Pain Science in Physiotherapy Education

Advancing contemporary pain knowledge, beliefs, attitudes and clinical behavior of future physiotherapists

Anneke J. Beetsma

Colophon

Pain Science in Physiotherapy Education. Advancing contemporary pain knowledge, beliefs, attitudes and clinical behavior of future physiotherapists.

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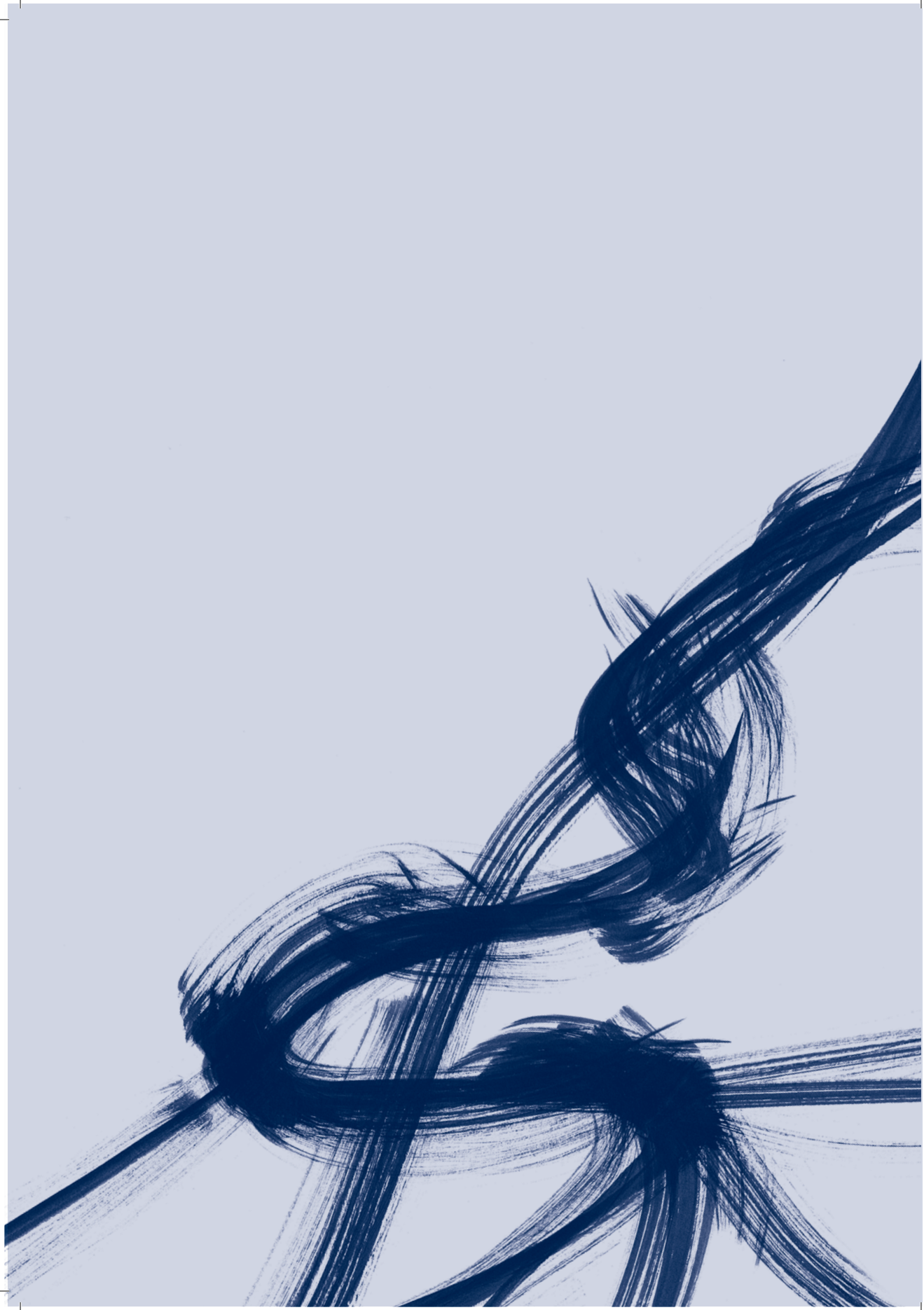
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Table of contents

Chapter 1	General introduction	9
PART I	**Assessing contemporary pain knowledge, beliefs and biopsychosocial attitudes**	
Chapter 2	Assessing future health care practitioners' knowledge and attitudes of musculoskeletal pain; development and measurement properties of a new questionnaire.	31
Chapter 3	Assessing Pain Science Education: The measurement properties of proximal and distal assessment tools of conceptual change: a narrative and rapid review.	71
Chapter 4	Knowledge and attitudes toward musculoskeletal pain neuroscience of manual therapy postgraduate students in the Netherlands.	123
PART II	**Adopting and evaluating a biopsychosocial approach towards musculoskeletal pain in health care education**	
Chapter 5	Towards consensus in pain related content in undergraduate physiotherapy programs in the Netherlands: a Delphi-study.	145
Chapter 6	Meaningful contributions of rehabilitation for people with persistent pain; a reflexive thematic analysis.	193
Chapter 7	Benefits of an enhanced educational intervention on biopsychosocial pain knowledge, attitudes and clinical behavior of physiotherapy students. A cluster randomised trial.	225
Chapter 8	General discussion	263
Summary		281
Samenvatting		289
Bibliography		297
Dankwoord (Acknowledgements)		301
Over de auteur		307



CHAPTER 1

General introduction

Persistent musculoskeletal pain

Pain is defined by the International Association of the study of Pain (IASP) (1) as "An unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage." A variety of physical (2), environmental and psychological factors (3) interact with pathophysiology to contribute to the transition and maintenance from acute pain into persistent pain. Many types of musculoskeletal (MSK) persistent pain begin as acute pain with changes in the affected pain area. (2) Persistent MSK pain is typically defined as pain that continues for more than 3 months (4) and it is thought that in a local body region, changes in the central nervous system (brain and spinal cord) begin to occur. (5) Maybe because of reversing the rewiring of the central nervous system it is more difficult to treat persistent pain, than improving physiology at the site of pain. (6) Health care professionals (HCPs) should take an individualized patient-centered approach and focus on multimodal treatment to prevent the transition to persistent pain.(7)

Persistent (MSK) pain is a leading cause of disability worldwide, imposing a significant disability burden on those affected by persistent pain.(8–11). One in five surveyed Europeans reported having persistent (MSK) pain.(12) Persistent pain and associated disability affect social functioning and decreases individuals' health status and quality of life.(13–15) The extensive prevalence and significant global impact of MSK-pain, with four MSK-related conditions ranking among the top 11 out of 354 diseases, is expected to increase dramatically over the next two decades, placing an unsustainable burden on healthcare systems.(8,16) Most current interventions yield limited outcomes highlighting the urgent need for more effective care for MSK-pain. (17,18)

The biopsychosocial model in understanding persistent musculoskeletal pain

The contemporary understanding and treatment of MSK-pain are underpinned by the biopsychosocial (BPS) model (19,20), which aligns with the comprehensive model of health education.(21–23) A person's experience of MSK-pain is shaped by a dynamic interaction of multiple factors, including biological, psychological, social elements, comorbidities, and lifestyle, all of which contribute to tissue sensitivity and influence how a person perceives and interprets their pain.(24–27) A BPS approach has been acknowledged as the best option for practice of HCPs working with people with

MSK-pain, such as physiotherapists (PTs) (28–31) and is considered more effective than usual biomedical oriented treatment. PTs are well established as providers of treatments for common, painful and disabling conditions. Thus, they are well placed to deliver treatments that integrate physical and psycho-social elements in pain management.

However, understanding the complex nature of pain and the associated disability and the ability to implement integrated BPS approaches when required in MSK pain, is challenging for (future) PTs. (32–39) Many PTs adhere poorly to best practice guidelines, such as those for low back pain (40–43) and routine clinical pain management often fails to comply with the BPS approach.(39) In the absence of severe pathology, clinical practice guidelines encourage physical activity, despite pain, and recommend that patients continue with normal daily activities and return to work as soon as possible. (40,44,45)

The biomedical pain model is insufficient to explain the transition from acute to persistent MSK pain, as well as the factors contributing to its persistence, and poses a barrier to optimal BPS assessment and treatment. (33,35,46,47) The biomedical understanding of pain is problematic, as it inaccurately implies a linear relationship between noxious stimuli and pain, and often reflects a dualistic or reductionist perspective.(48) PTs with a biomedical orientation tend to act more against best-practice guidelines and hold competing beliefs, e.g. movement is important but avoid bending when lifting or carrying weights, (49–52) which may result in uncertainty about framing advice to patients. Biomedical MSK pain education for PTs can exacerbate maladaptive beliefs and consequently results in inadequate activity recommendation which may have important implications for health trainings programs.(53)

It has proposed that person-centered care underpins the humanistic aspects of the BPS model, including the patient's perspective as part of the therapeutic process. (54) In MSK care this encourages greater partnership between clinician and patient and person-centered behavior change.(55–59) This incorporates the beliefs and attitudes of both the patient and clinician, which may more effectively facilitate self-management, enhance patient satisfaction, and lead to improved health outcomes.(60,61). The focus is not on providing a 'cure', but rather on developing a management plan aimed at controlling the disorder, minimizing its impact on the individual's well-being, and ultimately supporting ongoing, evidence-informed self-management.(62). Person-centered care respects the patient as a whole person, seeking to understand their perspective, goals, cultural context, needs, and concerns,

while fostering collaboration and shared decision-making between clinician and patient.(28,58,63,64). However, findings suggest that we are far from achieving patient-centered care.(55,65)

Future physiotherapists pain knowledge, beliefs and attitudes

Pain-related knowledge is defined as 'knowledge about the biological underpinnings of pain and recovery'.(24) Pain-related beliefs are defined as 'a feeling of being certain about pain related aspects', whereas pain-related attitudes can be defined as 'any belief or opinion towards pain related aspects' and are thought to more obviously manifest in behaviors.(66) Beliefs and attitudes overlap and are often used interchangeably both within the Pain Science Education and wider pain literature. Negative beliefs about the cause of the pain, fear of pain, and avoidance behaviors have been found to be associated with pain chronicity and pain-related disability (67,68) and are often enhanced by interactions with clinicians who provide threatening diagnoses. Nocebo messages (Latin "I shall harm") refer to negative responses, associated with a negative expectation in the recovery and/or maintenance of pain. (69,70)

Identifying future PTs BPS pain beliefs are important, because PTs shape patients' beliefs and guide them to perceive pain as non-threatening when appropriate. (46,47,50,71–75) PTs non-guideline-based beliefs and recommendations can result in poor health outcomes.(72,75,76) PTs can contribute to persistent MSK disability by negatively modifying the patients' perceptions of the impact of their condition, creating new attitudes by focusing too much on the disease, or limiting the patients' daily activities.(77,78) Many future PTs hold the biomedically informed belief that pain is directly caused by physical impairments that needs to be investigated, healed or fixed (46,50,73) and consider painful activities as harmful, often advising against them.(79–81) This suggest beliefs about vulnerability and the need for protection of the body (51) that have been associated with higher levels of pain-related fear and avoidance behaviors.(82,83) Based on knowledge of the relationship between pain and fear, the Fear Avoidance Model proposes that fear-related protective behaviors can drive a vicious cycle with subsequent activity limitations, disability, negative affect, and pain.(77)

Leventhal's common-sense model (84–86) is proposed as a framework to assist future PTs understanding pain-related fear from a common-sense perspective. (fig.1) PTs could support recovery by helping people with MSK pain reframe their understanding of pain and recognize the behavioral and emotional responses to their

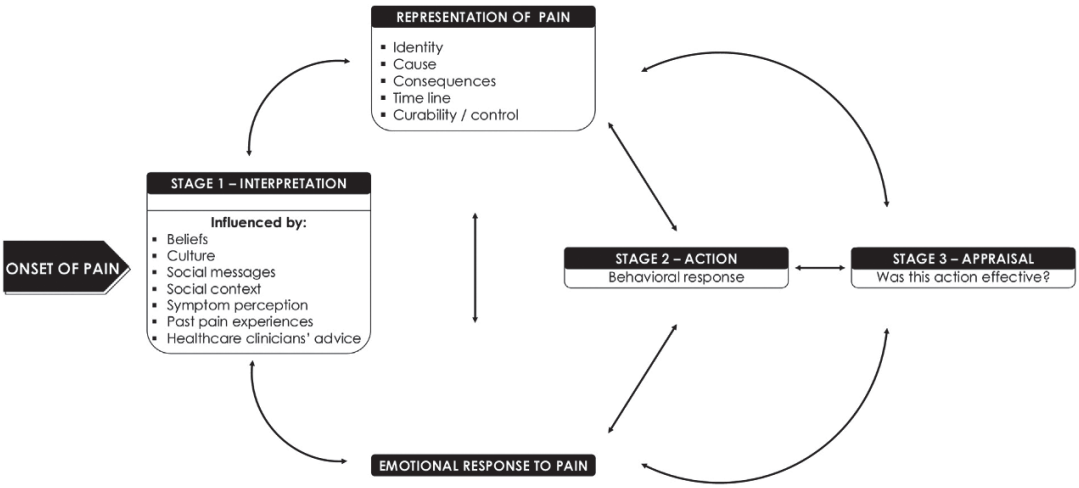


Figure 1. Common Sense Model framework (adapted from Leventhal et al., 1992)

condition.(87) Pain-related fear and unhelpful beliefs (e.g., the belief that pain signals tissue damage) are modifiable and are therefore considered important targets for intervention.(88) When pain is perceived as having a low threat value, the benefits of engaging in activities of daily life may outweigh the threat of pain. Consequently, the individual engages in valued activities, which is associated with recovery and decreased disability, instead of avoidance or other protective behaviors.(82) By targeting protective behaviors (e.g., slow and guarded movement) and avoidance behaviors (e.g., avoiding certain tasks), interventions can help reduce disability and the burden of persistent MSK pain.(77,89–91)

Health care education related to musculoskeletal pain

Health educational programs lay the foundation of future PTs in terms of helpful beliefs, attitudes and the adherence to clinical guidelines. However, current health educational programs and their traditional pedagogical approaches still tend to focus on a reductionist biomedical perspective (92–95), thus being insufficient for helping future PTs in feeling confident and competent in delivering person-centered care.(36,96–106) Education about pain for future PTs is inadequate to meet the clinical need for pain assessment and treatment.(43,107) Becoming a 'clinician competent in pain care' involves acquiring multiple competencies necessary to deliver BPS informed care.(100,101,104,108) This involves educational training programs focused on building

competency through a cognitive-behavioral framework, facilitating the behavior changes needed for future PTs to successfully implement a BPS intervention.(38,109–112) This emphasizes the need for increased efforts to integrate core competencies, outcomes and accompanying learning strategies into PT health education programs.

The BPS framework has become the model for HCP training (22), however the utility of this framework cannot be fully assessed until we truly adopt and integrate it into research, education and subsequently in clinical practice.(39,113,114) This could explain why evidence-based treatment grounded in the BPS model has not produced impressive patient outcomes.(39) The major deficits in knowledge, attitudes, and accompanying skills of (future) PTs about the mechanisms and management of pain are one of the reasons that pain management is inadequate worldwide.(115–118) The documented content of pain curricula in health care programs is highly variable and often dominated by the biomedical model and tending to ignore the BPS framework, despite being advocated in clinical guidelines, cognitive-behavioral methods and multidisciplinary management. (36,96–98,115,119–122) Western biomedicine has created a PT curriculum that is too narrow and a practice that is too mechanical. (123) Health education about pain has failed to realign its curricula to fully incorporate the BPS model and its requisite patient-centered approach as a goal or outcome of training.(22) Misconceptions about pain persist, impacting prognoses and highlighting the importance of comprehensive health education.(124) It is considered that implementation of the BPS model within PT education is affected by its lack of conceptual clarity and scientific quality (56) and training in the application of the BPS model has been limited. (125) Although the BPS model is useful for understanding MSK pain, it remains unclear how this model can be effectively adopted in MSK-pain education curricula. (55) Therefore, there is clearly a need to prioritize and examine how the BPS model is integrated into PT education and training about pain, but health systems will also need to accommodate these new approaches if they are to flourish. (33,97,126)

PTs' pain knowledge, beliefs, attitudes and accompanying skills are developed during their professional education, making this a relevant window for education that is consistent with current evidence and to prioritize high-value care in MSK pain conditions.(18,127) High value care is the understanding of pain and promoting healthy pain beliefs to enhance the controllability and the predictably of pain. It has been proposed that fostering more positive beliefs regarding MSK-pain during entry-level training could ensure future PTs hold more evidence-based views.(81,100,128) The recent Lancet series on LBP (18) proposed PT training reform and changes in curricula to endow students with more positive pain beliefs.

To date, it is unclear to what extent future PTs possess pain knowledge, beliefs and attitudes to be able to apply the BPS model in patients with MSK-pain.(55) Currently, there is limited insight into the essential BPS related pain topics that future PTs need to learn to effectively treat patients with pain. Also, there is no adequate tool available to assess contemporary pain knowledge, beliefs, and attitudes of future PTs. Despite the widespread use and benefits of Pain Science Education (PSE) for HCPs and patients, no systematic overview exists for assessing its outcomes. Moreover, little is known what persons with persistent pain find meaningful contributions of rehabilitation. This could provide an opportunity to revisit health education curricula through the lens of people with lived experience.

The curricula of the International Association for the Study of Pain (IASP) (117) and the European Pain Federation (EFIC), (129) are recommended for education about pain for future HCPs. Education about pain is aiming to improve future PTs clinical competencies for integrating BPS persistent pain management, particularly in making appropriate functioning recommendations.(104,130,131) Currently, it is unknow if an educational intervention for future PTs is beneficial in influencing the BPS pain knowledge, beliefs, attitudes, and self-reported clinical behaviors of PT students.

Aim and research questions

Despite the revised IASP definition of pain and the promotion of person-centered care in MSK pain care, integrating the BPS model in limited in PT professional health care training. Therefore, the overarching aim of this thesis was to expand knowledge on how to improve contemporary pain knowledge, attitudes and clinical behavior of future PTs when assessing and treating MSK pain. To achieve this, the first aim was to assess contemporary pain knowledge and bps attitudes towards pain of future PTs and to get an overview of instruments assessing outcomes of PSE. The second aim was to identify a consented set of essential topics in the undergraduate pain curriculum of the Dutch PT program. The third aim was providing insights into a wide palette of meaningful contributions of rehabilitation for people with persistent pain, providing an opportunity to revisit health educational curricula through the lens of people with lived experience. The fourth aim was to evaluate the impact of an educational intervention aimed at influencing biopsychosocial pain knowledge, attitudes, and clinical behaviors of PT students.

The general aim is addressed by the following main research questions:

1. What are the measurement properties of a newly developed questionnaire; Knowledge and attitude of pain (KNAP)?
2. Which instruments could be identified assessing proximal and distal outcomes of pain science education?
3. What is the contemporary pain knowledge and attitudes of Dutch manual therapy students at baseline and in all three years of the program?
4. Is the difference in the contemporary pain knowledge and attitudes of MT students related to focused pain education?
5. What are the essential pain-related topics in pain evaluation and management that should be integrated within the curriculum of undergraduate physical therapy students to enable them to treat pain patients according to evidence-based guidelines?"
6. What are the meaningful contributions of rehabilitation for people who have substantially improved in living with persistent pain?"
7. To what extent is an enhanced education intervention, compared to education as usual, beneficial in influencing the biopsychosocial pain knowledge, attitudes, and self-reported clinical behaviors of PT students?

Outline of the thesis

The findings of assessing contemporary pain knowledge, beliefs, and attitudes of Physiotherapy (PT)students and Manual Therapy (MT) students in the Netherlands are presented in **Chapters 2** and **4**. **Chapter 2** contains the development and measurement properties of the Knowledge and Attitudes of Pain (KNAP) questionnaire. **Chapter 4** explores the extent to which MT students possess contemporary pain knowledge and biopsychosocial (BPS) attitudes necessary for applying a BPS approach to patients with musculoskeletal (MSK) pain. In **Chapter 3** an overview of assessment instruments to evaluate outcomes of PSE for consumers is provided.

Adopting a BPS approach towards MSK-pain in health care education is a key component emphasized in the National Pain Strategies of the International Association for the Study of Pain (IASP). **Chapter 5** contains a Delphi study conducted with pain-experienced lecturers from universities of applied sciences in the Netherlands and validation panels, focusing on essential pain-related topics that undergraduate physical therapy students should learn to adequately treat patients with pain.

The revised IASP definition of pain and the promotion of person-centered care in rehabilitation guidelines, encourage integrating the lived experience of pain in rehabilitation and in health care training. In **Chapter 6** insight into the meaningful contributions of rehabilitation for people who have substantially improved in living with persistent pain is provided.

For evaluating health education on pain perceptions and clinical behaviors, in **Chapter 7** an interventional study aimed to evaluate the effects of an enhanced educational intervention on the BPS pain knowledge, attitudes, and self-reported clinical behaviors of PT students in the Netherlands is presented. The enhanced educational intervention is informed by the findings from the KNAP studies, the Delphi study, and by the findings of the qualitative study, alongside the guidelines of IASP and European Pain Federation (EFIC). In **Chapter 8** the main findings are summarized and discussed, and methodological considerations are described. Finally, the recommendations and implications for health education and future perspectives will conclude this thesis.

