop individual and effective treatment plans for patients with chronic pain, we aimed to replicate Grolimund et al.'s (2017) empirical categorization of chronic pain patients on a new and larger sample. Moreover, this work aimed to extend previous knowledge by considering various treatment outcomes and exploratorily analyzing which coping skills might be particularly relevant for treatment success in each subtype.

Methods: Latent class analysis was used to identify homogenous subtypes with different pain processing patterns using the pain processing questionnaire (FESV).

Results: By analyzing 602 inpatients with chronic primary pain, we identified three subtypes: (1) *severely burdened individuals with low coping skills*, (2) *mildly burdened individuals with high coping skills*, and (3) *moderately burdened individuals with moderate coping skills.* Pain interference, psychological distress, cognitive and behavioral coping skills improved after treatment in all subtypes. Pain-related mental interference significantly improved only in subtypes (1) and (3). Only individuals of subtype (3) reported significant reductions in pain intensity after treatment. Exploratory regression analysis suggested that of subtype (1), the most promising targets in reducing pain interference and psychological distress post-treatment might be to foster *relaxation techniques*, *counteractive activities*, and *cognitive restructuring*. None of the FESV dimensions significantly predicted treatment outcomes among individuals of subtype (2). Individuals of subtype (3) might benefit the most from *experiencing* more *competence* during treatment.

Discussion: Our findings highlight the importance of identifying and characterizing subtypes of chronic primary pain patients and that these subtypes should be considered for individualized and effective treatment.

Keywords: chronic primary pain - interdisciplinary pain treatment – subtypes – pain processing – pain coping

Introduction

Chronic pain is a global health problem that profoundly impacts both individuals and society [1]. Patients with chronic pain experience severe physical and psychosocial consequences as their pain is recurrent or persists over three months or more [2]. Moreover, chronic pain is often accompanied by mental disorders such as depression and anxiety, which may mutually precede and/or increase each other over time [2]. As the incidence and prevalence of chronic pain continued to grow over the past few decades, effective treatment for chronic pain is of utmost importance, and tools to better individualize therapy are needed [1,3].

Chronic pain treatment aims to increase patients' physical and psychological functioning by learning and implementing new cognitive and behavioral coping skills or adapting current (potentially inefficient) coping skills [4,5]. An interdisciplinary multimodal treatment is considered particularly suitable for chronic pain, as it combines different treatment methods (e.g., psychological treatment, physiotherapy, relaxation techniques, occupational therapy). This enables the treatment to be tailored to the specific patient's needs [6].

To prepare an optimally tailored treatment, it is important to identify individual risk and protective factors [4,7]. Therefore, it is essential to understand how patients deal with their chronic pain and identify functional and dysfunctional pain processing patterns for an individualized case formulation and treatment planning. Identifying phenotypes that categorize patients according to their pain processing pattern is a pivotal step toward individualized case formulation and might especially help under limited temporal resources [8].

Various categorizations of patients with chronic pain based on their pain processing style have been suggested in previous research [9–13]. Grolimund et al.'s (2017) categorization seems to have clinical utility for individualized and effective treatment planning, as it takes into account

both pain-related mental interference and different coping skills as assessed by the German version of the pain processing questionnaire (FESV) [14]. For categorizing patients, three distinct subtypes of inpatients with chronic pain were identified by a two-step cluster analysis: (1) individuals with high interference and low coping skills, (2) individuals with low interference and high coping skills, and (3) individuals with high interference and high coping skills. Comparing the different subtypes, Grolimund and coauthors found significant differences in various psychosocial properties such as psychological distress, stress, and social support [9]. Grolimund et al.'s three subtypes also corresponded with three of Roditi et al.'s (2010) four subtypes, who focused on the frequency and perceived effectiveness of coping strategies used to cope with chronic pain among patients. Similarly, Wenzel et al. (2021), who investigated pain coping types among older community-dwelling care receivers with chronic pain, identified very similar subtypes as Grolimund and colleagues.

Considering the importance of identifying and characterizing subtypes of chronic pain inpatients, we aimed to replicate Grolimund et al.'s (2017) empirical categorization of chronic pain patients. We used latent class analysis on a new and larger sample of inpatients with chronic primary pain receiving inpatient interdisciplinary multimodal pain treatment to improve convergence, correct replications, and reduce parameter bias [15]. In extension of the previous study, we considered different treatment outcomes and exploratorily analyzed which coping skills might be particularly important for treatment success among the subtypes.

Material and methods

Sample

The new and larger sample consisted of 602 patients with chronic primary pain receiving inpatient care in the same tertiary psychosomatic university hospital for three weeks where

Grolimund et al.'s data was collected. Patients received an individualized selection of interventions from various available treatments (i.e., psychotherapy, medical interventions, pharmacotherapy, physiotherapy, and occupational therapy) [4]. Patients were assigned to the different treatment modalities based on indication and availability. They had weekly scheduled sessions, and each therapy was individually tailored to the patient's complaints, needs, and goals.

All patients were considered for inclusion if they fulfilled: (a) the criteria for chronic primary pain (MG30.0) according to the International Classification of Diseases (11th revision; ICD-11) [16]; (b) were aged 18 or older; (c) had sufficient German-language proficiency; (d) provided written consent regarding the further use and publication of their anonymized data.

Ethics statement

The Ethics Committee of the Canton of Bern approved the study (project ID 2018-00493, ID 2021-02214). The study complies with the Declaration of Helsinki. It was ensured that patients had ample time to get information about the further use of their anonymized data for research and were required to provide written consent if they agreed and wished to participate.

Procedures

All inpatients receiving interdisciplinary pain treatment between December 2015 – February 2022 were invited for psychometric assessment for quality management and completed self-reported questionnaires within the first two days after intake as well as a few days before discharge. Participating patients completed a battery of self-report questionnaires in the presence of a research assistant, who helped with eventual difficulties understanding single items or for providing additional information. This battery included questionnaires on the patient's overall condition, psychopathological symptoms, clinically relevant behavior and experience, as well as other treatment-related psychological constructs. However, some patients were not able to

complete all the questionnaires for various reasons, e.g., scheduling conflicts, early (unplanned) discharge, or severe current complaints. For this study, all inpatients who had completed all questionnaires needed for latent class analysis at intake were included. Thus, fewer data may have been available for the secondary analyses, such as for further characterization of subtypes, pre-post comparisons, and exploratory regression analyses.