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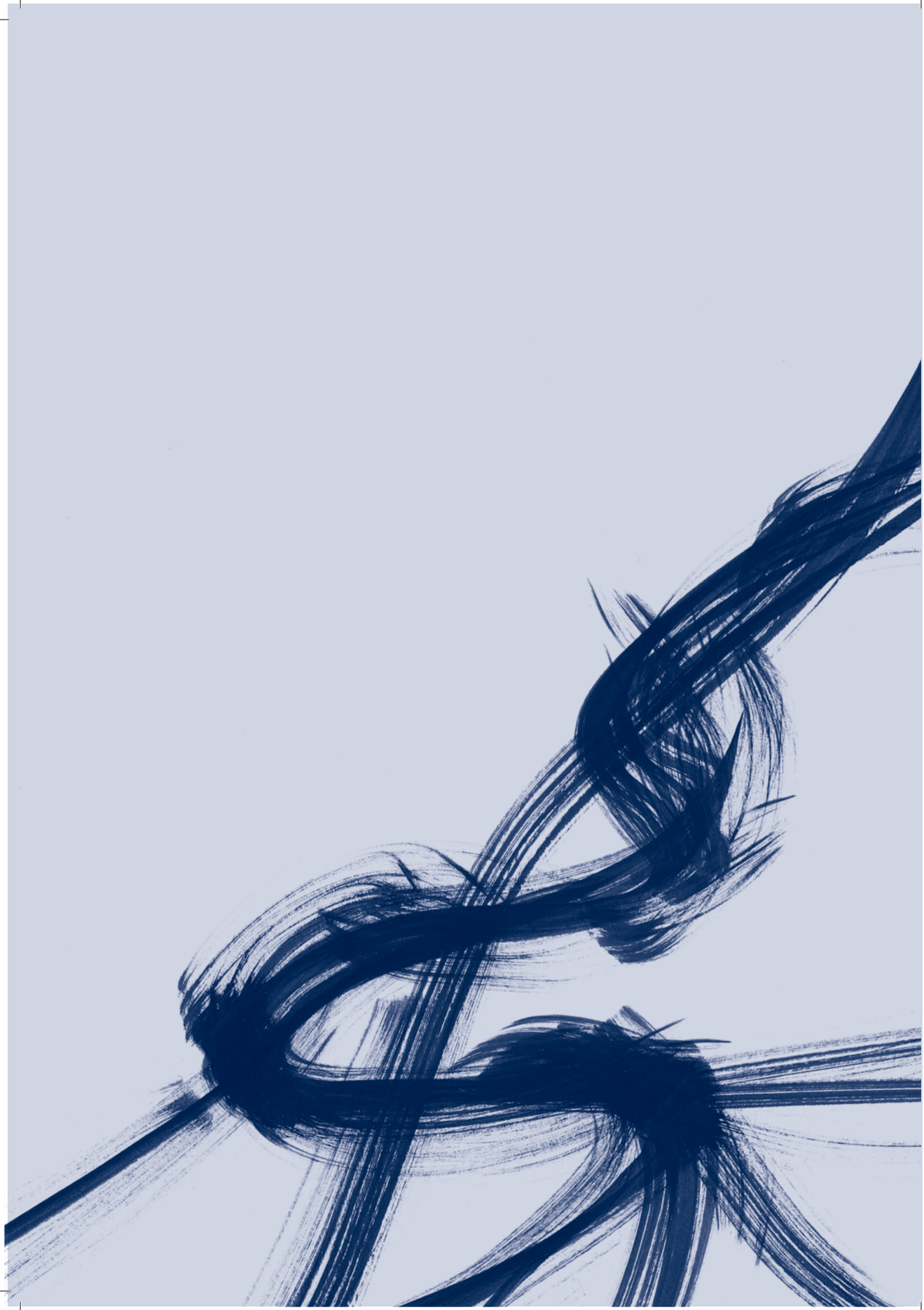
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PART I

Assessing contemporary pain knowledge, beliefs and biopsychosocial attitudes



CHAPTER 2

Assessing future health care practitioners' knowledge and attitudes of musculoskeletal pain; development and measurement properties of a new questionnaire

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ABSTRACT

Background: Healthcare practitioner beliefs influence patients' beliefs and health outcomes in musculoskeletal (MSK) pain. A validated questionnaire based on modern pain neuroscience assessing Knowledge and Attitudes of Pain (KNAP) was unavailable.

Objectives: The aim of this study was to develop and test measurement properties of KNAP.

Design: Phase 1; Development of KNAP reflecting modern pain neuroscience and expert opinion. Phase 2; a cross-sectional and longitudinal study among Dutch physiotherapy students.

Method: In the cross-sectional study (n=424), internal consistency, structural validity, hypotheses testing, and Rasch analysis were examined. Longitudinal designs were applied to analyse test-retest reliability (n=156), responsiveness, and interpretability (n=76).

Results: A 30-item KNAP was developed in 4 stages. Test-retest reliability: ICC (2,1) 0.80. Internal consistency: Cronbach's α 0.80. Smallest Detectable Difference 90%: 4.99 (4.31; 5.75). Structural validity: exploratory factor analysis showed 2 factors. Hypotheses testing: associations with the Pain Attitudes and Beliefs Scale for Physiotherapists biopsychosocial subscale r=0.60, with biomedical subscale r=-0.58, with the Neurophysiology of Pain Questionnaire r=0.52. Responsiveness: 93% improved on KNAP after studying pain education. Minimal Important Change: 4.84 (95%CI: 2.77; 6.91).

Conclusions: The KNAP has adequate measurement properties. This new questionnaire could be useful to evaluate physiotherapy students' knowledge and attitudes of modern pain neuroscience that could help to create awareness and evaluate physiotherapy education programs, and ultimately provide better pain management.

Keywords: Biopsychosocial; Musculoskeletal pain (MeSH); Online course; Pain Neuroscience Education; Physiotherapy students

Introduction

Health Care Practitioners' (HCPs) biomedical attitudes and beliefs about musculoskeletal (MSK) pain have a negative influence on patients' beliefs and health outcomes.[1–9] The ability of HCPs to identify their beliefs about MSK pain is crucial given the significant role practitioners can play in achieving patients' biopsychosocial beliefs about low back pain (LBP).[10–12] Identifying HCPs' beliefs that may contribute to suboptimal clinical outcomes is a relevant prerequisite towards improving the quality of patient care.[13] Pain Neuroscience Education (PNE) is a cognitive-based intervention to teach people about pain biology and physiology and de-emphasise the issues associated with the anatomical structures and focus on the biopsychosocial factors that contribute to the development of pain.[14–18] Given the influence of HCPs on a patient's recovery from MSK pain by providing PNE and designing and testing education programs on pain, assessing knowledge and attitudes of modern pain neuroscience of HCPs, including future HCPs, is needed.

Questionnaires are available that aim to evaluate knowledge, attitudes, and beliefs among HCPs.[13,19–24] Because there is no gold standard for assessing knowledge and attitudes of pain among students[25], the Pain Attitudes and Beliefs Scale for Physiotherapists (PABS-PT) and the Neurophysiology of Pain Questionnaire (NPQ) were added as secondary measures. One of the most thoroughly tested instrument is the PABS-PT[26,27], developed in 2003. Over time, the PABS-PT does not fully align with current pain neuroscience; relevant topics concerning pain biology and physiology as the adaptation of the pain system, central sensitisation of the nervous system, the top-down and bottom-up systems, and the pain neuromatrix are not included. Moreover, the PABS-PT aims to measure attitudes and beliefs, not current pain knowledge, which is an important outcome measure of PNE. Furthermore, the measurement properties are suboptimal; information on interpretability and content validity is lacking and the biopsychosocial subscale, as well as the separate PABS-PT subscales, contains low discriminative ability.[28–30] The NPQ[31] measures knowledge, but not attitudes, of HCPs and its psychometric properties have only been partially examined. Suboptimal and psychometrically unnecessary items of the NPQ need further examination.[32,33] Also, the true-false nature of results of the questionnaire is susceptible to interpretation and thereby the NPQ is limited in content validity.

Therefore, we developed a new questionnaire called KNowledge and Attitudes of Pain (KNAP). KNAP aims to assess both knowledge about **modern pain science** and biopsychosocial attitudes towards pain in HCPs. KNAP is based on the online pain education course' Understanding Pain' of the Retrain Pain Foundation.[34] This

study aimed to develop KNAP and to extensively test its measurement properties in a sample of physiotherapy students in the Netherlands. A future step will be to adjust and validate the KNAP for active HCPs. The COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) was applied.[35]

Methods

Phase I - Development

Four steps were taken for developing KNAP to develop its content validity, including face validity.[36] Step 1. Items were created based on the online pain education course "Understand Pain" of the Retrain Pain Foundation.[34] Step 2. These items were reviewed by the researchers (AB, RR, DP) on content and face validity. Missing and deemed important items were added. Step 3. An expert review procedure was performed: a survey containing a set of resulting items were sent online to 10 experts. These experts are experienced researchers combining research with educational or clinical activities in the field of (persistent) pain in the Netherlands or Belgium. They were asked to judge relevance and comprehensiveness in the context of measuring knowledge and attitudes of pain.[36] Researchers (AB, RR, DP) processed the answers. Step 4. The Dutch KNAP was translated forward and backward.[37] The English KNAP was tested in a sample of students of the International Program Physiotherapy (n=36). During these procedures, the understanding of the instructions, the purpose of the items, the wording of the items, and the response options were evaluated. This step resulted in some textual changes of items, also in the Dutch KNAP. Two Dutch physiotherapy students filled in the pre-final version to determine the completion time and feasibility of the KNAP.

Phase II - Testing measurement properties

Design and participants

A cross-sectional survey was conducted among all registered students of the 4-year entry-level physiotherapy education program at the Hanze University of Applied Sciences in Groningen, the Netherlands (T0). To study test-retest reliability, the measurements were repeated three weeks later among students of year 1-3 (T1). No pain neuroscience education (PNE) was given between T0 and T1. Approximately one year after T1, another group was measured after studying the PNE course (T2). The ten weeks PNE course was delivered during three sessions of 1 hour and three sessions of 2 hours. Lectures and practical sessions (practising PNE) were given about the biology of pain, the differences between acute and chronic pain, top-down and bottom-up

systems, central sensitisation of the nervous system and the pain neuromatrix based on the books 'Pijneducatie, een praktische handleiding voor (para)medici' (Dutch) and 'Explain Pain'.[18,38] A waiver was obtained from the medical ethics committee at the University Medical Center of Groningen (UMCG), indicating that formal ethical approval was not needed within the Dutch regulations (number M18.241418). All participants provided digital written informed consent before the start of the survey. Study design and reporting was based upon the COSMIN.[35,39]

Measures

Primary measure

KNAP. At this phase, KNAP contains 34 items, and each scored on a six-point Likert scale to indicate the extent to which they agree with the statement; 1. completely disagree, 2. to a large extent disagree, 3. somewhat disagree, 4. somewhat agree, 5. to a large extent agree and 6. completely agree. The total score can range from 34 to 204 points. A higher score indicates knowledge and attitudes better reflecting modern pain neuroscience. Examples of statements are; 'Pain sensitivity can persist, even if there is no longer an injury or tissue damage, 'Unexplained pain is not real pain', 'Exercise is a good treatment option in persistent pain', 'Correcting poor posture reduces persistent pain'. See appendix 1 for the full version of the Dutch KNAP and appendix 2 for the English KNAP and its scoring method.

Secondary measures

Sociodemographic items of the participants included gender, age, achieved level of education before entering the physiotherapy education program, and personal experiences with persistent pain.

PABS-PT. A 14 items Rasch modified version of the PABS-PT was used, of which seven items belong to the biomedical subscale (subscale scores range from 7 to 40) and seven items to the biopsychosocial subscale (subscale scores range from 7 to 32).[29] Higher scores on a subscale indicates a stronger orientation. The PABS-PT showed 'fair' methodological quality scores on the COSMIN criteria.[28,29] The internal consistency for the bio-psychosocial subscale was Cronbach's $\alpha = 0.62\text{-}0.68$ and for the biomedical subscale Cronbach's $\alpha = 0.77\text{-}0.84$. Test-retest reliability of the biomedical subscale was ICC = 0.81 and of the biopsychosocial subscale ICC = 0.65.[28]

NPQ. NPQ contains 12 items relating to the neurophysiology of pain (revised 12-item rNPQ).[32] The total score ranges from 0 to 12, with higher scores indicating more correct responses. The Dutch NPQ contains an acceptable level of reliability (ICC 0.76)

and internal consistency (Chronbach's α = 0.77) for evaluating the knowledge of the neurophysiology of pain in patients with chronic fatigue syndrome.[33]

A single statement was added as anchor after studying PNE course (T2), to assess how much change in knowledge and attitudes since the baseline measurement was experienced by the participant himself.[40–42] The statement was: 'after studying pain education I have..': 1) not improved on knowledge and attitudes of pain, 2) somewhat improved on knowledge and attitudes of pain, but not important, 3) improved on knowledge and attitudes of pain and 4) greatly improved on knowledge and attitudes of pain.

Data collection

After the explanation of the purpose and procedure by the authors (RR or AB), the students completed the survey digitally during regular class. The students were supervised to guarantee results represent individual student responses. Anonymity was guaranteed, and participation was voluntary. The survey consisted of three questionnaires and demographics. The order of the questionnaires was randomly assigned at the level of the individual. Participants were able to correct answers on previous pages by use of a "back" button; however, they were prevented from reentering the survey after they had ticked the "Finish" button. E-mail invitations were sent shortly before the start of the class. The survey was left open for one week after class for those students who did not participate during class. A reminder was sent one week after the first response. The procedure for the retest was identical. The average completion time was 12 minutes for all three questionnaires.

Data analysis

Missing data were examined in the data files. Participants were excluded from analysis if one of the three questionnaires as a whole was not filled in. We performed a multiple imputation procedure on missing values (using five imputations).[43] All items were examined for normality. The demographic data were described by means and standard deviations (SD). Statistical analysis was performed utilising the IBM Statistical Package for Social Sciences (SPSS) version 24.0 (SPSS Inc, Chicago, IL). The interval Rasch model was analysed using Winsteps software (v4.0.03) (www.winsteps.com).[44] To examine the measurement properties of KNAP; internal consistency, test-retest reliability, measurement error, smallest detectable difference (SDD), structural validity, hypotheses testing, items in Rasch analysis, responsiveness and interpretability was analysed.[39,45]

Internal consistency was assessed by calculation of Cronbach's α of items included in each factor in the Exploratory Factor Analysis (EFA). Alpha values were considered adequate when >0.70 and <0.95.[46] Item–total correlations should be >0.20, and items with lower correlations were discarded.[47] Test-retest reliability was evaluated via intraclass correlation coefficients (ICC (2,1)). ICC of >0.75 was considered adequate.[48] Measurement error was analysed by calculating the Standard Error of Measurement (SEM= SD$\sqrt{}$1-ICC).[49] Smallest detectable difference (SDD) was calculated as 1.96x$\sqrt{}$2xSEM.[40,50] Because the SDD is sensitive to outliers, iterative outlier removal with two iterations were performed when the difference was >3xSD (99%).[51] Data from T0 and T1, with a two weeks' interval were used to determine ICC, SEM, and SDD.

Structural validity was analysed using Exploratory Factor Analysis (EFA) to guide future hypotheses, reveal patterns within the data set, and to identify a candidate set of items for Rasch analysis. All 34 KNAP items were subjected to EFA. To analyse whether factor analysis was appropriate, the Kaiser–Meyer–Olkin (KMO) coefficient should be ≥0.60, and the Bartlett test of Sphericity significant ($p<0.05$). Furthermore, varimax rotation with Kaiser Normalization (3 iterations) was used. The number of factors extracted was based on the scree plot, the item loading on the different factors and the eigenvalue >1 (Kaiser's criterion).[52] Items with a factor loading of < 0.30 and negative effect on Cronbach's α were considered for removal. Additionally, floor or ceiling effects were existent if >15% of KNAP scores are within the highest or lowest scores.[46]

Hypotheses testing was applied to test the construct validity. Four a priori hypotheses were tested. Support for convergent validity was assumed when correlations between the KNAP and PABS-PS was r>0.40 and with NPQ r>0.50. Support for divergent validity was assumed when correlations between the KNAP and the PABS-BM was r<-0.40. A hypothesised increase of KNAP-scores from year 1 to year 4 was tested using a one-way ANOVA with Bonferroni corrected post hoc comparisons. Support of construct validity was assumed when 3 out of 4 (75%) of the hypotheses were accepted.

Rasch analysis was performed to test the presumptions of the Rasch model, including local independency and unidimensionality.[53] We examined the item difficulty; items were considered too easy if over 95% of persons answered correctly and too hard if under 5% were answered correctly. The overall fit of data to the model and potential misfit was further explored, and items were considered for removal if fit residuals were beyond standardised ±2.5 (99%CI) or if fit statistics were >1.3 (model underfit) or <0.7 (model overfit).[54] A Person Separation Index (PSI) value of >0.8 in Winsteps implies the scale is sensitive enough to distinguish between individuals with high and

low agreeability, suggesting a good reliability.[44] The assumption of local dependence should be <0.70. To assess the function of the Likert-type scale categories, the category order was assessed on a per-item level (partial credit model). Category collapsing was considered to improve the fit of the items. Items were reviewed and considered for removal if they had excessive fit statistics and breeched the assumption of local independence. After fit to the Rasch model was achieved, a transformation of ordinal raw scores to interval scaled measures was obtained by producing transformation tables.[55,56] For further psychometric testing, Rasch transformed measures were used.

Responsiveness was defined as the ability of the KNAP to detect change over time in knowledge and attitudes of pain after studying PNE. The Minimal Important Change (MIC) was defined as the smallest measured change score that is deemed important.[46,57] MIC was measured by using an anchor-based mean change technique (crude method).[58] For each category of the anchor question, the MIC is calculated. Category 1: no improvement on knowledge and attitudes of pain after PNE, Category 2: somewhat improvement on knowledge and attitudes of pain, but not important, Category 3: improvement on knowledge and attitudes of pain and Category 4: great improvement on knowledge and attitudes of pain. Interpretability was defined as the degree to which one can assign qualitative meaning to change in scores.[46,59] Interpreting change in KNAP-scores requires two benchmarks: the SDD and MIC. For the interpretability of change scores on KNAP, mean changes and 90%CI were calculated in a study sample who attended pain education. A positive rating for interpretability was assumed when KNAP change scores are >SDD, and if SDD<MIC.[46]

Results

Phase I – Development

Step 1; resulted in a preliminary 30 item KNAP. Step 2; 9 items considered relevant in the context of knowledge and attitudes of pain were added, resulting in a 39 item KNAP, grouped into 2 domains: (a) pain physiology and influencing factors and (b) treatment of pain. Step 3; after expert review procedure, the number of items was reduced to 34. Step 4; no change in the number of items. After testing measurement properties, including Rasch analysis, items were reduced to 30 (Figure 1).

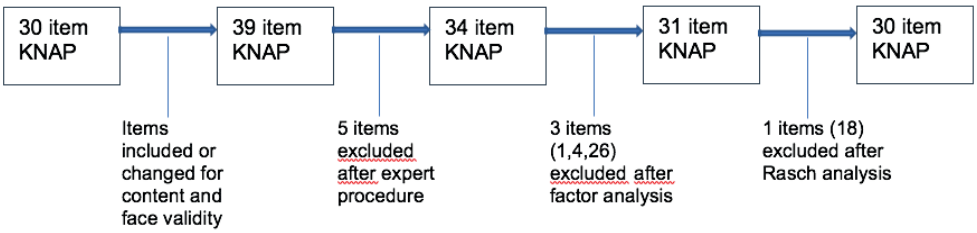


Figure 1. Number of KNAP items. KNAP; Knowledge and attitudes of pain

Phase II - Measurement properties

Study sample

Surveys were sent to 863 physiotherapy students. In total 473 participants responded, 49 were excluded from analysis due to missing one of the questionnaires. Of the overall questionnaire data, 0,87% was missing. The final analysis included 424 participants for structural validity (response rate of 55%) (T0). For the test-retest and SDD analyses, we included 156 participants, who completed the questionnaires at both T0 and T1. For the MIC analyses, we included 76 participants who completed PNE (T2). Nearly half (47%) of the students had experienced persistent pain and had been treated for persistent pain. Results did not differ between participants with and without persistent pain experience. Table 1 shows the characteristics of the study participants.

Reliability

The EFA yielded two factors. Cronbach's α coefficients for the two factors were 0.78 and 0.63. Removal of items number 1, 4 and 26 resulted in Cronbach's α 0.78 and 0.71 (Appendix 3). The overall internal reliability was Cronbach's α 0.80. All α values reached the 0.7 cut-off suggesting adequate internal reliability of the two factors.[45] Test-retest reliability was: ICC 0.80 (95% CI: 0.74; 0.85), the SEM was 2.1 and the SDD90% was 4.99 (4.31; 5.75).

Structural validity

The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis KMO=0.80, including all 34 items. Item 1 (F1: 0.196, F2: 0.224), item 4 (F1: 0.050, F2: 0.234) and item 26 (F1: 0.128, F2: 0.251) were removed, resulting in a KMO of 0.857. Bartlett's test of Sphericity was p<.001. Two components had eigenvalues over Kaiser's criterion of 1. After the removal of items, the components combined explained 28.4%

Table 1. Characteristics of participants across the 3 samples.

Sample (measurement properties)	Cross sectional/ T0 (internal consistency, construct validity, Rasch analysis) (n=424)	Test-retest/T1 (ICC, SDD) (n=156)	PNE/T2 (MIC) (n=76)
Male, n (%)	155 (36.6)	57 (36.5)	30 (39.5)
Age (years): mean (SD)	20.52 (2.3)	20.0 (2.5)	22.0 (20.5-23.0) [a]
Completed education level, n (%):			
High school	296 (69.8)	107 (68.5)	41 (54.0)
Associate's degree (EQF 4)	91 (21.5)	36 (23.1)	24 (31.6)
Bachelor's degree (EQF 6/hbo)	18 (4.2)	8 (5.1)	7 (9.2)
Bachelor's degree (EQF 6/wo)	16 (3.8)	3 (1.9)	4 (5.3)
Other	3 (0.7)	2 (1.3)	-
Experiencing persistent pain, n (%)	200 (47.2)	86 (55.1)	26 (34.2)
Treated for persistent pain n (%)			
At the moment	32 (7.5)	14(9.0)	8 (10.5)
In the past	202 (47.6)	79 (50.6)	30 (39.5)
Having family or friends with persistent pain n (%)	278 (65.6)	105 (67.3)	49 (64.5)
Knowing persons who work with people with persistent pain n (%)	158 (37.3)	60 (38.5)	34 (44.7)

ICC: intraclass correlation coefficients, SDD: smallest detectable difference, PNE: Pain Neuroscience education, MIC: Minimal Important Change ; n: sample size; SD: standard deviation; [a]: median, IQR: interquartile range, EFQ: European Qualifications Framework[60] , WO; Wetenschappelijk Onderwijs (Dutch), HBO; Hoger Beroeps Onderwijs (Dutch).

of the variance, and <15% of participants achieved the lowest or highest possible scores, indicating an absence of floor and ceiling effects (Appendix 3).

Hypotheses testing

Correlation between KNAP and PABS-PT biopsychosocial subscale was: r = 0.60 (95%CI 0.54; 0.66), between KNAP and NPQ was r = 0.52 (95%CI 0.45; 0.58) and between KNAP and PABS-PT biomedical subscale r = -0.58 (95%CI -0.63; -0.53). Differences between year 1 and year 4 were significant ($F = 63.92$, $p \leq .001$, $\eta^2_p = 0.313$), post hoc analysis showed a difference between year 1 and 4 of 8.70 (95%CI 6.98; 10.43) ($p \leq .001$). No hypotheses were rejected, thereby supporting construct validity.

Rasch analyses showed that the item difficulty was adequate. Items 18 and 9 showed an excessive positive infit (2.04 resp.1.59) to the Rasch model. Items 18 and 9 showed

an excessive positive outfit (2.11 resp.1.63). Item 18 was removed because an excessive outfit maintained after response category collapse. No item breached the assumption of local independence. The person reliability was α 0.82 (modest), and the item reliability was α 0.99 (strong). The PSI was 2.15 (good).[61] The item separation index was 11.82 (desirable).[44] For 19 of 31 items categories were recoded in 6 ways of collapsing (Appendix 4). For the transformation table, see appendix 5.

Responsiveness and interpretability

On group level, 93% improved on KNAP after studying PNE, 43% improved at or above the SDD and at or above the MIC. For category 3 'improved', the MIC is 4.84 (95%CI: 2.77; 6.91) and slightly below the SDD90%: 4.99 (4.31; 5.75). For category 4 'greatly improved', the MIC is 7.53 and above the SDD90% (Table 2).

Table 2: Minimal Important Change (MIC) on knowledge and attitudes of pain.

Category	n (%)	MIC (n=76)
1: not improved	0 (0.0)	-
2: somewhat improved but not important	5 (6.6)	2.00 (95%CI -7.22; 11.22)
3: improved	38 (50.0)	4.84 (95%CI 2.77; 6.91)
4: greatly improved	33 (43.4)	7.53 (95%CI 5.57; 9.47)

MIC: Minimal Important Change, n: sample size, CI: Confidence Interval.

Discussion and conclusion

During four phases, a 30-item questionnaire was developed. Overall, extensive testing demonstrated adequate measurement properties. The results do not falsify the hypotheses, suggesting support for the construct validity of KNAP. High values on PSI and person reliability suggest that KNAP has sufficient sensitivity to differentiate between respondents consistently. Local dependence (< 0.7) suggests that all items are needed for measurement. After fit to the Rasch model, a transformation of ordinal raw scores to interval scaling was achieved, so that the rating scale did fully maximise the measurement potential, which was supported by the absence of floor or ceiling effects.

The results show that KNAP is responsive to detect clinically relevant changes in knowledge and attitudes of pain after completion of a course focusing on PNE. The MIC of 4.84 is considered a meaningful change in a sample of physiotherapy students.

The MIC represents the magnitude of change perceived to be beneficial in the context of educational interventions intended to influence future HCPs' knowledge and attitudes of pain. This would aid the interpretation of studies investigating educational interventions using these types of instruments as outcome measures.[62]

Higher KNAP score means that knowledge and attitudes of pain are more congruent with modern pain neuroscience. Because knowledge and attitudes of pain evolves, we need to evaluate the KNAP on a regular basis on current pain knowledge. The content validity of the KNAP should be updated repeatedly. Whether the effect sizes of the educational intervention are large enough to determine changed clinical practice and patient-related outcomes is unknown at present and should be subject for further research.[63–66] Effect of educational interventions should be tested by adding outcome measures on the level of practice behaviour, and ultimately on relevant patient-related outcomes.[12,28,67] In the traditional biomedical model, pain relief is perceived to be needed to improve physical functioning, which can be a barrier for optimal management of pain.[1,10,17] Patients indicated that they learned negative biomedical beliefs from HCPs.[2,68] Contrary to current "best practice" guidelines for LBP management, a potential consequence of such beliefs is avoidance of physical activities, which is likely to result in increased morbidity. Providing this new instrument for assessing knowledge and attitudes to create awareness towards (persistent) pain in HCPs aims to identify and positively influence patient beliefs which may decrease the threat associated with MSK pain.[11,69] Also, awareness can help to design better education programs that could improve persistent pain prevention, more effective implementation of existing guidelines and new treatment models.[69,70]

The present study has several strengths, including a robust and extensive procedure for developing and testing measurement properties of KNAP using both classic and Rasch methods, more robust and extensive than similar questionnaires. The large sample size (>400 participants) was sufficient for testing structural validity and minimised participation bias. The MIC of the present study must be interpreted with caution since we could not make use of the ROC-technique (Receiver Operating Characteristic), due to a too low amount of non-positive changing participants. Consequently, parameters as the AUC (Area Under Curve), sensitivity and specificity are missing, which limits unbiased discriminating between improved and unchanged respondents.[71] Reporting a SDD of 90% means the test is more sensitive in detecting (relevant) changes in knowledge and attitudes compared to a SDD of 95%, considering the consequence of more false-positives in this case as not harmful. All participants had almost the same age and socioeconomic profiles, which are typical for the target population. They stem from the same geographic areas of the Netherlands,

the relevance of which is unknown, but probably low. The findings provide a basis to investigate differences and develop reference values of knowledge and attitudes scores using other samples of HCPs and the general public.[72] This study aimed to develop and validate KNAP in future HCPs. A future step will be to validate the KNAP in HCPs, which should be done in HCPs with different years of working experience.

Results of repeated measurements of the KNAP may be influenced by recall bias. To prevent recall bias, the time interval should be long enough. A time interval of about two weeks is often considered appropriate[73], also applied in this study. It must be noted that the KNAP is less useful as an exam to test the comprehensive body of knowledge of pain repeatedly. For this purpose, alternative forms of knowledge tests would be recommended. The Dutch KNAP has been submitted to a small sample of the target group a priori to testing the psychometric properties, which could have affect the feasibility and the content validity. The magnitude of correlation between instruments may suggest acceptable convergent validity, but given the absence of good measurement properties of the PABS-PT and NPQ, the findings needed to be interpreted with caution.[28,32]

In conclusion: The KNAP has adequate measurement properties to evaluate future HCPs' knowledge and attitudes of modern pain neuroscience. This new questionnaire could be useful to evaluate future HCPs' knowledge and attitudes that could help to design awareness and education activities and ultimately provide better pain management. It requires further study on active HCPs to get insight into the implicit attitudes and their influence on actual practitioner behaviours during clinical practice and ultimately on intervention outcomes.

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Supplementary data

The following is the Supplementary data to this article

Appendix A

30 item KNAP Dutch version

Domein 1: Pijnfysiologie en beïnvloedende factoren.

Geef met een score van 1 tot 6 aan in hoeverre u het oneens of eens bent met de stelling.

1. Als de weefselschade of ontsteking volledig is hersteld, verdwijnt de pijn.
   1. volledig mee oneens
   2. in grote mate mee oneens
   3. enigszins mee oneens
   4. enigszins mee eens
   5. in grote mate mee eens
   6. volledig mee eens

2. Het pijnsysteem kan zich aanpassen, een gevolg hiervan kan zijn dat het pijnsysteem overgevoelig wordt.
   1. volledig mee oneens
   2. in grote mate mee oneens
   3. enigszins mee oneens
   4. enigszins mee eens
   5. in grote mate mee eens
   6. volledig mee eens

3. Pijngevoeligheid kan aanhoudend zijn, ook als het letsel of schade al is verdwenen.
   1. volledig mee oneens
   2. in grote mate mee oneens
   3. enigszins mee oneens
   4. enigszins mee eens
   5. in grote mate mee eens
   6. volledig mee eens

4. Bij aanhoudende pijn, kan de pijn worden veroorzaakt door aanpassingen in het pijnsysteem zelf.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

5. Het brein laat chemische stoffen vrij, waardoor het pijnsysteem minder gevoelig kan worden.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

6. Overgevoeligheid van het pijnsysteem is soms nuttig.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

7. Pijn is altijd een uiting van het brein.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

8. Het brein heeft een intern pijndempend systeem voor verschillende signalen, waardoor je minder pijn kan voelen.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

9. De activiteit van het brein wordt beïnvloed door psychologische en sociale processen, zoals stress. Dit beïnvloedt weer de gevoeligheid van het pijnsysteem.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

10. Het brein heeft een systeem om zenuwsignalen in het lichaam te versterken.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

11. Als de zenuwsignalen van het lichaam worden geïnterpreteerd als gevaarlijk, leiden deze signalen waarschijnlijk tot een ervaring van pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

12. Negatieve gedachtes over de oorzaak van de pijn, kan zorgen voor het versterken van de pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

13. Bij aanhoudende pijn is het belangrijk om te weten dat de pijn niet gevaarlijk is.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

14. Bij aanhoudende pijn is het belangrijk om te weten waarom de pijn blijft bestaan.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

15. Als pijn beïnvloed wordt door psychologische factoren, betekent dit waarschijnlijk dat de pijn niet echt is of op z'n minst gedeeltelijk bedacht.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

16. De lichamelijke pijn die een persoon voelt, wordt beïnvloed door de gedachtes over de oorzaak van de pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

17. Aanhoudende pijn is vaak het gevolg van een zenuwbeknelling.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

18. Onverklaarbare pijn is geen echte pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

19. Bij pijn is bewegen of sporten gevaarlijk.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

20. Zolang er weefselschade zichtbaar is op een röntgenfoto of MRI, dan is er ook pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

21. Pijn betekent dat je je activiteiten dient te verminderen.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

Domein 2: Behandeling van pijn.

22. Bij aanhoudende pijn, is de behandeling gericht op het verlagen van de gevoeligheid van het pijnsysteem.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

23. Behandeling van pijn is altijd het meest effectief wanneer de focus wordt gelegd op de weefselschade of de ontsteking en het oplossen van dit probleem.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

24. Bewegen is bij aanhoudende pijn een goede behandeloptie.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

25. Pijnmedicatie is effectief bij aanhoudende pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

26. Het opheffen van een slechte houding, vermindert de aanhoudende pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

27. De fysiotherapeut kan een scheve rug weer recht zetten, waardoor de aanhoudende pijn vermindert.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

28. Tijdens een fysiotherapeutische behandeling, dienen pijnprovocerende oefeningen vermeden te worden.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

29. Meer kennis over pijn door uitleg van de fysiotherapeut, vermindert aanhoudende pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

30. Bij aanhoudende pijn, dient het activiteitenniveau opgebouwd te worden op geleide van pijn.
1. volledig mee oneens
2. in grote mate mee oneens
3. enigszins mee oneens
4. enigszins mee eens
5. in grote mate mee eens
6. volledig mee eens

Items removed after EFA:
- 'Pijn is een belangrijk waarschuwingssignaal'.
- 'Overgevoeligheid van het pijnsysteem kan helpen bij de genezing'.
- 'Mensen met pijn als gevolg van weefselschade of ontsteking, zouden het beste een lichamelijke behandeling kunnen krijgen'.-

Item removed after Rasch analysis:
- Pijn is óf een lichamelijk probleem óf een mentaal probleem'.

Appendix B

30 items KNAP English version

Domain 1: Pain physiology and influential factors

On a scale from 1 to 6, to what extent do you *agree or disagree* with this statement

1. If the tissue damage or inflammation has fully healed, the pain disappears.
   1. completely disagree
   2. to a large extent disagree
   3. somewhat disagree
   4. somewhat agree
   5. to a large extent agree
   6. completely agree

2. The pain system can adapt; therefore the pain system can become hypersensitive
   1. completely disagree
   2. to a large extent disagree
   3. somewhat disagree
   4. somewhat agree
   5. to a large extent agree
   6. completely agree

3. Pain sensitivity can persist, even if there is no longer an injury or tissue damage
   1. completely disagree
   2. to a large extent disagree
   3. somewhat disagree
   4. somewhat agree
   5. to a large extent agree
   6. completely agree

4. In persistent pain, the pain can be caused by adaptation of the pain system itself
   1. completely disagree
   2. to a large extent disagree
   3. somewhat disagree
   4. somewhat agree
   5. to a large extent agree
   6. completely agree

5. The brain releases chemicals, which can make the pain system less sensitive.
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

6. Hypersensitivity of the pain system can sometimes be beneficial
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

7. Pain is always an output of the brain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

8. The brain has an internal pain reduction system for different signals, to relieve pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

9. Brain activity is influenced by psychological and social processes (such as stress) which in turn influences the sensitivity of the pain system
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

10. The brain has a mechanism that can amplify nerve signals throughout the body
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

11. If the nerve signals from the body are interpreted as dangerous, this probably leads to the experience of pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

12. Negative thoughts about the cause of pain, can amplify the pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

13. In persistent pain, it is important to know that the pain isn't dangerous
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

14. In persistent pain, it is important to know why the pain persists
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

15. If pain is influenced by psychological factors, this probably means the pain is not real or has been partially made up
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

16. The physical pain that a person feels, is influenced by the thoughts about the cause of the pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

17. Persistent pain is often the result of nerve compression
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

18. Unexplained pain is not real pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

19. When in pain, it is dangerous to move or exercise
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

20. As long as tissue damage is visible on an X-ray or MRI, there will be pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

21. Pain indicates that you should reduce your activity level
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

Domain 2: Treatment of Pain

22. Treatment for persistent pain is aimed at reducing the sensitivity of the pain system
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

23. Treatment of pain is always the most effective when focussing on the tissue damage (or inflammation) and solving this problem
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

24. Exercise is a good treatment option in persistent pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

25. Pain medication is effective in persistent pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

26. Correcting poor posture reduces persistent pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

27. The physiotherapist can reduce persistent pain by correcting a malaligned spine
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

28. During a physiotherapy treatment, pain-provoking exercises should be avoided
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

29. Learning more about pain "due to explaining pain" by the physiotherapist reduces persistent pain
1. completely disagree
2. to a large extent disagree
3. somewhat disagree
4. somewhat agree
5. to a large extent agree
6. completely agree

30. In persistent pain, the level of activity should be increased depending on the pain experienced
   1. completely disagree
   2. to a large extent disagree
   3. somewhat disagree
   4. somewhat agree
   5. to a large extent agree
   6. completely agree

Items removed after EFA:
- 'Pain is an important warning signal'.
- 'Hypersensitivity of the pain system can aid healing'.
- 'Physical treatment is the best option for people with pain caused by tissue damage or inflammation'.

Item removed after Rasch analysis:
- 'Pain is either a physical problem or a mental problem'.

Appendix C

Rotated factor matrix of the KNAP questionnaire (N = 424), removed items: 1,4, 26

Item	Factor 1	Factor 2
6 In persistent pain, the pain can be caused by adaptation of the pain system itself	0,714	0,236
10 The brain has an internal pain reduction system for different signals, to relieve pain	0,659	0,097
14 Negative thoughts about the cause of pain, can amplify the pain	0,637	0,119
11 Brain activity is influenced by psychological and social processes (such as stress) which in turn influences the sensitivity of the pain system	0,586	0,234
3 The pain system can adapt; therefore the pain system can become hypersensitive	0,561	0,320
12 The brain has a mechanism that can amplify nerve signals throughout the body	0,556	-0,122
19 The physical pain that a person feels, is influenced by the thoughts about the cause of the pain	0,550	0,077
13 If the nerve signals from the body are interpreted as dangerous, this probably leads to the experience of pain	0,520	-0,006
5 Pain sensitivity can persist, even if there is no longer an injury or tissue damage	0,516	0,226
25 Treatment for persistent pain is aimed at reducing the sensitivity of the pain system	0,513	-0,015
33 Learning more about pain "due to explaining pain" by the physiotherapist reduces persistent pain	0,463	0,171
15 In persistent pain, it is important to know that the pain isn't dangerous	0,461	0,092
7 The brain releases chemicals, which can make the pain system less sensitive	0,425	-0,031
28 Exercise is a good treatment option in persistent pain	0,421	0,243
9 Pain is always an output of the brain	0,360	-0,034
16 In persistent pain, it is important to know why the pain persists	0,282	-0,106
34 In persistent pain, the level of activity should *not* be increased depending on the pain experienced	0,203	0,091
2* If the tissue damage or inflammation has fully healed, the pain disappears	0,183	-0,018
8 Hypersensitivity of the pain system can sometimes be beneficial	0,140	-0,105
22* When in pain, it is dangerous to move or exercise	0,139	0,651
20* Persistent pain is often the result of nerve compression	0,197	0,613
24* Pain indicates that you should reduce your activity level	0,052	0,586
27* Treatment of pain is always the most effective when focussing on the tissue damage (or inflammation) and solving this problem	0,135	0,577
23* As long as tissue damage is visible on an X-ray or MRI, there will be pain	0,281	0,549

17* If pain is influenced by psychological factors, this probably means the pain is not real or has been partially made up	-0,079	0,541
31* The physiotherapist can reduce persistent pain by correcting a malaligned spine	0,054	0,537
18* Pain is either a physical problem or a mental problem[7]	-0,006	0,440
30* Correcting poor posture reduces persistent pain	-0,084	0,399
29* Pain medication is effective in persistent pain	0,082	0,396
32* During a physiotherapy treatment, pain-provoking exercises should be avoided	-0,025	0,356
21* Unexplained pain is not real pain	0,158	0,273
% variance		
Cronbach's α	0.776	0.709

2.4 % of respondents who achieved the lowest possible score (5 lowest scores)
1.8.% of respondents who achieved the highest possible score (5 highest scores)

7 * flipped items
Item is removed after RASCH analysis

Appendix D

Recode commands of the 30 items KNAP for SPSS: 123456=

Item	Rasch score
1*	543000
2	000345
3	011345
4	001345
5	011345
6	012345
7	011345
8	000345
9	011345
10	011345
11	000345
12	011345
13	002245
14	011345
15*	543210
16	000456
17*	543110
18*	543210
19*	543210
20*	543110
21*	543210
22	012345
23*	543210
24	012345
25*	544210
26*	543210
27*	543210
28*	543210
29	001445
30*	543210

* flipped items

Appendix E

Conversion table of the 30-items KNAP

0=0

1=14.64; 2=23.20; 3=28.30; 4=31.97; 5=34.85; 6=37.24; 7=39.27; 8=41.05); 9=42.63; 10=44.05; 11=45.34; 12=46.52; 13=47.61 ;14=48.62; 15=49.57; 16=50.46; 17=51.29; 18=52.08; 19=52.83;

20=53.54; 21=54.22; 22=54.87; 23=55.49; 24=56.09; 25=56.66; 26=57.22; 27=57.75; 28=58.27; 29=58.77;

30=59.26; 31=59.73; 32=60.20; 33=60.65; 34=61.08; 35=61.51; 36=61.93; 37=62.34; 38=62.74; 39=63.14;