Measures

Sociodemographic and pain-related data

Age, sex, marital status, and pain duration were assessed at intake.

Pain processing

The German pain processing questionnaire (FESV) is one of the most frequently used instruments for assessing core aspects of pain processing [14]. In detail, the FESV consists of 38 items and measures three basic components of pain processing: cognitive and behavioral pain coping, as well as pain-related mental interference. Each component has three sub-dimensions for the cognitive coping component: *action planning*, *cognitive restructuring*, and *competence experience*; for the behavioral coping component: *mental distraction*, *counteractive activities*, and *relaxation techniques*; and for the component of pain-related mental interference: *pain-related helplessness and depression*, *pain-related anxiety*, and *pain-related anger*. Thus, six dimensions measure coping skills, and three dimensions account for pain-related mental interference. For each item, patients used a six-point Likert scale ranging from 1 = "not at all true" to 6 = "completely true" to describe their pain in the last few days. This questionnaire was administered at intake and discharge.

Additional measures of pain- and treatment-related characteristics

Various constructs were considered to characterize the individual subtypes further. All additional measures were collected at intake and were considered for the further characterization of patients.

The well-being index (WHO-5) was used as a screening tool for depressive symptoms measuring patients' (lack of) well-being over the last two weeks with five items, ranging from 0 = "at no time" to 5 = "all the time" [17].

The total score of the PSS-10 questionnaire was used to assess perceived stress over the previous month, with ten items ranging from 0 = "never" to 4 = "very often" [18].

Patients' degree of pain catastrophizing was assessed using the total score of the 13-item pain catastrophizing scale questionnaire (PCS) [19]. The PCS uses a 5-point Likert scale from 0 = "not at all" to 5 = "all the time".

ENRICHD-Social-Support-Instrument (ESSI-D) measures different aspects of social support with five items on a 5-point Likert scale from 1 = "never" to 5 = "always" [20].

The German short version of the questionnaire for psychotherapy motivation (FPTM-23) consists of 23 items measuring the six scales *hopelessness*, *initiative*, *denial of the need for psychological help*, *knowledge of psychological treatment*, *symptom-related attention*, and *suffering* [21]. Patients use a four-point Likert scale from 1 = "not agree" to 4 = "agree".

Illness perception was assessed with the Brief Illness Perception Questionnaire (BIPQ) [22]. The BIPQ measures the patient's perceived *consequences, timeline, personal control, treatment control, identity, concern, understanding,* and *emotional response* with one item each, resulting in eight scales rated on a continuous linear scale from 0 to 10 [22].

Treatment outcome measures

In line with the VAPAIN consensus statement [6] and Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) recommendations [23,24], treatment outcome was operationalized by reductions in pain intensity, pain interference, and psychological distress.

Pain intensity and pain interference are two scales of the Brief Pain Inventory (BPI) [25]. The mean of four items measuring worst, least, average, and current pain on a Likert scale ranging from no pain at all (0) to the worst pain imaginable (10) represents the pain intensity scale. Pain interference can be calculated by averaging seven items regarding different aspects of life (e.g., general activity, mood, relations with other people, normal work) on a Likert scale ranging from no interference (0) to complete interference (10). This questionnaire was administered at intake and discharge.

Psychological distress during the last week was measured using the German version of the Hospital Anxiety and Depression Scale (HADS-D) [26]. This questionnaire consists of 14 items and measures anxiety and depression symptoms as psychological distress on a four-point Likert scale from 0-3, leading to a possible total score of 0 - 42. Patients were asked to complete this questionnaire at intake and discharge.

Statistical analyses

Version 27 of IBM SPSS Statistics and version 2021.09.2+382 of RStudio were used to analyze the data [27,28]. Other than Grolimund et al. (2017), who used two-step cluster analysis, we used latent class analysis to identify homogenous subtypes with different pain processing patterns using the FESV questionnaire data at intake. In accordance with Weller et al. (2020), multiple indicators were considered to determine which class solution fitted best. Bayesian Information Criterion (BIC), which is often considered the most reliable indicator of model fit,

was considered alongside the Akaike information criterion (AIC), log-likelihood (LL), entropy, and average latent class posterior probability (ALCPP) for best model fit. Lower BIC, AIC, and LL typically indicate better model fits [29]. Elbow plots were used to determine changes in the BIC, AIC, and LL indicators and compare different class solutions [30]. Values close to 1 for entropy are considered ideal and indicate how accurately the model defines classes. The average latent class posterior probability (ALCPP) represents the average probability that measures how accurately a person can be assigned to a class. Values for ALCPP between .8 and .9 are acceptable if other criteria for model fit are met, and values higher than .90 are considered ideal [29].

In a first step, class solutions for 2 to 6 classes were tested, and model fit indicators were compared to identify the best class solution. To determine the best model fit, we considered lower BIC, AIC, and LL in elbow plots, as well as entropy values close to 1 and ALCPP values above .9 as good model fit indicators [29,30].

In a second step, descriptive characteristics for the FESV dimensions, the sociodemographic and clinical characteristics, were investigated and compared for the total sample and the identified subtypes. Furthermore, descriptive characteristics of additional pain- and treatment-relevant measures were analyzed and compared for the total sample and the identified subtypes at intake. Fisher`s ANOVA and Tukey post-hoc tests were computed for homogenous variances in the observed variables, whereas Welch`s ANOVA and Games-Howell post-hoc tests were computed for not homogenous variances. Chi-square tests were used for continuous variables.

Next, paired t-tests were calculated to assess changes in each subtype from pre- to post-treatment in pain intensity, pain interference, psychological distress, cognitive and behavioral coping skills, as well as pain-related mental interference.

Finally, exploratory regression analyses using a stepwise elimination strategy were computed for treatment outcome measures that changed significantly during treatment for each subtype to investigate the predictive value of change scores of the single FESV dimensions on treatment outcome measures post-treatment. Bonferroni correction was applied due to multiple comparisons.