40=63.52; 41=63.90; 42=64.28; 43=64.64; 44=65.01; 45=65.36; 46=65.72; 47=66.06; 48=66.41; 49=66.75;

50=67.08; 51=67.41; 52=67.74; 53=68.07; 54=68.39; 55=68.71; 56=69.03; 57=69.34; 58=69.66; 59=69.97;

60=70.28; 61=70.59; 62=70.89; 63=71.20; 64=71.50; 65=71.80; 66=72.11; 67=72.41; 68=72.71; 69=73.01;

70=73.31; 71=73.61; 72=73.91; 73=74.21; 74=74.51; 75=74.80; 76=75.10; 77=75.41; 78=75.71; 79=76.01;

80=76.31; 81=76.62; 82=76.92; 83=77.23; 84=77.54; 85=77.85; 86=78.16; 87=78.47; 88=78.79; 89=79.10;

90=79.42; 91=79.75; 92=80.07; 93=80.40; 94=80.73; 95=81.07; 96=81.40; 97=81.74; 98=82.09; 99=82.44;

100=82.79; 101=83.15; 102=83.51;103=83.88; 104=84.25; 105=84.63; 106=85.02; 107=85.41; 108=85.80; 109=86.21;

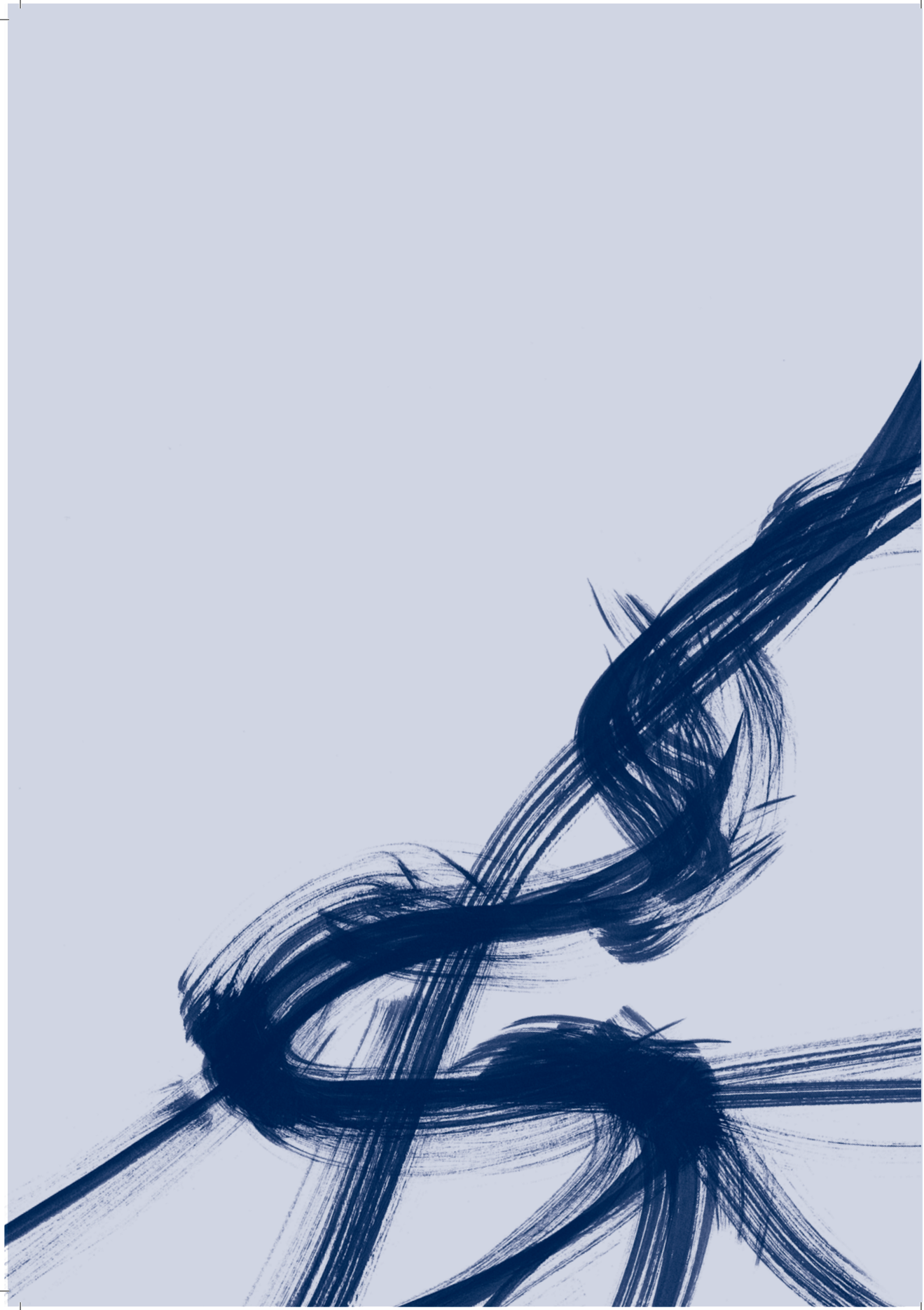
110=86.62; 111=87.04; 112=87.46; 113=87.90; 114=88.34; 115=88.79; 116=89.26; 117=89.73; 118=90.22; 119=90.71;

120=91.22; 121=91.75; 122=92.28; 123=92.84; 124=93.41; 125=94.00; 126=94.60; 127=95.23; 128=95.89; 129=96.56;

130=97.27; 131=98.00; 132=98.77; 133=99.58; 134=100.42; 135=101.32; 136=102.27; 137=103.28; 138=104.36; 139=105.52;

140=106.79; 141=108.17; 142=109.70; 143=111.42; 144=113.39; 145=115.69;146=118.49; 147=122.05; 148=127.03; 149=135.46;

150=150.



CHAPTER 3

Assessing pain science education; the measurement properties of assessment instruments of conceptual change: a narrative and rapid review

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Abstract

Despite the widespread use and benefits of Pain Science Education, no standardized approach exists for assessing outcomes relevant to individuals with pain. The aims of this review were: (1) to identify instruments assessing the proximal outcomes of Pain Science Education (pain-related knowledge or understanding, beliefs and attitudes), and present their psychometric properties, (2) to identify domains that could be used to assess distal outcomes (focusing on the process or impact), and (3) to explore how such instruments relate to pain reconceptualization.

A two-phase process was used, including expert panel discussions and a rapid review strategy, to identify and appraise articles reporting on instrument development and psychometric evaluation. The psychometric properties of the instruments were mapped against the criteria of COSMIN.

We identified 32 instruments targeting proximal outcomes. Gaps remain regarding instruments for specific populations, including those with low health literacy. Psychometric data revealed a focus on internal consistency and structural validity, with limited exploration of content validity, reliability, responsiveness, or application of Item Response Theory methods. Process variables have been identified, such as pain self-efficacy, fear of movement and pain catastrophizing. Impact variables, such as pain intensity, physical activity, emotional wellbeing/distress and fatigue overlap with core outcome sets created for chronic pain. Combining existing instruments with qualitative interview in a mixed-methods approach may be required to assess conceptual change in depth.

More psychometrically robust assessments of conceptual change, that are easy and quick to complete, and sufficiently flexible to use with multiple populations, would make a significant contribution.

Introduction

Pain science education (PSE) is a common intervention for people with chronic pain and is associated with clinically important benefits [21; 191; 198]. The Pain Education Team to Advance Learning (PETAL) Collaboration uses the term PSE to refer to contemporary iterations of what was originally called 'Pain Neuroscience Education' (PNE) or 'explaining pain' [121; 122]. The distinction between PSE and its earlier forms, particularly PNE (as discussed elsewhere [122]), relates to its more consumer-informed and targeted content. It shifts away from didactic delivery of pain science towards the use of educational theory and strategies to facilitate a dynamic, interactive, co-construction of pain understanding between the facilitator and the learner. Whilst PSE has traditionally been used with patients in clinical settings, it has more recently been applied in public health initiatives. These initiatives target the general public and key societal subgroups such as Health Care Professionals (HCP), school children, and the workers/employers – aiming to change the approach to pain across whole communities [156].

The aim of PSE is to improve an individual's understanding of pain by aligning it with modern pain science. This improved knowledge is intended to empower individuals to make more informed evidence-based choices about their care, reduce their likelihood of developing and/or maintaining persistent pain and improve their health and well-being [122]. The target of a PSE intervention is conceptual change and is defined as the restructuring of existing pain knowledge rather than merely acquiring new information (i.e. pain reconceptualization) [121; 122; 128; 186]. This perspective provides a useful lens for understanding PSE [29; 120; 128]. Since the pain scientific knowledge base is continuously advancing there is a need to adapt the items of assessing instrument according to current state of this field.

Outcome assessments related to PSE reflect its goal of aligning an individual's understanding of pain with modern pain science. Assessments can target either proximal or distal outcomes (not to be confused with short term and long-term outcomes). Proximal outcome assessments for PSE are those that attempt to assess the consumer's pain-related knowledge/understanding, beliefs, attitudes. Pain-related knowledge is defined as 'knowledge about the biological underpinnings of pain and recovery [121]. Pain-related beliefs are defined as 'a feeling of being certain *about* pain related aspects', whereas pain-related attitudes can be defined as 'any belief or opinion *towards* pain related aspects' and are thought to more obviously manifest in behaviors [65; 107]. Beliefs and attitudes overlap and are often used interchangeably both within the PSE and wider pain literature.

In addition to assessing the proximal outcomes, assessing distal pain-related outcomes focusing on the process or impact is important. Process variables which are proposed as potential mechanisms by which PSE brings about change, such as increasing pain self-efficacy, reducing catastrophizing and fear of movement [25; 102] and impact variables which are ultimately the outcome of relevance to the user, which can include clinical, general health and wellbeing outcomes. These variables commonly used to assess the impact of pain interventions, such as pain, disability and quality of life. Proximal and distal should be seen as a continuum rather than a discrete categorization. To illustrate this, behaviors related to pain could be viewed as both proximal and distal, where returning to work is a distal outcome and guarded movement patterns could be considered more proximal behaviors.

PSE is widely practiced and recommended, and clear guidelines exist on which core outcomes should be assessed in interventions for chronic pain [19; 137]. Core outcomes, established by multiple groups in specific populations [48; 190], are standardized areas of measurement to harmonize assessment in pain clinical trials and to increase relevancy and patient-centered care. There remains a lack of clarity about which instruments could be used to assess these outcomes in the context of PSE. While several instruments are available, it is uncertain which instruments are most appropriate for different contexts or research questions.

The aims of this review were: (1) to identify instruments assessing the proximal outcomes of PSE, (pain-related knowledge or understanding, beliefs and attitudes), and present their psychometric properties, (2) to identify domains that could be used to assess distal outcomes (focusing on the process or impact), and (3) to explore considerations on how such instruments relate to pain reconceptualization.

Methods

A two-phase process was conducted. Phase 1 was to generate an initial list of instruments related to aim 1. It consisted of six online expert panel discussions over 12 months, freely following a nominal group technique. Experts were members of the Assessment Working Group of the Pain Education Team to Advance Learning (PETAL) Collaboration (https://www.petalcollaboration.org/). The PETAL Collaboration collaborated to identify and prioritize the challenges facing the field [122; 156]. Working groups were established for each priority. The Pain education Assessment Working Group (PAWG) included PETAL-members with demonstrated expertise or publication in this sub-field. They went through a process of discussing assessment

instruments, theoretic frameworks and common challenges. Reporting was in keeping with SANRA guidelines (Supplementary materials).

Phase 1 generated a list of instruments to then be used for a rapid review in phase 2, related to aim 1. Phase 1 also generated a list of domains for aim 2 (to identify domains that could be used to assess distal outcomes (focusing on the process or impact) and included discussion around preliminary considerations for aim 3. Finally, Phase 1 was supplemented by invitations sent via PETAL-members' social media (LinkedIn, Facebook groups and Twitter) networks for other researchers and clinicians to nominate instruments they used and considered to be targeting the proximal outcomes of pain education. Responses were compared to the data generated from within the PAWG and any instruments that had been missed were added.

In Phase 2, the author group searched the literature for the narrative review on distal domains related to aim 2 and to establish considerations for aim 3. Furthermore, these findings were shared and discussed in sub-groups online and during the drafting process as a whole group. Parallel to this, phase 2 also used a rapid review strategy to identify studies that interrogated the psychometric properties of the instruments identified in phase 1, and to identify additional instruments missed in phase 1. Candidate articles were identified via an online search of key bibliographic databases (OVID Medline, Embase, APA Psychinfo) via the Ovid platform in September 2024. The search string used (Pain AND (belief* OR attitude* OR knowledge OR concept* OR thought*) AND (clinimetric or psychometric or valid* or reliab* or responsive*) AND (scale or questionnaire or survey or inventory OR quiz) AND (patient* OR public OR clinic*)))) specifically targeting instruments that had been psychometrically evaluated. Consistent with our rapid review approach and for pragmatic reasons, the search was limited to title and abstract, and to human participants. No restrictions were placed on language or date.

Duplicates were removed using Endnote software (Version 21, *Clarivate Analytics*) and the articles were uploaded into Covidence review managing software (*Veritas Health Innovation*). The titles and abstracts of candidate articles were assessed by author MJC to identify those that potentially reported on the evaluation, development or adaptation of instruments that assess pain-related attitudes, beliefs and/or knowledge. The full texts of potentially relevant articles were retrieved and independently reviewed by authors MJC and RRR. Conflicts were resolved through discussion and arbitration by author AJB if conflict remained. Articles were included if they reported primary data on (a) the development, adaption or psychometric evaluation of an instrument assessing pain-related attitudes, beliefs and/or knowledge

of pain theory and science, (b) the translation and/or cross-cultural adaptation of an instrument, (c) the psychometric properties of an instrument, or (d) the revision of a previously reported instrument. To supplement the rapid review search strategy and to identify additional relevant articles, the reference lists of the included articles were examined and a search of articles citing the included studies was conducted using Google Scholar.

From the initially included articles, a secondary list of instruments was generated and added to those identified in Phase 1. Two authors (MJC and RRR) sourced and reviewed each of the included instruments to determine whether the instruments assessed attitudes, beliefs and/or knowledge related to pain theory and science. Instruments deemed to assess distal pain-related outcomes that could be expected to change with the provision of PSE (e.g. pain-related behaviors), or factors not expected to be directly influenced by PSE (e.g. knowledge of methods of assessing pain, managementprotocols or guidelines) were excluded.

The following instrument-related data were extracted from the articles and tabulated: name of instrument, preferred abbreviation, year published, construct assessed as stated by authors (not necessarily aligned with definitions stated here), utilized or proposed population, language, and scoring structure. Any translated or adapted versions of the included instruments were also extracted from the included articles and tabulated. All available psychometric data pertaining to the original and/or English versions of the instruments were extracted in accord with the COSMIN (Consensus-based Standards for the selection of health Measurement Instruments) initiative's taxonomy of psychometric properties [114] and tabulated. These data included content validity, internal consistency, reliability (test-retest), construct validity (structural validity, relationships to other instruments), and whether Item Response Theory (IRT) models were used [79]. A data-synthesis was not performed, in line with the aims. The extracted data are reported in Table 1 and 2.

Results

Instruments assessing proximal outcomes of PSE

Phase 1 generated a list of 32 potentially relevant instruments measuring pain-related knowledge, understanding, beliefs and attitudes (Table 1). Phase 2 search results are shown in Figure 1 (PRISMA flow chart). The initial search identified 2187 unique records; 2061 were excluded in the initial screening of titles and abstracts; a further 50 were excluded during the review of the full text articles; 76 articles were eligible.

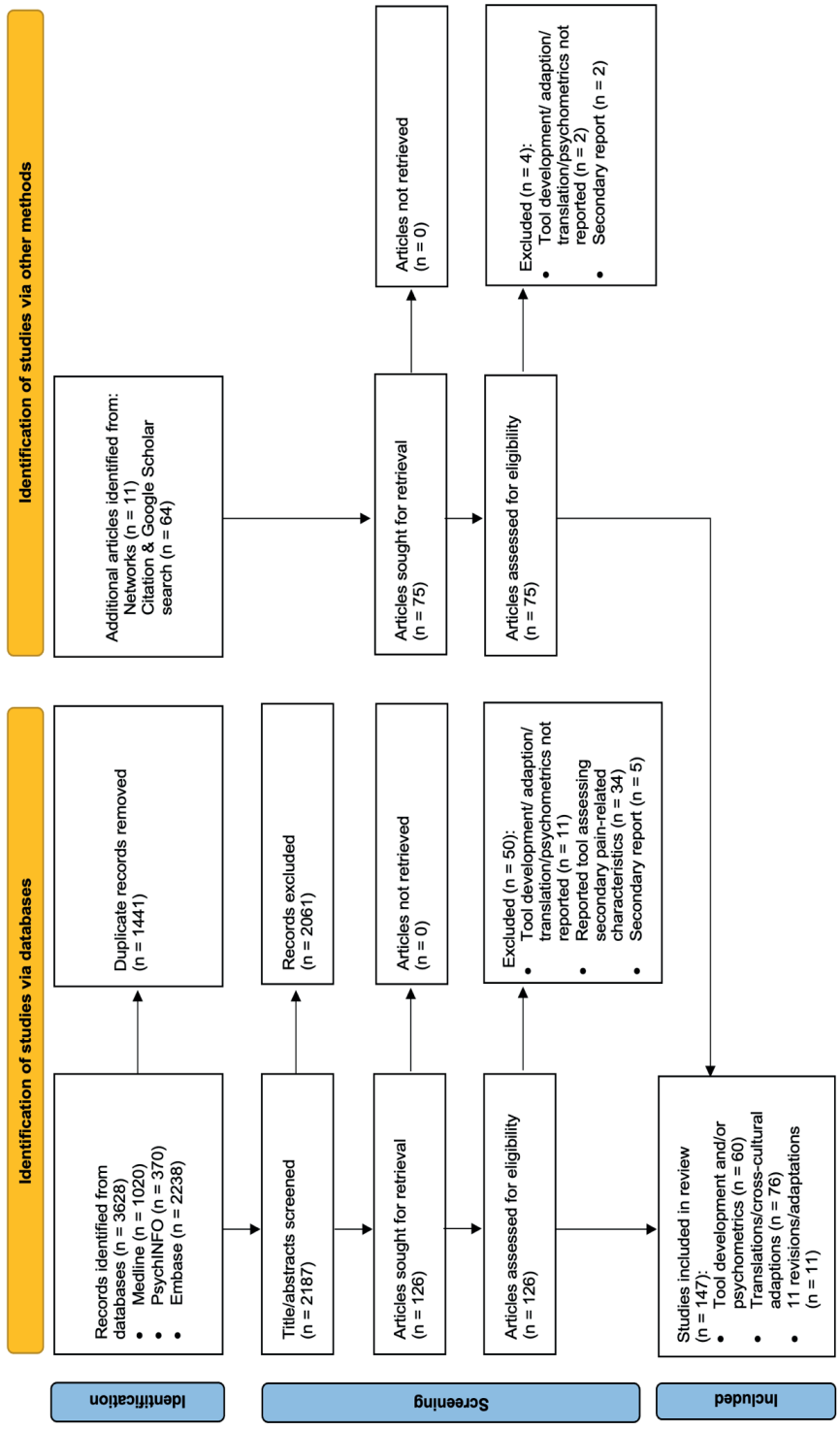


Figure 1. PRISMA flow chart

An additional 71 eligible articles were identified through author social networks, searching the reference lists of eligible studies, and searching for articles citing the eligible articles in Google Scholar. Of the overall total of 147 eligible articles, 60 reported on the development and/or psychometrics of an instrument, 76 on the translation and/or cross-cultural adaptation of an instrument, and 11 on the revision/ adaption of an original instrument.

Consequently, a further 28 potentially relevant instruments (Supplementary materials 2) were identified, for a total of potential 60 instruments. Details on these instruments were extracted from the articles (or sourced when not reported) and reviewed, resulting in the inclusion of 32 instruments (see supplementary material for detail of excluded instruments). The details of these instruments, including translations and adaptations, are displayed in Table 1. The Survey of Pain Attitudes (SOPA) [81] was the oldest instrument, predating the emergence of PNE [124] by over a decade. Most instruments were developed in English, but recent years have seen several instruments developed and/or translated in other languages. There remains a paucity of instruments that have been translated and/or cross-culturally adapted for African and South-East Asian languages. Most instruments were developed for use with patients or health professionals working with patients; some are anatomically specific (e.g. back pain); many are applicable for use in anyone - with or without pain. Interestingly, over one third of the instruments were developed in the last five years with several of these developed for use with children and adolescents. The instruments ranged in length from four items to 73 items.

The psychometric data for the included instruments are displayed in Table 2. Internal consistency and structural validity were the most commonly properties interrogated and criterion validity, reliability, and responsiveness the least commonly reported. Less than one third were evaluated with IRT-approaches and very few met the sample size recommendations of the COSMIN initiative [113; 176].

Table 1. Instruments assessing pain-related knowledge, beliefs and attitudes.

Name of Instrument *(year of introduction)*	Construct	Target population	Primary Language	Scoring	Published translations	Alternate versions
1. Attitudes to Back Pain Scale in Musculoskeletal Practitioners (ABS-mp)[145] ***(2006)***	Attitudes	Musculoskeletal practitioners	English	19 items, Likert scale format, two domains summed seperately (Personal interaction total score 13 to 91, Treatment orientation score 6 to 42)	Hebrew[132]	
2. Back Beliefs Questionnaire (BBQ)[171] ***(1996)***	Beliefs	Workers	English	14 items, Likert scale format, 9 items summed for total score 9 to 45 with lower scores indicating more pessimistic beliefs.	Arabic[3], Brazilian Portuguese[175], Danish[68], French[46], Hausa[77], Marathi[150], Norweigian[177], Simplified Chinese[27], Suriname Dutch[72], Traditional Chinese[28], Turkish[6], Yoruba[109]	Modified BBQ (MBBQ)[2] assesses attitudes, beliefs, knowledge in health professionals
3. Back Pain Attitudes Questionnaire (Back-PAQ)[39] ***(2014)***	Attitudes, beliefs	Patients with back pain	English	34 items, Likert scale format, total score -68 to 68 with lower scores reflecting unhelpful beliefs	Arabic[85], Argentine Spanish[143], Brazillian Portuguese[95], Danish[130], Dutch[60], French[60], Swedish[133], Turkish[174]	Short form (10 item) [39]
4. Back pain Knowledge and beliefs Survey (BacKS)[34] ***(2024)***	Beliefs, knowledge	Patients with back pain	English	20 items, Likert scale format, total score 20 to 100 with higher scores indicating higher alignment with evidence-based recommendations.		
5. Beliefs about pain control questionnaire (BPCQ)[164] ***(1990)***	Beliefs	General Public	English	13 items, Likert scale format, total score 13 to 78 with three subscales assessing the controllability of pain.		

Table 1. continued

Name of Instrument *(year of introduction)*	Construct	Target population	Primary Language	Scoring	Published translations	Alternate versions
6. Biopsychosocial Pain Concept Matrix (BiPS matrix) [192; 193] ***(2023)***	Beliefs	Children	German	40 items, Likert scale format, five domains (cause, consequences, type of pain, timeline, and treatment), higher scores indicating higher alignment of beliefs with contenporary pain science.		
7. Chronic pain myths scale (CPMS)[96] ***(2016)***	Attitudes, beliefs, knowledge	Health professionals	French Canadian	26 items, Likert scale format, three subscales measuring knowledge, beliefs & attitudes towards (1) people suffering from chronic pain, (2) biopsychosocial impacts of chronic pain, and (3) treatment of chronic pain. Subscales summed seperately with total scores 9 to 45, 10 to 50 and 7 to 35 respectively with higher scores indicating higher knowledge and more positive beliefs and attitudes.	English[108]	
8. Concept of Pain Inventory (COPI) [140] ***(2020)***	Attitudes, beliefs	Children	English	14 items, Likert scale format, total score 0 to 56 with higher scores indicating higher alignment of beliefs with contenporary pain science.	Turkish[5]	
9.Concept of Pain Inventory for Adults (COPI-Adult)[141] ***(2022)***	Attitudes, beliefs	General Public	English	13 items, Likert scale format, total score 0 to 56 with higher scores indicating higher alignment of beliefs with contemporary pain science.	Danish[52]	

Table 1. continued

Name of Instrument *(year of introduction)*	Construct	Target population	Primary Language	Scoring	Published translations	Alternate versions
10. Conceptualization of Pain Questionnaire (COPAQ) [158] *(2021)*	Beliefs	Children/adolescents	Catalan	15 items, true/false format, , total score 0 to 15 with higher scores indicating greater understanding of contemporary pain concepts.	English[158]	
11. Essential Knowledge of Pain Questionnaire (EKPQ[10]) ***(2023)***	Beliefs	Physiotherapists	German	20 items (including 8 'dummy' items), true/false format, total score 0 to 12 with higher scores indicating less postural-structural-biomechanical-oriented beliefs.		
12. General Attitudes Towards Pain Inventory (GATPI)[184] ***(2022)***	Attitudes	General public, sadomasochists	German	48 items, Likert scale format, 10 subscales (fascination-pleasure, challenge, warning function, acceptance & stoicism, secondary gain, tragedy, threat, helplessness, punishment, obstacle).		
13. Health Care Providers' Pain and Impairment Relationship Scale (HC-PAIRS)[149] ***(1995)***	Attitudes, beliefs	Health professionals	English	15 items, Likert scale format, total score 15 to 105 with higher scores indicating greater beliefs that pain justifies disability and activity limitations	Arabic[4], Brazilian Portuguese[59], Dutch[75], Finnish[51], French[103], Hebrew[167], Simplified Chinese[27], Spanish[44], Swedish[136], Traditional Chinese[22]	
14. Implicit Theory of Pain Scale (ITPS)[170] ***(2019)***	Beliefs	General public	English	8 items, Likert scale format, total score 8 to 48 wih higher scores indicating greater belief that pain is malleable rather than fixed.		

Table 1. continued

Name of Instrument *(year of introduction)*	Construct	Target population	Primary Language	Scoring	Published translations	Alternate versions
15. Inventory of Attitudes towards Pain-Professionals [62] *(2007)*	Attitudes *(adaptation of SOPA)*	Health Professionals	Brazillian Portuguese	20 items, Likert scale format, six domains (control, medical cure, solicitude, emotion, harm, disability).		
16. Know Pain 50 [71] *(2014)*	Knowledge	Health Professionals	English	50 items, Likert scale & multiple choice questions, six subscales, total score 0 to 250 with higher scores indicating better knowledge.	French[97], Hebrew[56],	Short form (12 items) [64]
17. Knowledge & Attitudes of Pain (KNAP)[12] *(2021)*	Attitudes, knowledge	Health professionals	Dutch	30 items, Likert scale format, total score 34 to 204 with higher scores indicating higher alignment of knowledge with contemporary pain science.	Brazilian Portuguese[23], English[12], French[125], Japanese[173], Spanish[42]	
18. Negative Pain Thoughts Questionnaire (NPTQ)[187] *(2021)*	Beliefs	Patients with hand and arm pain		11 items, Likert scale format, total score 11 to 66 with higher scores indicating more negative pain-related cognitions & misconceptions about medical treatments.		Short form (4 items) [40]
19. Neurophysiology of pain questionnaire (NPQ)[119] *(2003)*	Beliefs, knowledge	Health professionals	English	19 items, true/false format, total score 0 to 12 with higher scores indicating greater knowledge.	Brazilian Portuguese[131], Dutch[110], Finnish[50], French[41], German[153], Hebrew[167], Italian[57], Japanese[112], Spanish[178], Thai[138], Turkish[70]	Short-form (12 items) [26; 70; 152]
20. Osteoarthritis Conceptualisation Questionnaire (OACQ)[148] *(2023)*	Beliefs	Patients with knee osteoarthritis	English	36 items, Likert scale format, four subscales, higher scores indicating higher alignment of OA and pain understanding with contemporary science.		

Table 1. continued

Name of Instrument *(year of introduction)*	Construct	Target population	Primary Language	Scoring	Published translations	Alternate versions
21. Osteoarthritis Knowledge Scale (OAKS) [37] ***(2023)***	Knowledge	Patients with hip or knee osteoarthritis	English	11 items, Likert scale format, total score 11 to 55 with higher scores indicate greater knowledge about osteoarthritis.		
22. Pain & Impairment Relationship Scale (PAIRS)[154] ***(1988)***	Beliefs, knowledge	Chronic low back pain	English	15 items, Likert scale format, total score 15 to 105 with higher scores indicating greater beliefs that pain justifies disability and activity limitations		Health professional version (see HC-PAIRS)
23. Pain Attitudes & Beliefs Scale (PABS-PT)[135] ***(2003)***	Attitudes & Beliefs	Health professionals	Dutch	31 items, Likert scale format, two domains (biomedical treatment orientation, biopsychosocial treatment orientation)	Brazilian Portuguese[105], English[135], French[163; 166], German[98], Italian[9], Norwegian[54], Spanish[43; 61], Swedish[136], Turkish[35]	Revised version (19 items)[74]
24. Pain Beliefs & Perceptions Inventory (PBPI)[195] ***(1989)***	Beliefs	Workers with chronic pain	English	16 items, Likert scale format, total score -32 to 32 with higher scores indicating greater endorsement of beliefs.	Chinese[197], Czech[92], French[36], Greek[33], Italian[116], Portuguese[7], Russian[63].	
25. Pain Beliefs Questionnaire (PBQ)[49] ***(1992)***	Beliefs	General Public	English	20 items, Likert scale format, includes two subscales, higher scores indicating a higher attribution of organic or psychological causes of pain.	Turkish[13]	Pediatric version[168]
26. (Paediatric) Pain Beliefs Questionnaire (PPBQ)[189] ***(2005)***	Beliefs	Children with abdominal pain	English	32 items, Likert scale format, higher scores reflective of more frequent cognitions	Dutch[182]	Short form[168]

Table 1. continued

Name of Instrument *(year of introduction)*	Construct	Target population	Primary Language	Scoring	Published translations	Alternate versions
27. Pain Belief Screening Instrument (PBSI)[159] ***(2007)***	Beliefs	Patients in primary care	English	7 items, 0-10 rating scales, each item scored seperately with higher scores indicating higher levels of fear-avoidance, catastrophisation and self-efficacy.	Swedish[160]	
28. Pain Concepts Questionnaire (PCQ) [129] ***(2021)***	Beliefs	Low Socioeconomic populations	English	23 items, Likert scale format, includes two subscales assessing biomedical and biopsychosocial orientations.		
29. Pain Knowledge Questionnaire for Children (PKQ-CH)[188] ***(2018)***	Knowledge	Children	German	20 items, multiple choice format, total scores 0 to 20 with higher scores indicating higher knowldge.		
30. Patients' Endorsement of a Biopsychosocial Model of Chronic Pain Scale (PEB)[91] ***(2024)***	Beliefs	Adults with chronic pain	English	11 items, Likert scale format, total scores 11 to 44 with higher indicating higher alignment of beliefs with a biopsychosocial model of chronic pain.		
31. Pediatric Pain Knowledge and Attitudes Questionnaire (PPKAQ)[157; 179] ***(2013)***	Attitudes, knowledge	Health professionals	Original Finnish version validated as a scale in English	73 items, Likert scale & true/false, five subscales (attitudes, physiology, non-drug treatment, drug treatment, sociology & psychology).	Arabic[162], English[179], Dutch[199], Turkish[180]	
32. Survey of Pain Attitudes (SOPA)[81] ***(1987)***	Attitudes	General Public	English	24 items, Likert scale format, five subscales (pain control, medical cure, solicitude, medication, disability).	Chinese[196], French[67], Greek[32], Icelandic[134] Portuguese[144], Quebec French[47], Spanish[115]	SOPA-R (35 items, 6 subscales)[80], SOPA-57 (57 items, 7 subscales)[84], SOPA-B (30 items, 7 subscales)[172], SOPA-35 (35 items, 7 subscales)[83], Short versions (7/14 items, 7 subscales)[82], pediatric version (Peds-SOPA)[55]

Table 2. Instrument psychometrics

Measurement Instrument†	Reliability		Validity				Responsiveness
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT	
1. Attitudes to back pain scale in musculoskeletal practitioners (ABS-mp), 19 items [145]	-	-	Face validity on practitioners	-	EFA (n = 200): 4 components Personal interaction attitudes R^2 = 56.2% 2 components treatment orientation R^2= 56.4% CFA (n = 256): RMSEA = 0.056, CFI = 0.87, GFI = 0.91, AGFI = 0.88	-	-
2. Back Beliefs Questionnaire (BBQ), 14 items, 9 scored [18; 58; 171]	α = .70 (n = 158) α = .75 (n = 7201)	ICC = .87 (n = 158)	-	-	EFA (n = 7201): 3 components R^2 = 28% CFA (n = 3143 / 3051) CFI = 0.93 RMSEA = 0.05 SRMR = 0.03	-	-
3. Back Pain Attitudes Questionnaire (Back-PAQ), [39; 93]	34 items: α = .70 (n = 526) / .91 (n = 126) 10 items: α = .61 (n = 526)	34 items: ICC = .84 (.76 - .89) SEM = 3.94 SDC_{90} = 1.69 (n = 126)	Interviews with patients for item creation. Face validity in patients and experts.	34 items: FABT: r = .51 HC-PAIRS: r = -.62 TSK-HC: r = -.58 (n = 126)	EFA (n = 526): 34 items: KMO = 0.71 11 components R^2 = 60% 10 items: 5 components R^2 = 74%	20 items: Rash analysed & transformed (n = 600 & n = 184) PSI = .79	-

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT	
4. Back pain Knowledge and beliefs Survey (BacKS), 20 items, [34]	Total; α: .94 Biomedical .91 Self-Care .84 (n = 209)	Total ICC .86 (.83 to .89) Biomedical ICC .84 (.80 to .88) Self-Care ICC .73 (.66 to .79) (n = 208) SDC = 4.4 (biomedical) and 7.0 (self-care), total 8.9 SEM = Total 3.2, Biomedical 1.6, Self-care 2.5	Creation with previous Delphi, focus groups with experts and consumers. Face validity with focus groups with consumers on relevance, comprehensiveness and comprehensibility	r = .53 with BBQ total	EFA (n = 258): KMO = .809 2 components Convergent validity with BBQ, r = .53	-	-
5. Beliefs about pain control questionnaire (BPCQ), 13 items, [164]	α = .56 - .82 (n = 281)	-	-	-	-	-	-
6. Biopsychosocial Pain Concept Matrix (BiPS matrix), 31 items, [192; 193]	α = .86 (n = 26)	-	Interviews with children, online survey with children on readability and understandability	-	-	-	-
7. Chronic pain myths scale (CPMS), 26 items, [96; 108]	α = .72-.82 (n = 1555) α = .67 - .86 (n = 482)	-	Face validity in pain experts, divergent validity in general population including patients Face validity also on student nurses	-	EFA (n = 1555); KMO = 0.89, 0.84 3 components R^2 = 16% R^2 = 34% ceiling/floor effects A priori hypotheses are met	-	-

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness	
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT		
8. Concept of Pain Inventory (COPI), 14 items, [140]	α = .78 (n = 124)	ICC = .55 (95% CI: .37 - 68) (n = 124) SDC = 12.7	Face validity with experts Readability, understandability and appropriateness with children	Pain intensity: r = -.21 Disability: r = -.19 PCS: r = .05 Fear of pain: r = .15 Avoidance: r = -.01	EFA: 1 factor	-	-	
9. Concept of Pain Inventory for Adults (COPI-Adult), 13 items, [141]	α = .78 (n = 502)	ICC = .84 (.71-.91) (n = 45) SDC = 3.4	-	RNPQ: r = .55 (n = 502)	EFA: 1 factor	-	-	
10. Conceptualization of Pain Questionnaire (COPAQ), 15 items, [158]	PSI = 0.814 (n = 324)	-	-	-	Rasch analysed (n = 324) PSI = 0.814	-	-	
11. Essential Knowledge of Pain Questionnaire (EKPQ), 22 items, [10]	α = .784 (n = 32)	-	Face validity with two experts	Correlation with rNPQ-D, r = .618 (n = 32)	-	-	-	
12. General Attitudes Towards Pain Inventory (GATPI), 48 items, [184]	α = .59 - .87 (n = 362)	r = .59 - .83 (n = 99)	Face validity in experts	-	EFA & CFA; 10 factors Convergent validity with Pain Sensitivity Questionnaire, Coping Strategies Questionnaire, Pain Appraisal Inventory at subscale levels reported.	-	-	

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness	
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT		
13. Health Care Providers' Pain and Impairment Relationship Scale (HC-PAIRS), 15 items, [14; 22; 75; 104; 117; 149]	α = .78 (n = 144) α = .92 (n = 126) α = .84 (n = 156) α = .81 (n = 216)	ICC = .84 (n = 126) SEM = 3.75 SDC_{90} = 8.74	-	TSK-HC: r = .69 / r = .62 Back-PAQ: r = -.62 FABT: r = .70 PHODA: r = .49 (n = 126) PABS-PT (Biopsychosocial): r = -.17 PABS-PT (Biomedical): r = .53 (n = 216)	EFA (n = 144): 4 factors R^2 = 56% (n = 156) 1 factor A priori hypotheses were met	-	-
14. Implicit Theory of Pain (ITPS), 8 items, [170]	α = .90	-	-	-	Convergent validity with the SOPA Control scale, r = .718, p < .01	-	-
15. Inventory of Attitudes towards Pain -Professionals (IAD Professionals), 20 items, [62]	α = .567 - .807 (n = 75)	-	Face validity by experts	-	EFA; 6 components (n = 75)	-	-
16. Know Pain 50, 50 items, [71]	α = .77 - .85 (n=27)	-	Face validity in experts, equal to development team	-	A priori hypotheses were met	-	-
17. Knowledge & Attitudes of Pain (KNAP), 30 items, [12]	α = .80 (n = 424)	ICC = .90 (95% CI: .74 - .85, n = 156) SEM = 2.1 SDD90% = 4.99 (95% CI: 4.31 - 5.75)	Face validity in experts, comprehensibility in experts and students	PABS-PT Biopsychosocial; r = .60 PABS-PT Biomedical; r = -.58 NPQ; r = .52 (n = 424)	EFA (n = 424); KMO = 0.857 2 factors R^2 = 28.4% no floor/ceiling effects A priori hypotheses were met	Rasch analysed & transformed (n = 424) Person reliability α = .82 (modest) Item reliability α =.99 (strong) PSI = 2.15 (good) ISI = 11.82 (desirable)	MIC "improved" = 4.84 MIC "greatly improved" = 7.53 (n = 76)

Table 2. continued

Measurement Instrument†	Reliability		Validity			Responsiveness	
	Internal consistency	**Test-retest**	**Content**	**Criterion**	**Construct / Structural**	**IRT**	
18. Negative Pain Thoughts Questionnaire (NPTQ), 11 items, [187]	α = .92 (n = 65) α = .95 (n = 90)	-	-	-	PCA (n = 65); 1 component, eigenvalue >1 accounting for 67% variance PCA (n = 90) 1 component, eigenvalue >1 accounting for 70% variance	-	-
19. Neurophysiology of pain questionnaire (NPQ), [26; 183]	19 item version: PSI = .84 (n = 300) PSI = .70 (n = 294)	19 item version: ICC = .971 - .989 (n = 45)	-	-	-	Rasch analysis (n = 300) Unidimensional Rasch analysis (n = 294) 19 item version did not fit model ($\chi 2$ = 163.36, P < .001), 14 item version unidimensional ($\chi 2$ = 61.29, p = .291)	-
20. Osteoarthritis Conceptualisation Questionnaire (OACQ), 45 items, [147]	-	-	Interviews and quantitative evaluation on patients and experts, including comprehension, readability and interpretation.	-	-	-	-
21. Osteoarthritis Knowledge Scale (OAKS), 11 Items, [37; 38]	PSI = .75 (n = 642)	ICC = .81 Hip version ICC = .66 (n = 51) Knee version ICC = .85 (n = 142)	Item generation by expert Delphi and interviews with patients, including relevance, comprehensiveness and comprehensibility	-	-	Rasch analyses (n = 642) PSI = .75 Unidimensional	-

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT	
22. Pain & Impairment Relationship Scale (PAIRS), 15 items, [69; 154; 165]	α = .82	r = .66 (n = 29)	-	SIP: r = .54 WIPII: r = .27 CEQ: r = -.035: r = .54 (n = 50)	A priori hypotheses are met	-	-
23. Pain Attitudes & Beliefs Scale (PABS-PT), 36 items, [15; 20; 30; 53; 73; 127; 135; 136; 185]	Biomedical: α = .77 - .84 Biopsychosocial: α = .54 - .62	Biomedical: ICC = .81 Biopsychosocial: ICC = .65	Expert review for face validity and comprehensibility in physiotherapists and general practitioners	-	EFA and CFA: 2 factors R^2: Biomedical: 23.4%, 25.2% Biopsychosocial: 8.2%, 10% A priori hypotheses are met Discriminative validity 15/24 were met	IRT (n = 1016), Unidimensional	Biomedical: -4.4; -8.88 Biopsychosocial: 2.44
24. Pain Beliefs & Perceptions Inventory (PBPI), 16 items, [17; 111; 118; 169; 194; 195]	α = .65 - .80 (n = 96) or .67 - 78 (strong et al)	-	Informal interview with 90 chronic pain patients describing beliefs to create themes	PDI: r = .29, .16, -.07 NPRS: r = .32, .11, -.31 (n = 96)	EFA (n = 96); 3 factors R^2 = 41% A priori hypotheses are met	-	-
25. Pain Beliefs Questionnaire (PBQ), 12 items, [49; 66]	Organic; α = .73 Psychological; α = .70 (n = 294)	-	-	Correlations with MHLC, Age, Sex, Duration, Intensity, Pain-killers usage were tested, a priori hypotheses are met (n = 294)	EFA (n = 294); 2 factors, R^2 = 82,4 %	-	-