Results

Latent class analysis

Table 1 summarizes model fit and diagnostic criteria evaluation of the considered class solutions. A model with three classes appeared to be the most suitable solution for the observed sample. The characteristics of the different dimensions of the FESV for the respective subtypes are summarized in Table 2 and visualized in Figure 1. Compared to the FESV norm sample of pain patients, most of the subtypes' mean values of the different FESV dimensions are within the normal value range (±1 standard deviation) [14]. Following Grolimund et al. (2017), the subtypes were named based on their pain processing profiles as (1) *severely burdened individuals with low coping skills* (N = 148; 24.6%), (2) *mildly burdened individuals with high coping skills* (N = 60; 10.0%), and (3) *moderately burdened individuals with moderate coping skills* (N = 394; 65.4%). All dimensions of the FESV differed significantly between the subtypes except the use of *counteractive activities*, which were only significantly lower in subtype (1) than in subtypes (2) and (3).

Sociodemographic and pain-related data

The mean age of the total sample (n = 602) was 47.2 ± 13.7 years. More than 60% of the patients were female (63.6%), married or in a relationship (54.6%), and had suffered from their pain for 1-5 years (43.7%). On average, patients stayed for 22.8 days (SD = 6.4 days). Additional descriptive results on sociodemographic characteristics and questionnaire data for the entire sample are shown in Tables 2, 3, and 4.

Comparison of patient subtypes regarding sociodemographic and pain-related variables

Table 3 summarizes the descriptive characteristics of the total sample and patient subtypes in sociodemographic and pain-related variables and illustrates patient subtype comparisons. Age, sex distribution, marital status, and pain duration did not differ significantly between the different patient subtypes.

Table 4 summarizes descriptive characteristics of the total sample and the patient subtypes in additional pain- and treatment-relevant variables, as well as the results of their comparison. Class comparisons revealed that individuals in subtype 1 (*severely burdened individuals with low coping skills*) experience higher pain intensity and pain interference than individuals in subtypes 2 (*mildly burdened individuals with high coping skills*) and 3 (*moderately burdened individuals with moderate coping skills*). Furthermore, individuals in subtype (1) experience the most psychological distress, stress, as well as pain catastrophizing, followed by individuals from subtype (3), then subtype (2). Similarly, individuals in subtype (1) report the lowest well-being and social support, followed by subtypes (3) and (2). Significant differences in therapy motivation could only be found for the scales of *hopelessness* and *suffering*. Individuals in subtype (1) showed the highest values in the scales of *hopelessness* and *suffering*, followed by individuals in subtype (3) and subtype (2). The identified subtypes did not differ significantly

regarding the therapy motivation scales *initiative, denial of psychological need, symptom-related attention,* and *knowledge about psychological treatment*.

Comparisons of illness perception scores revealed that individuals of subtype (1) indicated more strongly that their illness burdened their lives than the other subtypes. Furthermore, subtype (1) experienced most strongly that symptoms were related to their illness, followed by subtype (3) and (2). Similarly, individuals in subtype (1) believed most strongly that their illness would last for a long time than patients in the other two subtypes did. Moreover, this subtype reported the least control or influence over their symptoms and believed most strongly that the treatment would not help them. In addition, patients in subtype (1) reported understanding their symptoms the least, followed by individuals of subtypes (3) and subtype (2). Furthermore, this subtype reports being most concerned and emotionally burdened by their pain condition, and subtype (2) reports being less concerned and emotionally burdened by their illness than subtype (3).

Comparisons between pre- and post-treatment

More detailed evaluations of the individual subtypes show that pain interference and psychological distress were significantly reduced during treatment in all subtypes, and patients' cognitive and behavioral coping skills improved significantly over all subtypes (see Table 5).

Subtype (1), i.e., being severely burdened with low coping skills, did not show significant reductions in pain intensity. Moreover, mildly burdened individuals with high coping skills (subtype 2) did not report significant reductions in pain intensity and pain-related mental interference after treatment.

According to the IMMPACT criteria, a reduction in pain intensity of more than 30% can be regarded as an at least moderate clinically relevant decrease during treatment, which is found

in 15.8% of this sample's patients. However, 57.5% of all patients reported a clinically significant reduction in pain interference across treatment, measured by a one-unit decrease on the NRS scale [23]. Overall, only 4.9% of patients indicated meaningful improvements regarding psychological distress from pre- to post-treatment according to the reliable change index (RCI) of at least a difference of 5.96 for the subscale of anxiety and 5.25 for the subscale of depression.

Exploratory regression analyses

Exploratory regression analyses using a stepwise elimination strategy were conducted to determine which FESV dimensions were associated with treatment outcomes in reducing pain intensity, pain interference, and psychological distress. Regression analyses were performed for these treatment outcomes that changed significantly during treatment for each subtype. FESV dimensions that changed significantly in each subtype were included as predictors. Bonferroni correction was applied due to multiple comparisons. Change scores were computed separately for all FESV dimensions, pain intensity, and pain interference. Tables 6, 7, and 8 summarize the exploratory regression analyses regarding the prediction of different treatment outcomes post-treatment by change scores of the separate FESV dimensions with Bonferroni correction.

As individuals in subtype (1) significantly improved in pain interference, and psychological distress, as well as in cognitive coping skills, behavioral coping skills, and pain-related mental interference, exploratory regressions were calculated to predict these outcome measures post-treatment by the mentioned FESV dimensions. Due to multiple comparisons of these nine FESV dimensions, Bonferroni correction was applied. The adjusted $p < .006$ marked statistical significance. In the first step, the prediction of post-treatment pain interference ($F(1,90) = 31.03$, $p < .001$) and psychological distress ($F(1,90) = 77.93$, $p < .001$) was significant, including pre-treatment scores of these measures as predictors. In the second step, the

various cognitive and behavioral coping and pain-related mental interference dimensions of the FESV questionnaire were added. This second analysis reached significance for predicting post-treatment scores of pain interference ($F(4,91) = 24.74$, $p < .001$) and of psychological distress ($F(3,91) = 47.27$, $p < .001$). The added dimensions uniquely accounted for 26% of the variance in mean pain interference and 14% in mean psychological distress. Findings suggested that improvements in *relaxation techniques* and *counteractive activities* predicted lower levels of both, pain interference and psychological distress post-treatment. Additionally, increased levels of *pain-related helplessness and depression* predicted higher levels of pain interference post-treatment.

Similarly, as individuals from subtype (2) showed significant reductions in pain interference and psychological distress, as well as significant improvements in cognitive and behavioral coping skills, exploratory regressions were calculated to predict these outcome measures post-treatment by the mentioned FESV dimensions. Due to multiple comparisons of these six FESV dimensions, Bonferroni correction was applied, and the adjusted $p < .008$ marked statistical significance. In the first step, the prediction of post-treatment pain interference ($F(1,45) = 16.39$, $p < .001$) and psychological distress ($F(1,45) = 40.52$, $p < .001$) was significant, including pre-treatment levels of the outcome variables. The second step, including the six dimensions of the FESV coping skills, did not reach significance and, therefore, did not suggest that any dimension of the FESV coping skills predicted pain interference or psychological distress levels post-treatment in this subtype (2).