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness	
	Internal consistency	**Test-retest**	**Content**	**Criterion**	**Construct / Structural**	**IRT**		
26. (Paediatric) Pain Beliefs Questionnaire (PPBQ), 18 items, [189]	Problem-focused α = .82 Emotion-focused: α = .76 (n = 133) Problem-focused: α = .79 Emotion-focused: α = .79 (n = 871)	r = .75 - .77 (n = 300)	-	Internal subscale vs parent scale correlation was tested, a priori hypotheses are met	A priori hypotheses on subscales are met	-	-	
27. Pain Belief Screening Instrument (PBSI), 7 items, [1; 45; 159; 160]	-	-	-	PDI, TSK, SES, CAT: r = .50-.80 (n=93)	PCA (n = 215) for item selection. Cluster analysis (n = 93); 2 subgroups, (k = .61, p < .001)	-	-	
28. Pain Concepts Questionnaire (PCQ) in Low SES, 23 items, [129]	Total: α = .73 BM: α = .74 BPS: α = .74 (n = 156)	-	-	PCS: r = .22 Pain intensity: r = .13 Correlations with CES-D, disability, BPI-Interference were tested, a-priori hypotheses are met (n = 156)	EFA (n = 156); 2 factors, R^2 = 25.6%	-	-	
29. Pain Knowledge Questionnaire for Children (PKQ-CH), 20 items, [188]	-	-	Face validity by experts and patients	-	-	-	-	

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness	
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT		
30. Patients' Endorsement of a Biopsychosocial Model of Chronic Pain Scale (PEB), 11 items, [91]	α = .92 (n = 199)	-	Face validity with experts and patients in development phase.	Convergent: PSOCQ Precontemplation; r = -.164 PSOCQ contemplation; r = .541 PSOCQ action-maintenance; r = .509 Divergent: Pain intensity; r = -.079 Pain interference; r = -.063 BSI Anxiety; r = .459 BSI Depression; r = .366	EFA (n = 199); unidimensional, R^2 = 51,2% Distinction between 2 clusters of participants: Hedge g = 0.77 – 1.63 on 3 subscales PSOCQ, Hedge g = 0.74 on pain self-management EFA (n = 186); 1 factor, R^2 = .509 Convergent validity with Pain Stages of Change Questionnaire, Precontemplation; r = -.164, Contemplation; r = .541, Action-Maintenance; r = .509 (n = 197)	-	-
31. Paediatric Pain Knowledge and Attitudes Questionnaire (PPKAQ), 73 items, [142; 179]	α = .70 - .82 (n = 20)	Knowledge; r = .54, Attitudes; r = .44 r = .7 (n = 20) ICC = .938 (n = 5)	Single expert first, five paediatric experts in second phase Content validity index >0.90 of revised version	-	-	-	-	

Table 2. continued

Measurement Instrument†	Reliability		Validity				Responsiveness
	Internal consistency	Test-retest	Content	Criterion	Construct / Structural	IRT	
32. Survey of Pain Attitudes (SOPA), 57 items (most cited version), [83; 84; 172]	α: .70 - .84 (n = 126) α: .71 - .81 (n = 241) α: .64 - .79 (n = 395)	r: .73 - .81 (n = 111)		Correlations with CES-D, Disability, Physician visits, Chronic Pain Coping Inventory were tested, a-priori hypotheses are met.	A priori hypotheses are met	-	-

Notes: †References provided for psychometric data. Reliability; α; Cronbach's α. Abbreviations - ICC – Intraclass Correlation, SEM – Standard Error of Measurement, SDC – Smallest Detectable Chance. Validity; EFA; Exploratory Factor Analysis, CFA; Confirmatory Factor Analysis, PCA; Principal Component Analysis, SRMR; Standardized Root Mean Squared Residual, KMO; Kaiser-Meyer-Olkin. Responsiveness; MIC; Minimal Important Change. Item Response Theory; RMSEA; Root Mean Square Error of Approximation, CFI; Comparative Fit Index, GFI; Goodness-of-Fit Index, AGF; Adjusted Goodness-of-Fit Index, ISI; Item Separation Index, PSI ; Personal Separation Index-, Questionnaires; FABT; Fear-Avoidance Beliefs Tool, TSK-HC; Tampa Scale of Kinesio phobia – Health Care Version, PCS; Pain Catastrophizing Scale, rNPQ-D; Revised Neurophysiology of Pain Questionnaire – Dutch Version, PHODA; Photograph Series of Daily Activities, SIP; Sickness Impact Profile, WIPII: Waddell Physical Impairment Index, CEQ: Cognitive Errors Questionnaire, BDI: Beck Depression Inventory , NPRS; Numeric Pain Rating Scale, MHLC; Multidimensional Health Locus of Control, PDI; Pain Disability Index , CAT; Catastrophizing subscale in the Coping Strategies Questionnaire, CES-D; Center for Epidemiologic Studies Depression Scale, PSOCQ ; Pain Stages of Change Questionnaire, SES; Self-efficacy Scale. SES: Socioeconomic Status

Domains related to distal pain-related characteristics

We categorized domains as (1) process outcome domains and (2) impact outcome domains (see Table 3).

Table 3. Distal outcome domains categorized as process or impact focused.

Process outcome domains	Impact outcome domains
• Pain self-efficacy • Attitudes to exercise and activity • Fear of movement or kinesiophobia • Maladaptive pain behaviours • Pain catastrophizing or worry • Expectations • Health literacy • Communication preferences • Stigma • Resilience	• Pain intensity • Pain interference • Pain frequency • Physical activity/function • Emotional wellbeing/distress • Fatigue • Sleep quality • Satisfaction with social roles and activities • Productivity • Health-related quality of life • Perception of treatment goal achievement • Opioid misuse risk • Medication use • Healthcare utilization • Cost-effectiveness

Process outcome domains refer to mechanisms of conceptual change that PSE-targets to influence health outcomes. These variables help explain why and how PSE leads to intended effects on impact outcomes. Several process variables have been identified (Table 3) such as pain self-efficacy, attitudes to exercise and activity, fear of movement or kinesiophobia, and pain catastrophizing or worry. Several papers have begun to investigate mediator variables for PSE, but findings are limited currently. Here are two studies: Murillo et al. [126] – found that reductions in kinesiophobia and distress mediated improvements in Health related qualify of life (HRQOL) in primary care patients with spinal pain while pain catastrophizing did not; Van Bogaert et al. [181] – found that pain catastrophizing mediated the effect of PSE on quality of life (QOL) after surgery while pain sensitivity and pain cognitions did not. For example, Lee et al. [102] found that catastrophizing did not mediate the effect of pain knowledge acquisition on change in pain or function. These outcome domains, as listed in Table 3, overlap and align with core outcome sets created for chronic pain.

Discussion

We identified 32 instruments that assessed pain-related knowledge, attitudes, and/or beliefs, but data on their psychometric properties were often absent. Since most instruments had not been analyzed using Item Response Theory (IRT), it was not possible to assess their ability to provide precise and reliable measurements based on item difficulty and discrimination of individual test items.

As expected, older and more widely utilized instruments have undergone more extensive validation than recently developed ones. While newer instruments are generally better aligned with the COSMIN-development guidelines (published first in 2010), they are less studied and consequently lack analysis of multiple components. In terms of content, instruments focusing on low back pain are relatively common, whereas condition-specific instruments, for example specific to cancer or neuropathic pain, are notably absent. Additionally, most instruments target adult populations, with only one designed for children and none for elderly individuals. Health literacy considerations were incorporated in only one instrument, the Pain Concepts Questionnaire (PCQ). Negating health literacy [78], which may influence the comprehensibility of complex wording in items, could lead to non-valid results of a questionnaire [31; 161].

Providing specific recommendations about which instruments are best is beyond the scope of this work – readers are referred to Table 1 and 2 to determine the instruments that seem best suited to their question and context - the availability of psychometric data and the target populations are not the only considerations. For example, users are urged to review the content of the instruments because the pain sciences are a continually advancing field and much has been learnt in recent years. In fact, the changes in content that have been generated by extensive consultation with recovered consumers [99; 100; 106; 123; 139] were considered substantial enough to warrant the new term PSE [122]; older instruments may have been thoroughly interrogated but may not necessarily align with current scientific understanding of pain and consumer-generated notions of concepts that are important to learn. Hopefully, in time, the more recently developed instruments will be more thoroughly evaluated.

This paper underscores the need for standardized, psychometrically robust instruments to evaluate PSE outcomes. Incorporating contemporary frameworks, such as COSMIN guidelines and IRT-approaches, alongside diverse population considerations, will enhance the utility and applicability of PSE-assessments. Improved measurement strategies will further elucidate the mechanisms underlying conceptual change and optimize PSE interventions, and thus outcomes.

Considerations about assessing pain reconceptualization

Most of the work in the PSE-field has been undertaken within the clinical setting focusing upon participants with persistent pain in the patient role. Thus, most instruments we found are targeted towards this group, and their psychometric properties have been explored within this context. More recently, the role of PSE within a public health setting has been highlighted [156] and PSE-informed public health initiatives such as Pain Revolution (painrevolution.org) and Flippin' Pain (flippinpain.co.uk) are being implemented. It will be important to ensure that appropriate outcome assessments, supported by robust psychometric evidence, exist to explore change in this non-clinical context where people with and without pain are targeted. In this 'general public' setting, it will be important to ensure that the items of instruments are sufficiently generic to accommodate people with pain of any kind, as well as those without pain. Moreover, any assessment will need to be sufficiently brief and simple to administer within a public health setting.

When assessing conceptual change or pain reconceptualization, here seen as an overarching concept containing multiple outcomes, the literature has predominantly taken a quantitative approach. Several questionnaires have been developed to assess pain related understanding (Table 1). Such questionnaires have the advantage of being quick to administer and interpret, minimizing patient and therapist/research burden, while also quantifying conceptual change, thus allowing statistical analysis of conceptual change within a positivist framework such as randomized controlled trials. However, there are limitations to such an approach. First, the validity of such measures is challenging to elucidate. This is because conceptualization is complicated [148], and pain reconceptualization more so - a multifactorial phenomenon, that lacks a clear and uncontested definition, and for which no gold standard measure exists: one instrument might be unlikely to access the full scope of someone's 'understandings of things'. We would also argue that a person's ideas around pain cannot be fully understood outside of their lived experience of it and the impact it has on their life. Perhaps the utility of these instruments rests primarily in the assessment of conceptual change at the 'Remember' level (see Table 1) of Blooms Taxonomy [94]. This level is comparable with the 'Passive' learning category of ICAP

[29] insofar as the learner can recognize desired responses but not have integrated it into their deeper conceptualizations. That PNE primarily involves passive learning strategies, but PSE includes active, constructive and inventive/interactive strategies [148] (akin to understand/apply/analyze levels on Bloom's Taxonomy), raises the possibility that qualitative methods may be required to assess changes in the latter. That is, an individual may perform well on a multiple-choice questionnaire with incomplete understanding of a concept, without believing that the concept applies to them, or without undergoing any behavioral change. Another consideration is that it is possible for an individual to simultaneously and comfortably hold two opposing views of the same concept, which is extremely difficult for a questionnaire to handle, a phenomenon which has been clearly demonstrated within the field of pain reconceptualization [90; 155]. An example of this is seen in a participant who simultaneously considered that their pain was tissue-related and caused by hevigheden sensitivity [155]. Such scenarios may also accurately reflect a clinical presentation involving both nociceptive and nociplastic pain contributions.

Taking a qualitative approach to assessing conceptual change may, at least in part, address these limitations. Undertaking interviews to explore understanding at a deeper level has long been highlighted within the conceptual change literature as a potentially powerful instrument for "*capturing what is hidden behind the immediate appearance of things*" [146]. Explicit and implicit perspectives on pain do not necessarily align [24], which may contribute to ambivalence and inconsistencies in how one interprets and potentially reconceptualizes their pain during PSE [121; 128; 191]. Providing HCPs with opportunities to listen to patient narratives creates space for transformative learning, shifting from a biomedical approach to a biopsychosocial, person-centered approach that promotes self-management [8; 76]. Guided reflection, with empathy and respect, can encourage participants to re-examine their beliefs and attitudes at a deeper level than didactic information provision alone might provide [121; 122]. Incorporating both quantitative and collaborative qualitative assessments aligns the evaluation of PSE with a person-centered approach [11].

Ultimately, how one approaches assessment of PSE depends on the objective and context. For example, in a research setting, assessment needs to answer the question being asked and may require a mixed-methods approach; in a clinical setting, deeper and more nuanced understanding might be gleaned from clinical interview and supplemented with a short and valid quantitative instrument. Consideration should always be given to the population being studied and the resource challenges within the specific setting. This work clearly illustrates that although many instruments are relevant, most have not been replicated or thoroughly evaluated psychometrically.

Deep consideration of the intent to assess concepts held by patients means that even the best instrument is unlikely to be perfect.

Strength and Limitations

This study employed a broad methodology, incorporating both narrative and rapid review approaches, alongside supplementary techniques such as double reference checking, social media consultation and expert panel consultations. These strategies aimed to minimize the risk of omitting relevant instruments and enhance the comprehensiveness of the findings. The inclusion of both proximal and distal domains and integrating this with an exploration of psychometric properties, strengthens the utility of the study by helping users identify instruments aligned with their specific needs.

There are also limitations. While the narrative and rapid review approaches allow for flexibility and efficiency, they lack the rigor and structured quality assessment characteristic of systematic reviews. We chose our approach over a full systematic review for pragmatic reasons. The work was unfunded and thus the team lacked the extensive time and resources to generate a full systematic review in a timely fashion and felt that such an approach would add little to the utility of the findings. We were able instead to quickly draw on the content knowledge of a wide network of researchers and clinicians and we assume that this provided a comprehensive account of the field. Importantly however, this assumption is not verifiable, and it remains possible that a full systematic review approach may have identified other candidate instruments. Last, the lack of pre-registration, a recommended practice in pain research [101], would have enhanced transparency of reporting.

Language and cultural representation also posed challenges. Most instruments identified were developed in English, though published translations and cross-cultural adaptations have been included where available. Where translations exist, quite often they have not been psychometrically evaluated. Until then, users working with non-English-speaking populations must rely on translations of instruments that were evaluated in their original form. We did not include appraisal of the process by which instruments were translated, and this remains a limitation of this work.

Finally, while some instruments have been adapted or shortened to reduce respondent burden, these variations are not comprehensively addressed in this review. Users are advised to carefully consider the intended application of the instruments and weigh the suitability of longer versus shorter versions, in relation to the burden of the participants and the resources available for analysis and interpretation. References

provided in the accompanying tables serve as a resource for further exploration and selection based on specific research or clinical needs.

Recommendations and future directions

This review provided the currently available assessment instruments and their psychometric properties for assessing the effects of PSE. No specific recommendations can be given about which instrument should be used, due to the differences in their aim and the population and setting in which the instrument will be used. In addition to the theoretical and scientific considerations, instruments should be chosen with consideration of practical issues such as the time and burden they bring for patients/participants to complete, and health professionals to collect and interpret, and what, exactly, the user wishes to know.

We acknowledge that there are gaps in our understanding of how best to capture pain-related knowledge and understanding, attitudes and beliefs, and whether these assessments are relevant in non-affluent, low health literacy or culturally diverse populations [11; 16; 151]. By using these instruments alongside questionnaires that retrieve information about key moderators and mediators, we can collectively increase our data pools to enable deeper understanding of what works for whom, when and in which context and get a tighter understanding of which concepts most directly track to distal impact outcomes like pain and disability.

Researchers evaluating the effectiveness of PSE or clinicians working with people with pain can use this resource to help them identify instruments that suit their purpose. It is important to note that here we have presented the instruments' characteristics and psychometric properties objectively and have deliberately refrained from recommending which instruments should be used. In line with COSMIN recommendations, researchers intending to use these instruments should firstly assess the studies and instruments comprehensively.

There is a pressing need for consistent use of the best instruments for given purposes, across research and clinical contexts. The most widely used instruments are not necessarily the most 'fit for purpose', but more research is required to identify which instruments are. New instruments are clearly required and there are processes by which development might best be guided [148]. Furthermore, health literacy considerations are important to ensure instrument accessibility and usability across diverse populations and under-served groups, which are often least well served by health education interventions [88]. Additionally, there is a need to create instruments tailored to specific target groups, such as pediatric and elderly populations, as well as

for specific conditions such as cancer pain, neuropathic pain and pelvic pain. Finally, very little is known about the social context in which participants in PSE and other pain studies live. This means it is difficult to know how different instruments will work among the most vulnerable. The international research collaboration undertaking the ISSHOOs project (isshoos.org) has identified the clear need to fill that gap [88; 89] and is creating a global consensus-based minimum social context data set for inclusion in all human pain research [86; 87]. This initiative may be particularly important for pain education research.

Instrument development should adhere to COSMIN guidelines, emphasizing the importance of appropriate sample sizes and the application of advanced techniques such as item response theory. This approach will enhance the methodological rigor and psychometric robustness of newly developed instruments, ensuring their relevance and reliability in both research and clinical contexts.

Conclusion

Pain Science Education has evolved from PNE away from didactic delivery of scientific pain information towards a more interactive, pedagogical theory informed, co-construction of pain understanding between the educator and the learner. Traditionally used within the clinical setting, more recently it has been utilized within public health initiatives as a strategy to change pain related culture amongst entire communities and encourage a more biopsychosocial approach to persistent pain prevention and management. PSE purports to work by facilitating pain reconceptualization. Being able to assess pain reconceptualization is important so that we can understand if and how it works, and how we might tailor it to optimize its benefits. This paper identifies the key assessments that currently target pain understanding, beliefs, and attitudes, with the intent of helping clinicians and researchers using PSE to choose the optimal instruments for their assessment needs. Combining existing instruments with qualitative interview in a mixed-methods approach may be required to assess conceptual change in depth. However, such an approach may not always be feasible. More psychometrically robust assessments of conceptual change, that are easy and quick to complete, and sufficiently flexible to use with multiple populations, would make a significant contribution to the PSE-field.

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Supplementary materials 1- SANRA

https://researchintegrityjournal.biomedcentral.com/articles/10.1186/s41073-019-0064-8

1) Justification of the article's importance for the readership

a. The importance is not justified
b. The importance is alluded to, but not explicitly justified
c. The importance is explicitly justified

2) Statement of concrete aims or formulation of questions

a. No aims or questions are formulated. 0
b. Aims are formulated generally but not concretely or in terms of clear questions. 1
c. One or more concrete aims or questions are formulated. 2

3) Description of the literature search

a. The search strategy is not presented. 0
b. The literature search is described briefly. 1
c. The literature search is described in detail, including search terms and inclusion criteria. 2

4) Referencing

1. Key statements are not supported by references. 0
2. The referencing of key statements is inconsistent. 1
3. Key statements are supported by references. 2

5) Scientific reasoning (e.g., incorporation of appropriate evidence, such as RCTs in clinical medicine)

1. The article's point is not based on appropriate arguments. 0
2. Appropriate evidence is introduced selectively. 1
3. Appropriate evidence is generally present. 2

6) Appropriate presentation of data (e.g., absolute vs relative risk; effect sizes without confidence intervals)

1. Data are presented inadequately. 0
2. Data are often not presented in the most appropriate way. 1
3. Relevant outcome data are generally presented appropriately. 2

Item 1 – Justification of the article's importance for the readership
Justification of importance for the readership must be seen in the context of each journal's readership. Consider how well the manuscript outlines the clinical problem and highlights unanswered questions or evidence gaps – thoroughly (2), superficially (1), or not at all (0).

Item 2 – Statement of concrete/specific aims or formulation of questions
A good paper will propose one or more specific aims or questions which will be dealt with or topics which will be reviewed. Please rate whether this has been done thoroughly and clearly (2), vaguely or unclearly (1), or not at all (0).

Item 3 – Description of the literature search
A convincing narrative review will be transparent about the sources of information on which the text is based. Please rate the degree to which you think this has been achieved. To achieve a rating of 2, it is not necessary to describe the literature search in as much detail as for a systematic review (searching multiple databases, including exact descriptions of search history, flowcharts, etc.), but it is necessary to specify search terms, and the types of literature included. A manuscript which only refers briefly to its literature search would score 1, while one not mentioning its methods would score 0.

Item 4 – Referencing
No manuscript references all statements. However, those that are essential for the arguments of the manuscript – "key statements" – should be backed by references in all or almost all cases. Exceptions could reasonably be made for rating purposes where a key statement has uncontroversial face-validity, such as "Diabetes is among the commonest causes of chronic morbidity worldwide." Please rate the completeness of referencing: for most or all relevant key statements (2), inconsistently (1), sporadically (0).

Item 5 – Scientific reasoning
The item describes the quality of the scientific point made. A convincing narrative review presents evidence for key arguments. It should mention study design (randomized controlled trial, qualitative study, etc), and where available, levels of evidence. Please rate whether you feel this has been done thoroughly (2), superficially (1), or hardly at all (0). Unlike item 6, which is concerned with the selection and presentation of concrete outcome data, this item relates to the use of evidence and of types of evidence in the manuscript's arguments.

Item 6 – Appropriate presentation of data

This item describes the correct presentation of data central to the article's argument. Which data are considered relevant varies from field to field. In some areas relevant data would be absolute rather than relative risks or clinical versus surrogate or intermediate endpoints. These outcomes must be presented correctly. For example, it is appropriate that effect sizes are accompanied by confidence intervals. Please rate how far the paper achieves this – thorough goingly (2), partially (1), or hardly at all (0). Unlike item 5, which relates to the use of evidence and of types of evidence in the manuscript's arguments, this item is concerned with the selection and presentation of concrete outcome data.

Supplementary materials 2 - List of instruments phase 1 and 2

Instruments	Included
Phase 1 identification	
Attitudes to Back Pain Scale in Musculoskeletal Practitioners (ABS-mp)	I
Back Beliefs Questionnaire (BBQ)	I
Back Pain Attitudes Questionnaire (Back-PAQ)	I
Beliefs about Pain Control Questionnaire (BPCQ)	I
Biopsychosocial Pain Concept Matrix (BiPS matrix)	I
Brief Illness Perceptions Questionnaire *[3]*	
Chronic Pain Acceptance Questionnaire (CPAQ) *[14]*	
Clinical Pain Knowledge Test *[2]*	
Concept of Pain Inventory (COPI)	I
Concept of Pain Inventory for Adults (COPI-Adult)	I
Conceptualization of Pain Questionnaire (COPAQ)	I
Emotional Intelligence Scale *[18]*	
Experience of Cognitive Intrusion of Pain Scale (ECIP) *[1]*	
Fear Avoidance Belief Questionnaire (FABQ) *[23]*	
Health Care Providers' Pain & Impairment Relationship Scale (HC-PAIRS)	I
Knowledge & Attitudes of Pain (KNAP)	I
Knowledge & Attitudes Survey Regarding Pain (KASRP) *[7]*	
Low Back Pain Treatment Beliefs Questionnaire (LBP-TBQ) *[6]*	
Metacognitions Questionnaire (MCQ) *[5]*	
Neurophysiology of Pain Questionnaire (NPQ)	I
Osteoarthritis Conceptualisation Questionnaire (OACQ)	I
Pain Attitudes & Beliefs Scale (PABS)	I
Pain Beliefs Questionnaire (PBQ)	I
(Paediatric) Pain Beliefs Questionnaire (PPBQ)	I
Pain Catastrophizing Scale (PCS) *[21]*	
Pain Knowledge and Beliefs Questionnaire (PKBQ) *[9]*	
Pain Metacognitions Questionnaire (PMQ) *[19]*	
Pain Knowledge Questionnaire for Children (PKQ-CH)	I
Pediatric Pain Knowledge & Attitude Questionnaire (PPKAQ)	I
Rehabilitation Professionals' Knowledge & Attitudes Survey Regarding Pain (City of Boston) *[17]*	
Survey of Pain Attitudes (SOPA)	I
Worry About Pain Questionnaire (WAPQ) *[11]*	

Phase 2 identification	
Arthritis Self-Efficacy Scale [12]	
Attitude toward Education and Advice for Low Back Pain (AxEL) [15]	
Back Pain Knowledge and beliefs Survey (BacKS)	I
Chronic Pain Cognition Scale (CPCS) [25]	
Chronic Pain Myths Scale (CPMS)	I
Essential Knowledge of Pain Questionnaire (EKPQ)	I
General Attitudes Towards Pain Inventory (GATPI)	I
Healthcare Professionals' Attitudes towards Patients with Chronic Pain (HCPAPCP) * *[4]*	
Implicit Theory of Pain Scale (ITPS)*	I
Inventory of Attitudes towards Pain-Professionals	I
Know Pain 50	I
Knowledge & Beliefs About Pain in the Elderly with Dementia *[27]*	
Health Care Professionals' Attitudes towards Patients with Chronic Pain (HCPAPCP) [4]	
Low Back Pain Knowledge Questionnaire (LKQ) *[13]*	
Negative Pain Thoughts Questionnaire (NPTQ)	I
Osteoarthritis Knowledge Scale (OAKS)	I
Pain & Impairment Relationship Scale (PAIRS)	I
Pain Attitudes Questionnaire (PAQ) [26]	
Pain Belief Screening Instrument (PBSI)	I
Pain Beliefs & Perceptions Inventory (PBPI)	I
Pain Concepts Questionnaire (PCQ)*	I
Pain Information & Beliefs Questionnaire (PIBQ) * *[20]*	
Pain Perception Questionnaire for Young People (PPQ-YP) *[8]*	
Pain Stages of Change Questionnaire (PSOCQ) [10]	
Pain Understanding and Confidence Questionnaire (PUnCQ) [22]	
Patients' Endorsement of a Biopsychosocial Model of Chronic Pain Scale (PEB)	I
Pharmacist Knowledge of Chronic Pain Survey *[16]*	
Traumatic Injuries Distress Scale (TIDS) [24]	

Note: * denotes tools identified in Google Scholar search of studies citing the original tool development papers.

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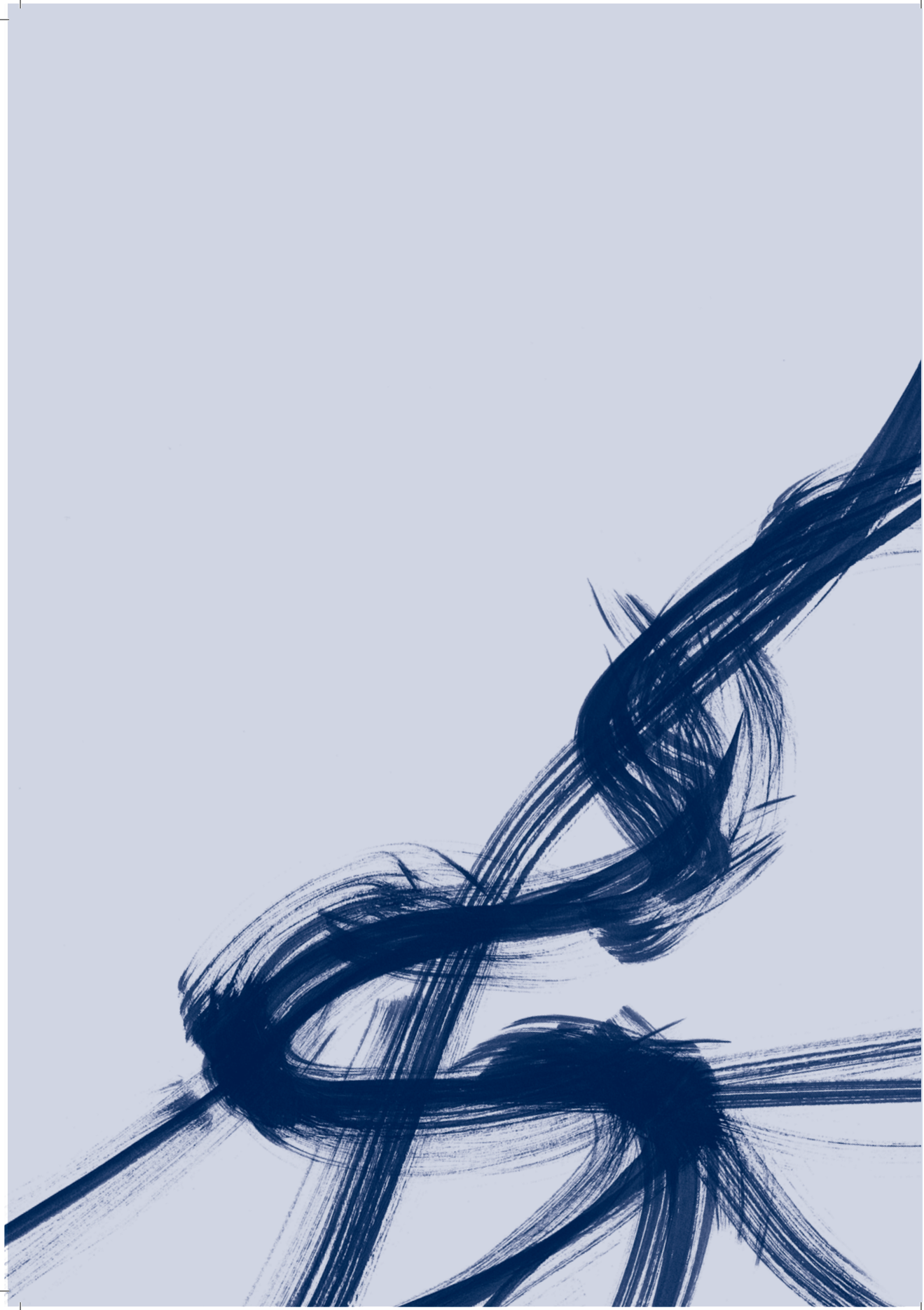
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CHAPTER 4

Knowledge and attitudes toward musculoskeletal pain neuroscience of manual therapy postgraduate students in the Netherlands

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Abstract

Background: Health care practitioners' knowledge and attitudes influence patients' beliefs and health outcomes in musculoskeletal (MSK) pain. It is unclear to what extent physiotherapists undertaking a postgraduate master in manual therapy (MT students) possess the knowledge and attitudes toward pain neuroscience to be able to apply the biopsychosocial model in patients with MSK pain.

Objectives: The aim of this study was to assess the knowledge and attitudes toward pain neuroscience in MT students.

Design: A cross-sectional study.

Method: Self-reported knowledge and attitudes were measured among students (n=662) at baseline and in all years of the MT postgraduate programs in the Netherlands. The Knowledge and Attitudes of Pain questionnaire (KNAP) was used as a primary measure. Difference in KNAP-scores between baseline (0), year 1, year 2 and year 3 was tested using a one-way ANOVA (hypothesis: 0<1<2<3). A two factor ANOVA was used to determine the interaction effect of focused pain education and year in the curriculum with KNAP.

Results: There was an overall significant difference of KNAP scores with a medium effect size ($F(3, 218.18)=13.56$, $p<.001$, $\omega^2=.059$). Differences between years ranged from small to medium. Interaction effect of knowledge and attitudes and focused pain education was significant with a small effect size ($F(6)=2.597$, $p=.017$, $\omega^2=.012$). Sensitivity analyses were consistent with the main results.

Conclusions: Positive differences in knowledge and attitudes toward pain neuroscience in MT students occur between the progressing years of the curriculum. Differences may be related to the provision of focused pain education.

Keywords: Musculoskeletal Pain (MeSH); Pain education; Biopsychosocial; Manual therapy postgraduate students

Introduction

The burden of musculoskeletal (MSK) diseases increased significantly worldwide between 2000 and 2015 and is substantially higher in Europe than on all other continents.[1] Many persistent musculoskeletal pain conditions and their multifactorial biopsychosocial origins are resistant to biomedically oriented diagnostics and treatment including medical imaging, pharmacological treatments, and surgical procedures.[2–8] The majority of persistent MSK pain cannot be adequately explained from an impairment of a peripheral structure.[6,9,10] Musculoskeletal physiotherapists, known as manual therapists in the Netherlands, have received extensive training in the MSK domain; however, they are traditionally dominantly educated in biomedical pain models that describe tissue pathology as a source of nociceptive input directly linked with pain expression.[11] This model is insufficient for explaining chronic MSK pain and forms a barrier for optimal biopsychosocial assessment and management.[12–21]

Health care practitioners' (HCP) biomedical attitudes regarding MSK pain negatively influence patients' beliefs, and this may lead to unnecessary avoidance of physical activities and negative health outcomes.[19–30] The multidimensional nature of persistent pain and the complex interactions of complementary mechanisms that can contribute to manual therapy (MT) treatment effects, must be recognised.[10,20,31,32] Additionally, manual therapists need to be able to apply the biopsychosocial model.[20,33–35] Identifying their beliefs about MSK pain is relevant due to their influence in encouraging patients to reconceptualise pain as safe and non-threatening. Evidence suggests effectiveness of combining movement-based therapy interventions such as exercising and interventions with patient-centered pain neuroscience education (PNE).[7,9,18,32,35–40] PNE is a cognitive-oriented intervention that teaches people about pain biology and physiology and de-emphasises the issues associated with the anatomical structures.[17,41–44] The International Association for the Study of Pain (IASP) suggests that HCPs should develop thorough pain knowledge and understanding of the biopsychosocial management approach and how HCPs may impact an individual when providing effective pain management.[33,45]

Studies suggesting the negative influence of biomedical attitudes and beliefs of HCPs toward patients have included physiotherapists, chiropractors, osteopaths, physicians, general practitioners, rheumatologists, orthopaedic surgeons, nurses, occupational therapists, and pharmacists but not physiotherapists with postgraduate training in manual therapy.[19,20,24–30,46,47] Several studies measured growth in the knowledge of pain neurophysiology and positive attitudes toward MSK pain during the undergraduate years of a variety of healthcare curricula but not for MT.[48–54] This study contains

physiotherapists undertaking postgraduate training in manual therapy (MT students). MT students develop modern knowledge and attitudes regarding MSK pain based on educational standards of the International Federation Orthopaedic Manipulative Physical Therapists (IFOMPT)[55]. Therefore, these knowledge and attitudes need to be examined in more detail.

Manual therapists can fill out measures for assessing the therapist's knowledge and attitudes regarding persistent pain (management). The present study used the KNowledge and Attitudes of Pain (KNAP) questionnaire to evaluate HCPs' knowledge and biopsychosocial attitudes toward pain neuroscience.[56] This cross-sectional study aimed to assess the knowledge and attitudes toward pain neuroscience in physiotherapists undertaking a postgraduate master in manual therapy (MT students) at baseline and in all three years of the program. The research questions were:

1. Do the knowledge and attitudes toward pain neuroscience of MT students differ between the progressing years of the postgraduate curriculum?
2. Is the difference in the knowledge and attitudes toward pain neuroscience of MT students related to focused pain education?

Methods

Design and participants

A cross-sectional survey was conducted among all registered students of the 3-year master manual therapy programs at all six Universities of Applied Sciences in the Netherlands: Utrecht (HU), Rotterdam (HR), Breederode Hogeschool, Arnhem-Nijmegen (HAN), Enschede (Saxion), and Amersfoort (SOMT). The MT students were all physiotherapists undertaking postgraduate training in the domain of MT, based on the educational standards of the IFOMPT.[55] These standards containing learning outcomes based on the biopsychosocial framework.[57] The postgraduate program is part-time and all participants also worked clinically. Measurements were executed at the start of year 1 (baseline), at the end of year 1, at the end of year 2, and at the end of year 3 of the program. A waiver was obtained from the medical ethics committee at the University Medical Center of Groningen, indicating that formal ethical approval was not required by Dutch law (number M18.241418). All of the participants provided written informed consent prior to the beginning of the survey. The Strobe Statement was used to guide the reporting of this study.[58]

Procedures

After the explanation of the purpose and procedure, the MT students completed the survey digitally during a regular class. The students were supervised to guarantee that the results represented individual student responses. Anonymity was guaranteed, and participation was voluntary. The survey consisted of three questionnaires and demographic questions. The order of the questionnaires was randomised so that participants could not confer on answers. Participants were able to correct answers on previous pages by use of a "back" button; however, they were prevented from reentering the survey after they had clicked the "finish" button. The survey remained open for one week after class for those students who could not fully complete the survey during class. Average completion time was 12 minutes ±5. For two third-year groups, the survey was sent by email because of graduation and completion of the program.

Pain education

All six MT programs provide pain education in different ways, amounts, and times in their curriculum. All curricula managers were asked a single question referring to the pain education programming: 'If you expect a positive difference in knowledge and attitudes toward pain in the MT program, when do you expect the strongest difference? ' It was hypothesised that the most positive difference in knowledge and attitudes toward pain was observed in the year in which focused pain education was provided.

Measures

Primary measure

Knowledge and attitudes toward pain were measured with the 30-item Rasch modified KNAP[56]. Each participant indicated the extent to which they agreed to the statement on a six-point Likert scale, ranging from completely disagree to completely agree. The total score can range from 0 to 150 points. A higher score indicates knowledge and attitudes that better reflect modern pain neuroscience. Examples of statements are: 'Pain sensitivity can persist, even if there is no longer an injury or tissue damage, 'Unexplained pain is not real pain', 'Exercise is a good treatment option in persistent pain', 'Correcting poor posture reduces persistent pain'. The measurement properties of the KNAP are adequate: test-retest reliability ICC(2,1) = 0.80, internal consistency Cronbach's α = 0.80, Smallest Detectable Difference (SDD90%) = 4.99 (95%CI 4.31; 5.75), responsiveness: Minimal Important Change (MIC) = 4.84 (95%CI 2.77; 6.91).[56]

Secondary measures

The Pain Attitudes and Beliefs Scale for Physiotherapists (PABS-PT) and the Neurophysiology of Pain Questionnaire (NPQ) were added as secondary measures because there is no gold standard for assessing knowledge of and attitudes toward pain among students[59] and to enable comparability with other studies. Additionally, these measures are suitable because students are provided with general principles of pain management rather than condition-specific pain management as measured by the Health Care Providers Pain and Impairment Relationship scale (HC-PAIRS).[60] A 14-item Rasch modified version of the PABS-PT was used of which seven items belong to the biomedical (BM) subscale (subscale scores range from 7 to 40) and seven items to the biopsychosocial (PS) subscale (subscale scores range from 7 to 32).[61] Higher scores on a subscale indicate a stronger orientation. The PABS-PT showed fair methodological quality scores on the COSMIN criteria.[61,62] The internal consistency for the bio-psychosocial subscale was Cronbach's $\alpha = 0.62\text{-}0.68$ and, for the biomedical subscale, Cronbach's $\alpha = 0.77\text{-}0.84$. Test-retest reliability for the biomedical subscale was ICC = 0.81 and ICC = 0.65 for the biopsychosocial subscale.[62]

The NPQ contains 12 items relating to the neurophysiology of pain (revised 12-item NPQ).[63] The total score ranges from 0 to 12 with higher scores indicating more correct responses. The Dutch NPQ has acceptable reliability (ICC = 0.76) and internal consistency (Cronbach's $\alpha = 0.77$) for evaluating the knowledge of neurophysiology of pain in Chronic Fatigue Syndrome.[64]

Sociodemographic data of the participants included: gender, age, achieved level of education before entering the master program, work setting, years of work experience, followed course(s) concerning pain, and personal experiences with persistent pain.

Data analysis

Demographic data were described by means and standard deviations (SD). The data files were examined for missing data. Participants were excluded from analysis if one of the three questionnaires as a whole were not completed. After iterative outlier removal (IOR), data points >3 SDs from the mean difference were excluded, which yielded greater precision in the data.[65] All of the data were examined for relevant statistical assumptions. The degrees of freedom used for the F-statistic was adjusted to correct for the degree of heterogeneity, according to Welch.[66] Statistical analysis was performed utilising the IBM Statistical Package for Social Sciences (SPSS) version 24.0 (SPSS Inc, Chicago, IL). A minimum responder rate per year of 50% was deemed adequate.

For the first research question, the difference in KNAP scores between baseline (0), year 1, year 2, and year 3 was tested using a one-way ANOVA with planned comparisons, which is a method for testing specific hypotheses[67]: baseline 0 < year 1 < year 2 < year 3. Four tests were performed: 0-1, 1-2, 2-3, and 0-3. A Bonferroni correction was used to adjust for multiple comparisons. As such, a p-value of .05/4=.0125 was considered statistically significant. For the overall effect size, the Omega squared (ω^2) was used. The magnitude of this effect size is interpreted as small ≥.01, medium ≥.06, and large ≥.14. Intermediate steps of growth were calculated utilising simple effect analyses of contracts between consecutive years, reported as effect size r and interpreted as .10 to .30 as small, .30 to .50 as medium, and .50 to 1.00 as large.[68,69]
For the second research question, a two factor ANOVA was used to determine the interaction effect of focused pain education and the year in the curriculum with KNAP.

A sensitivity analysis was performed to investigate the robustness of the main results.[58] Group differences and direction were calculated for the secondary measures similar to the primary measure. Furthermore, a graphical comparison was obtained by standardising the primary and secondary measures using a Z-transformation (Z-score = [observed score–mean score of all the observation]/standard deviation of all observations). For the graphical representation, the PABS-BM was inverted to resemble the other trendlines and to assist in interpretation (a lower value represents a more psychosocial attitude). Group means and confidence intervals were mapped over each other for visual comparison and trend analysis.

Results

Study sample

In total, *N* = 670 (nearly all) MT students responded during a regular class of which *n* = 8 were excluded from analysis due to missing one of the questionnaires. The final analysis included n = 662. The response rate of two institutes was below 50% in year 3 (n = 10/162 (6%) resp. n = 5/15 (33%). The KNAP score of respondents who attended a pain course or workshop (9.5%) differed significantly (*p* = .002) from those who did not. Table 1 depicts the characteristics of the study participants.

Table 1. Characteristics of participants (n = 662).

Characteristic	Mean (SD) or n (%)
Male	424 (64.0)
Age (years)	28.2 (4.8)
Highest completed education level	
Bachelor's degree	598 (90.3)
Master's degree	59 (8.9)
Other	5 (0.8)
Work setting	
Private practice	652 (98.5)
Other	10 (1.7)
Work experience (years)	4.6 (4.0)
Attended any pain course (n/% yes)	63 (9.5)
Personally experiencing persistent pain at present (n/% yes)	253 (38.2)
Treated for persistent pain (n/% yes)	
At the moment	31 (4.7)
In the past	244 (36.9)
Having family or friends with persistent pain (n/% yes)	405 (61.2)

N; sample size, SD; standard deviation.