Individuals from subtype (3) showed significant improvements in pain intensity, pain interference, and psychological distress, as well as improvements regarding cognitive coping, behavioral coping, and pain-related mental interference. Therefore, exploratory regression

analyses were calculated for all outcome measures using all nine dimensions of the FESV questionnaire as potential predictor variables. The adjusted $p < .006$ marked statistical significance due to multiple comparisons of the FESV dimensions. The first analysis reached significance for the prediction of pain intensity ($F(1,276) = 181.28$, $p < .001$), pain interference ($F(1,276) = 91.66$, $p < .001$), and psychological distress ($F(1,276) = 161.24$, $p < .001$) levels post-treatment, including outcome variable levels pre-treatment as control variables. In the second analysis, the separate cognitive and behavioral coping dimensions and the pain-related mental interference dimensions of the FESV questionnaire were added. This second analysis reached significance for predicting pain intensity ($F(2,276) = 102.60$, $p < .001$), pain interference ($F(4,276) = 62.27$, $p < .001$) and psychological distress ($F(4,276) = 71.09$, $p < .001$) levels post-treatment. The added dimensions uniquely accounted for 2% of the variance in mean pain intensity, 22% in mean pain interference, and 13% in mean psychological distress. In this subtype, increased levels of *pain-related anxiety* seemed to predict higher levels of pain intensity and psychological distress post-treatment. Furthermore, higher levels of *pain-related anger* predicted higher pain interference levels post-treatment, and higher levels of *pain-related helplessness and depression* predicted higher psychological distress levels post-treatment. Improvements in the *competence experience* dimension predicted reduced pain interference and psychological distress post-treatment.

Discussion

In the present replication study, we aimed to identify and describe subtypes of inpatients with chronic primary pain by latent class analysis of patient ratings of pain processing characteristics. We based our work on the findings of Grolimund et al. (2017) but critically extended their study by analyzing a new and larger sample, using a more advanced clustering

method (latent class analysis, LCA), investigating a wider range of outcomes, and exploring the relative outcome prediction by the different coping skills. Exploratory regressions were calculated to determine the change of which FESV dimensions might be particularly predictive of treatment outcome in each subtype, potentially generating suggestions for differential indications based on the assessed subtype.

We identified three distinct subtypes of inpatients with chronic primary pain: (1) *severely burdened individuals with low coping skills*, (2) *mildly burdened individuals with high coping skills*, and (3) *moderately burdened individuals with moderate coping skills*. Despite using a different statistical method (two-step cluster analysis) for analyzing data of a smaller sample (N = 166 inpatients), the three subtypes identified by Grolimund and colleagues (2017) are very similar to the subtypes identified in the current study. The subtypes also correspond well with the three subtypes found by Wenzel et al. (2021), as well as with three of the four subtypes identified earlier by Roditi et al. (2010). In line with Grolimund et al. (2017), the subtypes differed significantly in measures of other constructs. In addition, values in these measures corresponded meaningfully to the characterization of each subtype regarding pain coping and pain-related interference. By this, the relevance of the FESV questionnaire and the identified subtypes go beyond pain processing alone so that the FESV might be used for screening and preparing an individualized treatment planning.

Post-treatment, all subtypes showed significant reductions in pain interference and psychological distress, as well as improvements in cognitive and behavioral coping skills. However, pain intensity significantly changed only in subtype (3), i.e., individuals with moderate interference and moderate coping skills. Furthermore, pain-related mental interference did not improve significantly among individuals in subtype (2), i.e., patients with mild interference and

high coping skills. Thus, the large majority of outcome measures improved significantly in each subtype of patients after treatment, which generally supports the general suitability of an interdisciplinary multimodal inpatient treatment of chronic primary pain [6]. Whether the differences in pain intensity and psychological distress are clinically meaningful is debatable since only 15.8% of inpatients reported an at least 30% difference in pain intensity, and only 4.9% of inpatients reported improvements according to the reliable change index.

In the following, we discuss the findings of this study with regard to each subtype.

Individuals in subtype (1) report being highly burdened by their pain and report low cognitive and behavioral coping skills. Individuals in this subtype experienced more intense pain than the other two types and experienced the most pain interference. Moreover, patients of this subtype reported the strongest psychological distress, suffering, and perceived stress, the lowest well-being, as well as receiving the least social support. Comparisons of illness perception revealed that individuals of the first subtype felt more strongly than the other two subtypes that their illness burdened their life and experienced stronger symptoms attributed to their illness. Similarly, these individuals felt most strongly of all subtypes that their illness would last for a long time. Moreover, patients of this subtype perceived the least control or influence over their symptoms and believed most strongly of all subtypes that the treatment would not help them. In addition, patients of this subtype seemed to understand their symptoms the least and reported being more concerned and emotionally burdened than the other two subtypes. Feeling insufficiently able to cope with their pain might explain why these individuals catastrophized their pain the most and had the least hope regarding treatment compared to the other two types. As pain interference is reported as being very high and coping skills as very low, particularly individuals of this subtype could be expected to benefit from the inpatient treatment. In

accordance with these expectations, pain interference, psychological distress, as well as pain-related mental interference were reduced, and cognitive and behavioral coping skills improved significantly.

However, the reduction of pain intensity after treatment was not significant. Given that patients with chronic primary pain had suffered from pain and associated interferences for several years, the three-week duration of this inpatient treatment could have been simply too short to reduce pain intensity in this subtype of highly burdened patients. Moreover, large reductions in pain intensity are not expected after an interdisciplinary multimodal pain treatment, as it has been shown to be very challenging to alleviate pain intensity among patients with chronic primary pain [6,31,32]. Thus, interdisciplinary multimodal pain treatment usually focuses more on improving physical and psychological functioning despite the pain so that reducing pain interference and psychological distress can be considered more adequate outcomes in short-term pain treatment [6,31,32].

Exploratory regression analyses predicting reduced pain interference and psychological distress revealed that the most promising targets to address in the treatment of individuals of subtype (1) might be *relaxation techniques*, *counteractive activities,* and engaging in *cognitive restructuring*, which are already known effective strategies in the treatment of patients with chronic pain [33,34]. Therefore, incorporating these strategies into the treatment plan for patients of subtype (1) may improve treatment outcomes and could be a valuable area for further investigation. Moreover, as individuals of this subtype were highly burdened, it is important to explicitly address *pain-related helplessness and depression* in treatment. These targets can be integrated into pain-related psychotherapy, allowing patients of this subtype to learn and practice

specific new skills to cope with pain and pain-related mental interference [4,6], as also Grolimund et al. (2017) recommended.

Only 10% of all patients were assigned to subtype (2), representing patients being only mildly burdened by their pain and having high cognitive and behavioral coping skills. Moreover, individuals of this subtype reported receiving the most social support compared to the other two subtypes. Patients in subtype (2) reported a lower pain intensity than individuals of subtype (1), experienced the least pain interference of all patient groups, reported being the least burdened by psychological distress, stress, and suffering, and experienced the lowest level of illness-related symptoms. In addition, patients of subtype (2) assumed less strongly than patients of subtype (1) that their pain burdened their life and that it would last as long as patients of subtype (1) believed. Furthermore, patients of subtype (2) thought that the treatment would help them, were generally hopeful, reported the most control and/or influence over their symptoms, seemed to understand their symptoms the most, and were less concerned and emotionally burdened by their illness than the other two subtypes.

Being only mildly burdened by pain at intake might partially explain why individuals of this subtype did not show significant decreases in pain intensity and pain-related mental interference after treatment. Whereas individuals of this subtype showed significant reductions in pain interference and psychological distress as well as improvements in cognitive and behavioral coping skills after treatment, the according effect sizes were not as big as in other subtypes. Given the generally lower values at intake, there might have been limited room for decreases in the sense of a bottom effect. As individuals of subtype (2) obviously were not able to benefit as much from inpatient treatment as individuals of other subtypes, it is also of no surprise that none of the changes in FESV dimensions predicted post-treatment outcome variables. Also, because

this subtype contains very few patients, these results should be interpreted cautiously. Generally, individuals of this subtype might benefit most from supportive and resource-oriented interventions, optimizing their reportedly already efficient coping skills [9].

Subtype (3) includes moderately burdened individuals with moderate coping skills. In almost all measures examined, this subtype fell between the severely and the mildly burdened individuals. Even though these individuals reported having some coping skills, they still suffered from pain, which might indicate the presence of some dysfunctional coping patterns. After treatment, patients reported significant reductions in pain intensity, pain interference, psychological distress, and pain-related mental interference. Furthermore, they were able to improve their cognitive and behavioral coping skills. Regression analyses revealed that in this subtype, especially reductions in *pain-related anxiety, anger, helplessness and depression* were related to reductions in pain intensity, pain interference, and psychological distress. These results are rather unsurprising since these constructs largely overlap. Nonetheless, these patient experiences might qualify as indicators of symptom improvement during treatment or even as treatment targets themselves. Also, *experiences of competence* might be particularly relevant for patients of this subtype since improvements in this cognitive coping skill predicted reductions in pain interference and psychological distress post-treatment. A similar concept is self-efficacy, which has also been studied in relation to chronic pain. Improvements in self-efficacy (i.e., perceived ability to successfully cope with chronic pain) have been found to be associated with reduced interference among patients with chronic pain independently of changes in pain intensity [35]. Thus, it seems particularly worthwhile to elicit from these individuals exactly which strategies they use, to identify effective and ineffective coping strategies, and to foster and optimize effective skills [4,6]. At the same time, it could be beneficial for individuals of this subtype to learn

and build new coping skills via pain management training to experience more competence and self-efficacy regarding pain coping.

Limitations

It must be taken into account that the analyzed sample might not be representative of all inpatients with chronic pain, since our sample included only inpatients with chronic primary pain, consent was required for inclusion, and the studied patients were all from the same clinic in one country. Moreover, it was the same clinic where Grolimund and colleagues had previously conducted their study. Therefore, the identified subtypes might be specific for the investigated samples. Relatedly, the values on the scales used for classification generated from these two samples cannot be used for defining general cutoffs for, e.g., severely, moderately, and mildly burdened individuals. Future research in more diverse samples is needed for such generalizations. Similarly, different coping questionnaires should also be used to replicate similar patterns among patients with chronic primary pain, as the FESV questionnaire is mainly used in German-speaking parts of the world. Although this sample is already quite large and provides robust statistics, even larger samples would allow for a more detailed analysis of subtypes, as well as changes within the subtypes and in subtype membership. For example, pain processing patterns of an individual patient might change over time depending on the pain symptomatology or other factors. Furthermore, due to the naturalistic design of this study, it is not possible to attribute identified changes to specific interventions. Vice versa, specific interventions may have had differential effects on pain coping, psychological distress, or pain outcomes. Overall, future studies should implement longitudinal designs to observe the time course of pain processing patterns and inform on the sustainability of treatment effects. Future studies should also use controlled and experimental designs to allow for drawing causal

conclusions for the treatment of patients with chronic primary pain. Moreover, future research should consider other clinically meaningful changes in treatment-related outcome measures in more detail to better understand the clinical utility of these subtypes.

Conclusions

We identified three subtypes of chronic primary pain inpatients according to their pain-related mental interference and coping patterns. Thereby we replicated Grolimund et al.'s (2017) findings. The three subtypes are based on values assessed with the FESV but have been shown to be significantly related to differences in various other self-report measures. This suggests that the relevance of FESV measurements might go beyond pain processing. Identification and characterizing subtypes of chronic primary pain inpatients seems to be a critical step towards individualized and effective treatment.

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Figure 1; Standardized mean values in the FESV dimensions of the identified subtypes determined by latent class analysis. The grey area indicates norm values from the reference sample of Geissner (N = 401; M±1 SD; 2001).

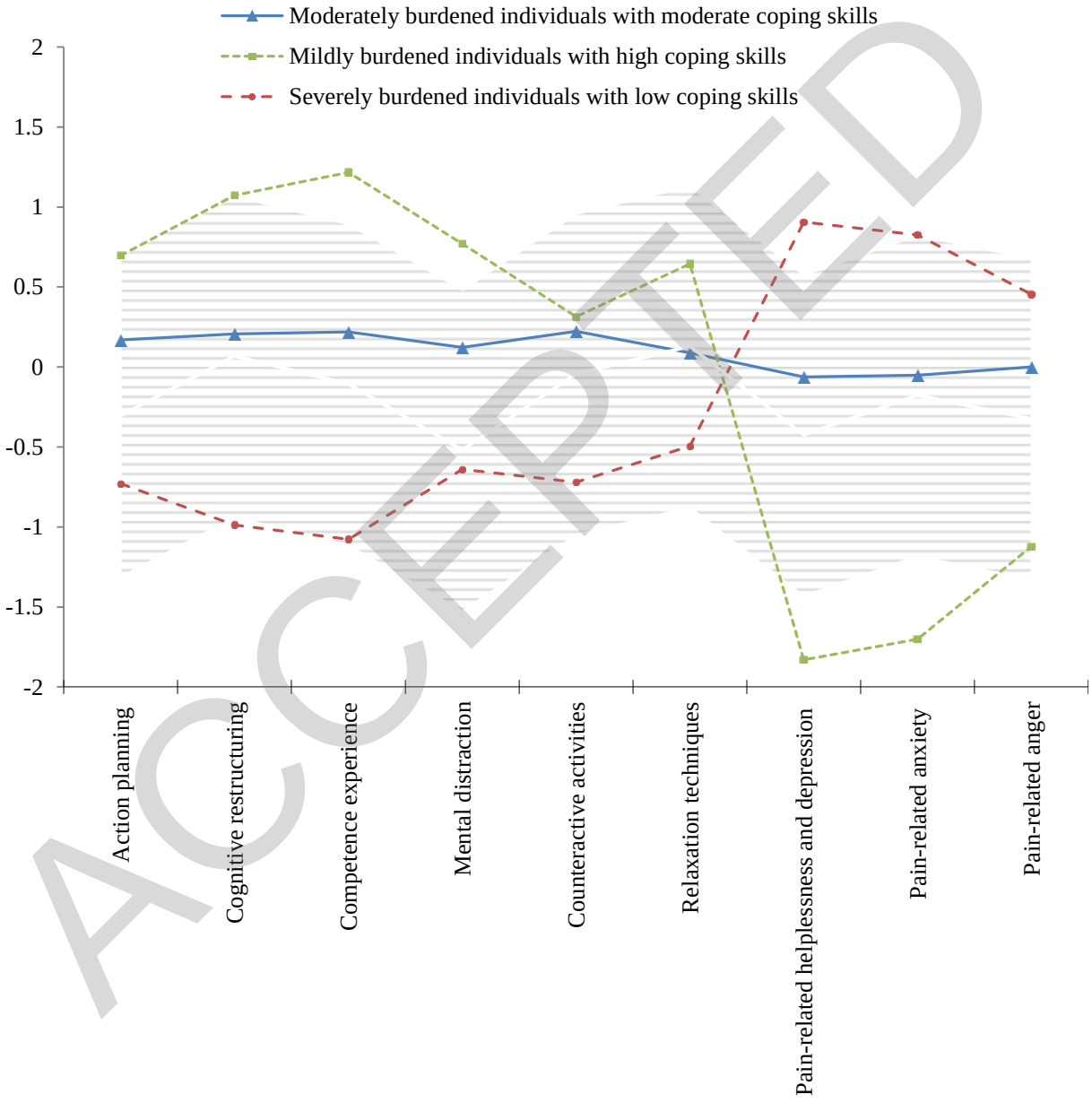

Table 1. Evaluating class solutions with model fit and diagnostic criteria.

Number of latent classes	Smallest class count (N)	Smallest class size (%)	Number of parameters estimated (df)	LL	BIC	AIC	Entropy	LCPP
2 Classes	213	35.3	37	7228.77	4531.54	4694.35	.813	.943
3 Classes	60	10	56	7033.01	4178.01	4424.42	.901	.958
4 Classes	61	10.3	75	6906.68	3963.35	4293.37	.821	.898
5 Classes	60	9.7	94	6835.36	3858.73	4272.35	.811	.877
6 Classes	61	9.6	113	6792.59	3811.19	4308.42	.793	.850

Abbreviations: N = number of patients; LL = Log-Likelihood; AIC =Akaike information criterion; BIC = Bayesian information criterion, ALCPP = Average latent class posterior probability.

Table 2. Descriptive characteristics of the total sample and patient subtypes for the FESV dimensions and patient subtype comparisons (range of the cognitive and behavioral coping dimensions: 4-24; range of pain-related mental interference dimensions: 5-30).

V	**FES**	**Overall sample (602)**		**(1) Severely burdened individuals with low coping skills N (148)**		**(2) Mildly burdened individuals with high coping skills N (60)**		**(3) Moderately burdened individuals with moderate coping skills N (394)**		**Fisher`s ANOVA**	**Welch`s ANOVA**	**ukey Post-Hoc Test**	**ames-Howell Post-hoc-Test**	**C**
			D		*D*		*D*		*D*	F (df_1, df_2) = F, *p*	F (df_1, df_2) = F, *p*			
Cognitive coping														
Action planning		4.9	.2	1.0	.8	8.5	.8	5.8	.7		**F (2, 147.5) = 71.3*** **		**1 < 3 < 2**	
Cognitive restructuring		3.7	.8	.0	.0	8.8	.0	4.6	.9	**F (2, 599) = 186.0*** **		**1 < 3 < 2**		
Competence experience		4.3	.9	.0	.2	0.3	.8	5.4	.8	**F (2, 599) = 260.1*** **		**1 < 3 < 2**		
Behavioral coping														

Mental distraction	1.8	.0	.6	.3	5.6	.6	2.4	.9	**F (2, 599) = 61.4*** **	**< 3 < 2**
Counteractive activities	1.7	.3	.9	.9	3.4	.7	2.9	.0	**F (2, 599) = 61.4*** **	**< 3; 1 < 2**
Relaxation techniques	2.0	.3	.4	.1	5.4	.9	2.5	.1	**F (2, 599) = 35.8*** **	**< 3 < 2**
Pain-related mental interference										
Pain-related helplessness and depression	1.2	.4	6.9	.8	.5	.4	0.8	.9	**F (2, 599) = 351.1*** **	**> 3 > 2**
Pain-related anxiety	6.2	.4	0.6	.1	.0	.6	5.9	.4	**F (2, 599) = 253.8*** **	**> 3 > 2**
Pain-related anger	6.8	.2	0.0	.6	.8	.6	6.8	.8	**F (2, 599) = 64.3*** **	**> 3 > 2**

Abbreviations: N = number of patients*; M* = mean; *SD* = standard deviation; FESV: Pain processing questionnaire.

Table 3. Descriptive characteristics of the total sample and patient subtypes in sociodemographic and pain-related variables and patient subtype comparisons.

	Overall sample N (602)		**(1) Severely burdened individuals with low coping skills N (148)**		**(2) Mildly burdened individuals with high coping skills N (60)**		**(3) Moderately burdened individuals with moderate coping skills N (394)**		**Fisher`s Exact Test**	**χ^2 Test**	**Fisher`s ANOVA**
		D		*D*		*D*		*D*	*p*	$p(\chi^2; df)$	**F(df_1, df_2) = F, *p***
Age – *M* (*SD*)	7.2	3.7	6.4	2.7	0.6	5.3	6.9	3.7			F(2, 599) = 2.36
Sex – N (%)											
female	83	3.6	00	7.6	3	1.7	40	0.9	148	.	
male	19	6.4	8	2.4	7	8.3	54	9.1			
Marital status – N (%)											
In a relationship	7	1.1	7	1.5		0.0	4	1.2		0.939 (2.92; 8)	
Married	62	3.5	4	3.2	6	3.3	72	3.7			
Divorced / separated	35	2.4	5	3.7	7	8.3	3	1.1			
Widowed	8	.0		.4		.3	1	.8			
Single	20	9.9	7	8.2		5.0	4	1.3			

Pain duration – N (%)									
0–3 months		.3		.7		.3		.3	0.312 (11.60; 10)
4–6 months	8	.7		.1		.7	5	.7	
7–11 months	1	.1		.4		.7	2	.2	
1–5 years	63	3.7	4	3.2	9	8.3	70	3.7	
6–10 years	6	5.9	8	2.2	3	1.7	5	6.0	
> 10 years	76	9.2	8	2.4	1	8.3	17	9.2	
Stay duration – *M (SD)*	2.8	.4	2.9	.7	1.9	.9	2.9	.1	F(2, 599) = 0.496

Notes: *p < .05, **p < .01, ***p <.001.

Abbreviations: N = number of patients*; M* = mean; *SD* = standard deviation.

Table 4. Descriptive characteristics of the total sample and patient subtypes in additional pain- and treatment-relevant variables and subtype comparisons.

	Overall sample			**(1) Severely burdened individuals with low coping skills N (148)**		**(2) Mildly burdened individuals with high coping skills N (60)**		**(3) Moderately burdened individuals with moderate coping skills N (394)**		**Fisher`s ANOVA**	**Welch`s ANOVA**	**Tukey Post-Hoc Test**	**Games-Howell Post-hoc-Test**
		D		*D*		*D*		*D*		**(df_1, df_2) = F, *p***	**(df_1, df_2) = F, *p***		
Brief pain inventory BPI													
Pain intensity	02	.4	.7	.1	.7	.1	.7	.2	.7	**(2, 599) = 14.5*** **		**> 2; 1 > 3**	
Pain interference	02	.9	.9	.2	.5	.4	.8	.8	.7	**(2, 599) = 95.3*** **		**> 3 > 2**	
Psychological distress HADS-D	02	1.3	.1	3.2	.9	.8	.6	0.9	.9	**(2, 599) = 57.9*** **		**> 3 > 2**	
Well-being index	16	.7	.4	.3	.1	5.7	.9	.9	.8		**(2,**		**< 3 <**

WHO-5										**98.8) = 73.3*** **	**2**
Perceived stress scale – PSS-10	60	2.4	.5	8.0	.2	2.9	.1	1.8	.7	**F (2, 106.3) = 98.0*** **	**> 3 > 2**
Pain catastrophizing scale PCS	07	6.9	1.7	6.6	.8	3.9	.6	5.4	0.4	**F (2, 404) = 81.3*** **	**> 3 > 2**
ENRICHD social support instrument ESSI	48	4.2	.7	2.3	.7	6.9	.3	4.4	.4	**F (2, 97.0) = 11.2*** **	**< 3 < 2**
Questionnaire for therapy motivation FPTM-23											
Hopelessness	34	.0	.7	.4	.7	.6	.6	.0	.7	**F (2, 331) = 19.2*** **	**> 3 > 2**
Initiative	34	.6	.9	.5	.0	.7	.0	.7	.9	F (2, 331) = 1.3	
Denial of psychological need	34	.7	.7	.8	.7	.7	.9	.6	.6	F (2, 65.1) = 0.8	
Symptom-related attention	34	.4	.8	.3	.8	.2	.8	.5	.8	F (2, 331) =	

Knowledge about psychological treatment	34	.9	.9	.0	.8	.9	.9	.8	.9	2.8 F (2, 331) = 1.2	
Suffering	34	.7	.8	.3	.5	.8	.8	.7	.7	**F (2, 73.1) = 61.6***	**> 3 > 2**
Brief illness perception questionnaire BIPQ											
Consequences	93	.7	.9	.7	.5	.1	.0	.6	.9	**F (2, 90.8) = 31.1***	**> 3 > 2**
Timeline	93	.2	.5	.3	.9	.5	.8	.0	.6	**F (2, 91.5) = 14.8***	**> 3; 1 > 2**
Identity	93	.9	.8	.7	.4	.1	.9	.8	.8	**F (2, 391) = 16.9***	**> 3; 1 > 2**
Concern	93	.8	.7	.5	.9	.3	.9	.6	.6	**F (2, 90.7) = 45.6***	**> 3 > 2**
Understanding	93	.9	.1	.5	.3	.4	.5	.2	.0	**F (2, 93.6) = 15.5***	**< 3 < 2**

Emotional response	93	.2	.5	.7	.6	.9	.7	.1	.2		**F (2, 89.7) = 65.7***	**> 3 > 2**
Personal control	93	.3	.5	.8	.5	.6	.0	.4	.3	**F (2, 391) = 37.0***		**< 3 < 2**
Treatment control	93	.2	.5	.7	.5	.6	.7	.5	.3	**F (2, 391) = 28.4***		**< 3 < 2**

Notes: *p < .05, **p < .01, ***p <.001.

Abbreviations: N = number of patients*; M* = mean; *SD* = standard deviation.

Table 5. Number of patients, mean, standard deviation, pre-post comparison, and effect size of different outcome measures and FESV dimensions of patient subtypes.

		Pre-treatment		Post-treatment			
		M	*SD*	*M*	*SD*	*t*	d
(1) Severely burdened individuals with low coping skills							
Pain intensity BPI	15	6.1	1.8	5.9	1.8	-1.3	-0.12
Pain interference BPI	15	7.0	1.7	5.8	2.1	-7.5***	-0.70
Psychological distress HADS-D	15	13.1	3.1	11.6	3.1	-6.0***	-0.55
Cognitive coping FESV	4	9.6	2.4	12.3	1.6	6.8***	0.70
Behavioral coping FESV	4	8.6	2.3	10.6	1.5	5.8***	0.60
Pain-related mental interference FESV	4	2.3.1	2.9	2.0.0	4.8	-6.6***	-0.68
(2) Mildly burdened individuals with high coping skills							
Pain intensity BPI	8	4.9	1.6	4.6	2.0	-1.4	-0.21
Pain		3	1	2	1	-	-

interference BPI	8	.4	.4	.7	.5	3.9***	0.57	
Psychological distress HADS-D	8	.3	8.5	2.3	7.3	3.0	-3.5***	-0.50
Cognitive coping FESV	7	9.4	1.7	2 0.4	2.4	2 *	2.3 .33	(
Behavioral coping FESV	7	5.4	1.7	3 6.6	1.6	3 *	2.2 .33	(
Pain-related mental interference FESV	7	.6	8.9	1.1	8.0	3 1.2	-3.2	-0.18
(3) Moderately burdened individuals with moderate coping skills								
Pain intensity BPI	24	.2	5.6	1.0	5.9	1 -3.3**	-3.2	-0.18
Pain interference BPI	24	.7	5.7	1.3	4.9	1 -14.3***	-3.2	-0.79
Psychological distress HADS-D	24	0.9	1.8	2.3	9.3	3 -11.2***	-3.2	-0.62
Cognitive coping FESV	84	4.6	1.8	2 6.6	1.5	3 ***	8.7 .52	(
Behavioral coping FESV	83	2.3	1.1	3 4.0	1.4	3 ***	8.9 .53	(
Pain-related mental interference FESV	83	7.9	1.9	3 5.0	1.1	5 -10.9***	-3.2	-0.65

Notes: *p < .05, **p < .01, ***p <.001.

Abbreviations: N = number of patients; *M* = mean; *SD* = standard deviation; *t* = *t* value; *d* =

Cohen's *d*; BPI: Brief Pain Inventory - German version; HADS-D: Hospital Anxiety and Depression Scale - German version; FESV: Pain processing questionnaire.

Table 6. Exploratory regression analysis with stepwise elimination for treatment outcomes post-treatment for subtype 1 with Bonferroni correction.

	Subtype 1						
	E	***S***	***β***	***t***	**R^2**	**adj. R^2**	***R^2_{ch}***
Pain interference post-treatment							
Step 1: Control variable					.26	.25	
Step 2: FESV dimensions					.53	.51	.26***
Control variable							
Pain interference pre-treatment	.58	.09	0.46	.17***			
FESV dimensions							
Change in *relaxation techniques*	0.10	.03	0.25	3.08**			
Change in *pain-related helplessness and depression*	.10	.03	0.27	.44***			
Change in *counteractive activities*	0.09	.03	0.22	2.88**			
Psychological distress post-treatment							
Step 1: Control variable					.46	.46	
Step 2: FESV dimensions					.62	.60	.14***
Control variable							
Psychological distress pre-treatment	.79	.09	0.68	.83***			
FESV dimensions							
Change in *cognitive restructuring*	0.16	.05	0.23	3.09**			
Change in *relaxation techniques*	0.16	.05	0.25	3.29**			

Notes: *$p < .05$, **$p < .01$, ***$p < .001$.

Abbreviations: *B* = unstandardized beta; *SE* = standard error; β = standardized beta; *t* = *t* value;

FESV: Pain processing questionnaire.

Table 7. Exploratory regression analysis with stepwise elimination for therapy outcomes post-treatment for subtype 2 with Bonferroni correction.

	Subtype 2						
	B	***SE***	***β***	***t***	R^2	**adj. R^2**	f^2_{ch}
Pain interference post-treatment							
Step 1: Control variable					.27	.26	
Control variable							
Pain interference pre-treatment	.54	.13	.52	.05***			
Psychological distress post-treatment							
Step 1: Control variable					.48	.47	
Control variable							
Psychological distress pre-treatment	.82	.13	.69	.37***			

Notes: *p < .05, **p < .01, ***p <.001.

Abbreviations: *B* = unstandardized beta; *SE* = standard error; β = standardized beta; *t* = *t* value.

Table 8. Exploratory regression analysis with stepwise elimination for therapy outcomes post-treatment for subtype 3 with Bonferroni correction.

	Subtype 3						
	E	***β***	***t***	^{2}	**dj. R^2**	^{2}***ch***	***F***
Pain intensity post-treatment							
Step 1: Control variable				.40	.40		
Step 2: FESV dimensions				.43	.42	.02***	0
Control variable							
Pain intensity pre-treatment	.74	.06	.63	13.46***			
FESV dimensions							
Change in *pain-related anxiety*	.07	.02	.18	3.85***			
Pain interference post-treatment							
Step 1: Control variable				.25	.25		
Step 2: FESV dimensions				.48	.47	.22***	0
Control variable							
Pain interference pre-treatment	.57	.06	.50	9.57***			
FESV dimensions							
Change in *competence experience*	0.12	.02	0.27	-5.72***			
Change in *pain-related anxiety*	.08	.02	.19	3.74***			
Change in *pain-related anger*	.06	.02	.18	3.54***			
Psychological distress post-treatment							
Step 1: Control variable				.37	.37		
Step 2: FESV dimensions				.51	.50	.13***	0
Control variable							

Psychological distress pre-treatment	.74	.06	.61	12.70***
FESV dimensions				
Change in *competence experience*	1.53	.04	0.19	-4.08***
Change in *pain-related anxiety*	.12	.04	.18	3.55***
Change in *pain-related helplessness and depression*	.67	.30	.12	2.32*

Notes: *p < .05, **p < .01, ***p <.001.

Abbreviations: *B* = unstandardized beta; *SE* = standard error; β = standardized beta; *t* = *t* value;

FESV: Pain processing questionnaire.