Difference in pain knowledge and attitudes

All KNAP scores and differences are presented in Table 2. KNAP scores positively differed significantly with a medium effect size ($F(3, 218.18) = 13.56$, $p<.001$, $\omega^2 = .059$). The difference between baseline and year 1 was small, $t(364.55) = 3.89$, $p<.001$, $r = .20$ and medium between baseline and year 3, $t(81,19) = 4.36$, $p<.001$, $r = .44$. Small non-significant differences were determined between year 1 and 2, $t(351.65)=1.58$, $p = .116$, $r = .08$ and between years 2 and 3, $t(89.95) = 0.71$, $p = .480$, $r = .07$. Researchers can use the MIC as the smallest change in what is measured that is considered to be important.[70,71] Mean difference did not exceed the MIC.[56]

Table 2: KNAP scores per year of MT program.

Year	Mean [95%CI]	p	Effect size *r*
Baseline (n = 250)	87.1 [86.3;87.9]		
Year 1 (n = 164)	89.5 [88.5;90.4]		
Year 2 (n = 192)	90.5 [89.6;91.4]		
Year 3 (n = 56)	91.2 [89,5; 92,8]		
Difference 0-3	-4,1 [-5.9;-2.3]	<.001*	.44
Difference 0-1	-2.4 [-3.6;-1.2]	<.001*	.20
Difference 1-2	-1.0 [-2.3;0.3]	.116	.08
Difference 2-3	-0.7 [-2.6;1.2]	.480	.07

KNAP; KNowlegde and Attitude of Pain, CI; Confidence Interval, *p<.0125

Difference related to focused pain education

Three institutes reported having focused pain education in year 1 (n = 454), two institutes in year 2 (n = 151) and one in year 3 (n = 57). The difference of the knowledge and attitudes separated by focused pain education is graphically presented in Figure 1. The interaction effect was significant on KNAP scores with a small effect size ($F(6) = 2.597$, p = .017, $\omega^2 = .012$). A positive difference is visible in knowledge and attitudes toward pain in year 2.

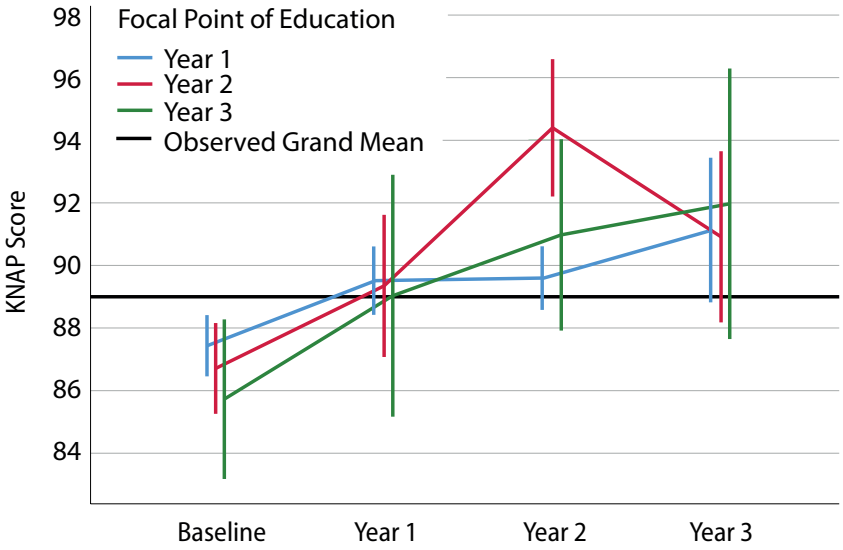


Fig 1. Interaction of year and focused pain education. KNAP; KNowlegde and Attitude of Pain

Sensitivity analyses

The scores of the PABS-PT biopsychosocial subscale (PS), the PABS-PT biomedical subscale (BM), and the NPQ related to KNAP scores are presented in Table 3 and Figure 2. There was a significant small effect of education on the PABS-PT/PS scores, $F(3, 212.22) = 2.95$, p = .034, $\omega^2 = .009$. Differences between years were small and non-significant. On the PABS-PT/BM scores, there was a significant small effect of education $F(3, 222.50) = 4.94$, p = .002, $\omega^2 = .017$, effect sizes between baseline and year 1 were small, and medium between baseline and year 3. The NPQ scores differed significantly, $F(3, 220.72) = 11.83$, p<.001, $\omega^2 = .052$), with a medium effect size. Differences between baseline and year 1 were small and medium between baseline and year 3, both being significant. For the graphical presentations of the interaction of year and focused pain education, see Appendix A.

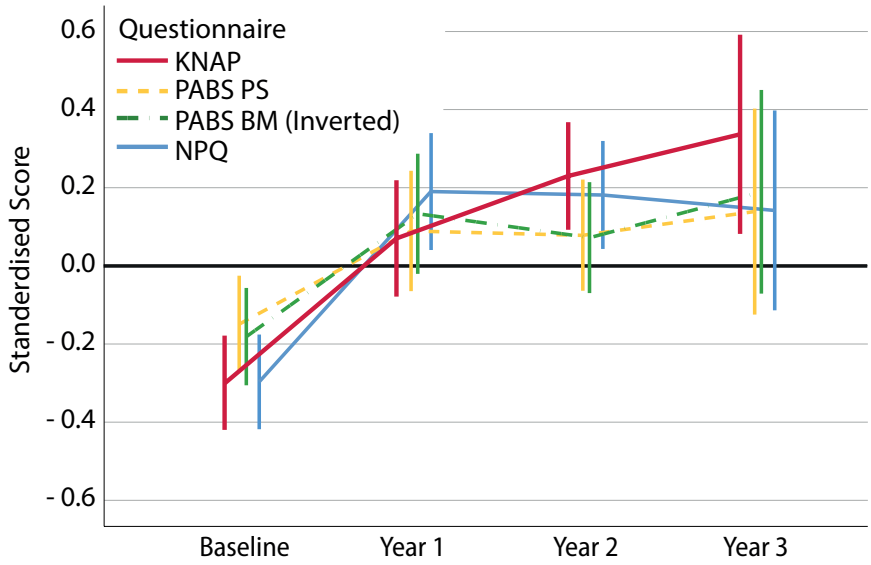


Fig 2. Sensitivity analyses KNAP, PABS-PT, NPQ.

KNAP; KNowlegde and Attitudes of Pain, PABS PS; Pain Attitudes and Beliefs Scale for Physiotherapists Biopsychosocial subscale, PABS BM; Pain Attitudes and Beliefs Scale for Physiotherapists Biomedical subscale, NPQ; Neurophysiology of Pain Questionnaire.

Table 3: Sensitivity analyses PABS-PT, NPQ (mean [95%CI]).

Year	PABS-PT/ PS	*p*	ES *r*	PABS-PT/ BM	*p*	ES *r*	NPQ	*p*	ES *r*
Baseline	18.9 [18.6;19.1]			19.9 [19.7;20.2]			8.4 [8.2;8.5]		
Year 1	19.3 [19.0;19.6]			19.3 [18.9;19.6]			9.1 [8.9;9.3]		
Year 2	19.3 [19.0;19.5]			19.4 [19.1;19.7]			9.1 [8.9;9.3]		
Year 3	19.4 [18.9;19.9]			19.1 [18.6;19.7]			9.0 [8.6;9.4]		
Diff 0-3	-0.5 [-1.0;-0.0]	.072	.20	-0.8 [-1.4;-0.2]	.005*	.29	-0.7 [-1.1;-0.2]	.003*	.31
Diff 0-1	-0.4 [-0.8;-0.1]	.017	.13	0.7 [0.3;1.1]	<.003*	.17	-0.7 [-1.0;-0.5]	<.001*	.25
Diff 1-2	0.0 [-0.4;0.4]	.918	.00	-0.1 [-0.6;0.3]	.587	.03	0.0 [-0.3;0.3]	.930	.00
Diff 2-3	-0.1 [-0.7;0.4]	.708	.04	0.3 [-0.4;0.9]	.387	.08	0.1 [-0.4;0.5]	.785	.03

KNAP; Knowledge and attitudes of pain, PABS-PT; Pain Attitudes and Beliefs Scale for Physiotherapists, PS; biopsychosocial subscale, BM; biomedical subscale, NPQ; Neurophysiology of Pain Questionnaire, CI; Confidence Interval, Diff; Difference, *p<.0125, ES; Effect size, Baseline n= 245-250, year 1 n = 161-164, year 2 n = 189-192, year 3 n = 55,56.

Discussion and conclusion

In MT postgraduate students, significant positive differences in knowledge and attitudes toward pain between baseline and years 1, 2, and 3 were observed with a medium effect size. Differences between baseline and year 1 and baseline and year 3 were statistically significant with a decreasing amount of growth during the years. Effect sizes for the contrasts of groups on KNAP were observed with a medium effect size between baseline and year 3 and a small effect size between baseline and year 1. Sensitivity analyses were consistent with the main results, suggesting robustness of the main results.

The results show that MT students develop more guideline consistent knowledge of and attitudes towards patients with persistent pain. Whether the effect sizes are large enough to determine changed clinical practice and patient-related outcomes is unknown at present and should be a subject for further research.[72,73]The mean overall KNAP difference of 4.1 points did not exceed the SDD (4.99) nor the MIC (4.84)[56], suggesting that the observed difference may not be sufficient to be educationally relevant.[71] The SDD and MIC values, however, were calculated for an undergraduate sample of physical therapy students, and the validity for the present sample is unknown. Caution is needed when interpreting and using the MIC values of different study populations.[74–77] In addition, KNAP difference was assessed between the years of a postgraduate curriculum and not directly after studying pain which could explain a lower result. The postgraduate program is a part-time study and, at the same time, students work clinically as physiotherapists. This can cause a lower result on the KNAP due to influences that are not based on modern pain neuroscience or on guidelines. Implicit and explicit attitudes of HCPs are only weakly related to each other, however, both are related to treatment recommendations.[28,29,78] The effect of educational interventions should be tested by adding outcome measures on the level of practice behavior and ultimately on relevant patient-related outcomes.[79,80]

There was a significant interaction effect of focused pain education and year in the curriculum, although the effect size is small. In one of the postgraduate MT programs, pain education was clearly defined in year 2 which resulted in a visible positive difference in knowledge and attitudes toward pain neuroscience. In this institute, the module was referred to as 'conceptual framework pain' and consisted of four meetings of 3.5 hours with pain-keywords included. In most cases, pain education is offered integrated into other MT education modules, and educational managers experienced major difficulties answering the question: 'If you expect a positive difference in knowledge and attitudes toward pain in the MT program, when do

you expect the strongest difference?' When less clearly defined pain education or even conflicting education is provided between instructors, students might vacillate between a biomedical to a biopsychosocial perspective. Addressing fragmented pain education may be sub-optimal from an educational perspective because students need to integrate knowledge across several modules and timepoints during the curriculum.[59,77,81] On the other hand, student-led active learning strategies including valid assessment may encourage in depth learning which is particularly beneficial in developing the skills necessary to apply knowledge when managing a person experiencing pain.[77,82–85] Multiple studies have shown a short training in pain education is effective for improving the knowledge, attitudes, and beliefs related to chronic pain, suggesting that specific and clearly defined pain education can have a positive effect.[54,86–90] However, short courses in pain do not elicit the desired long term change with regards to a behavioural shift in pain management.[83,87] Pain education in higher education is facing insufficient curriculum time.[77,84,85,91] Clearly defined education about pain should be integrated into active integrative learning strategies using a variety of pedagogic approaches.[92] In summary, better results can be assumed for knowledge and attitudes toward pain neuroscience if pain education including a PNE course is offered in a formal competency-based pain curriculum with a sufficient amount of time[77,93] and integrated with case study examples that include active clinical reasoning and live patient demonstrations.[77,85,93–96] These skills could contribute to a more comprehensive, mechanism-based assessment and treatment of patients with (persistent) pain because they are better capable of integrating biopsychosocial principles in their daily practices.

The present study has several strengths including its unique, comprehensive sample and setting and large sample size (> 660 participants). This study addressed responses in all MT institutes in the Netherlands, however, it is unknown to what extent it can be generalised to MT institutions outside the Netherlands. Sensitivity analyses were performed to study the robustness and validity of the main results. A limitation of the study is the low recruitment rate in the final year for two institutes (6% resp. 33%). While this reflects a reduced response rate for these two institutes, it had little effect on the overall response rate in year 3 (8,5% of total n=662), and it is unlikely that this has systematically biased the overall results. It cannot be demonstrated that the observed growth in knowledge and attitudes is caused by the MT programs alone because of the cross-sectional nature of this study, and this should be a subject of a further longitudinal study. Research is needed to evaluate what changes may occur from educational interventions that are necessary to measure clinically significant changes in the behaviour of practitioners and how this affects their patients' attitudes, beliefs, behaviour, and better pain management. Additionally, research is required to

investigate what type and amount of education is the most effective and has long term outcomes.[20,33,48,54,60,83,97] Finally, this study analysed differences in knowledge and attitudes between groups but not within groups. Future longitudinal studies should analyse intra-group or intra-individual progressions.

In conclusion: Positive differences in knowledge and attitudes toward pain neuroscience in MT students occur between the progressing years of the curriculum. Differences may be related to the provision of focused pain education. Ultimately, MT students develop more guideline consistent knowledge and attitudes toward persistent pain patients. Specific and clearly defined pain education tends to have the most positive effects.

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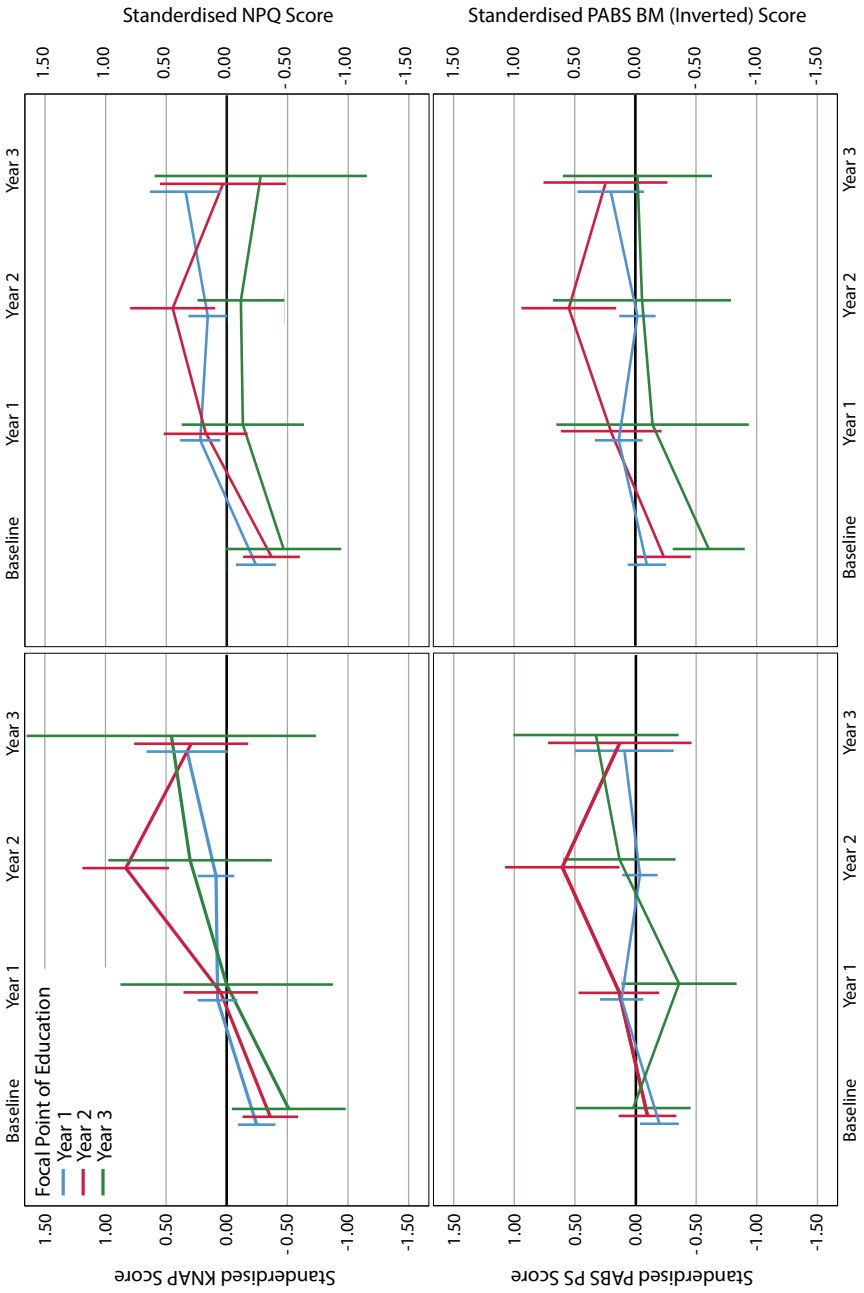
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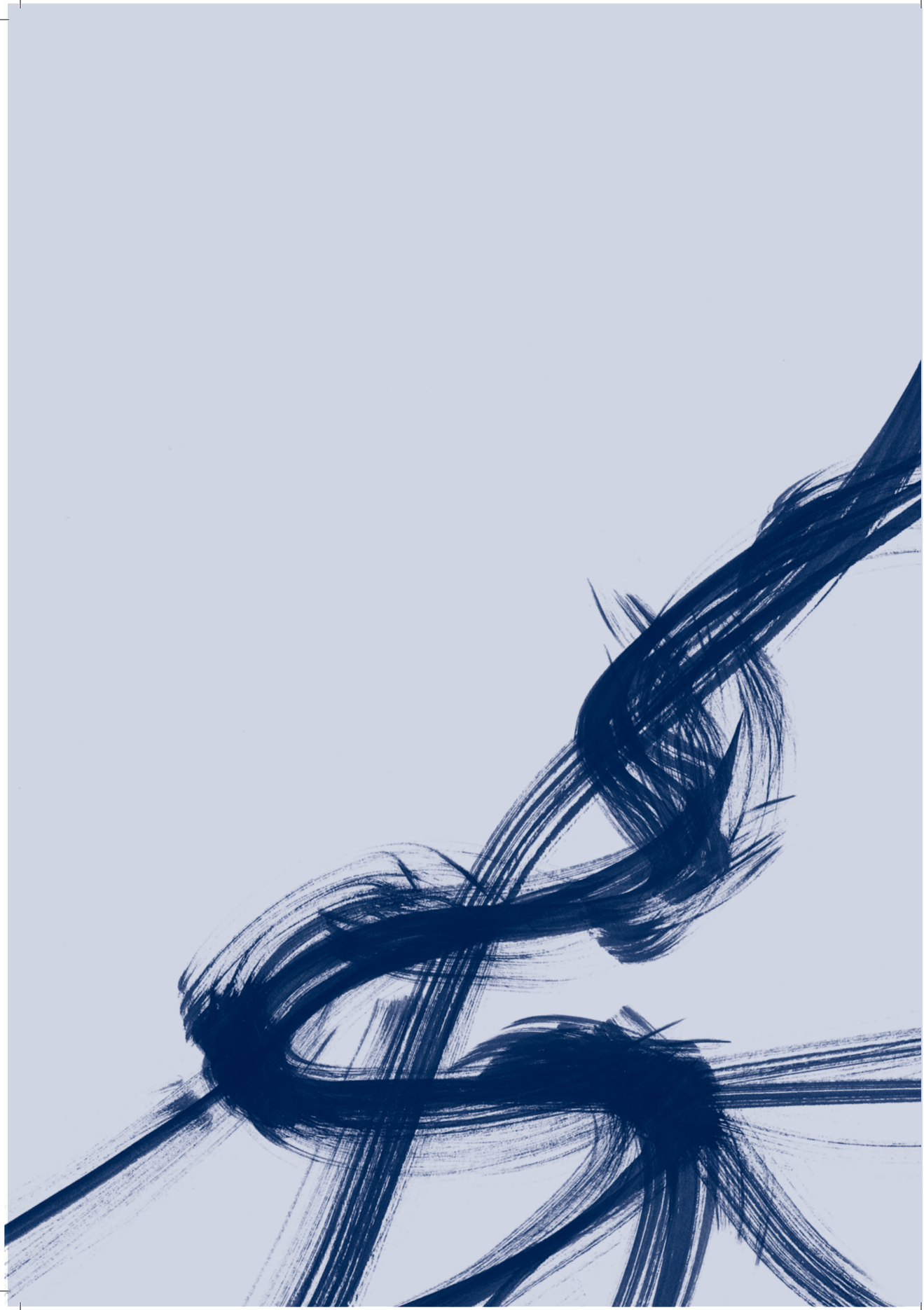
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Appendix A. Supplementary data



PART II

Adopting and evaluating a biopsychosocial approach towards musculoskeletal pain in health care education



CHAPTER 5

Towards consensus in pain-related content in the pre-registration, undergraduate physical therapy curriculum: a Delphi-study

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Abstract

Background: Access to pain education for health care professionals is a IASP key recommendation to improve pain care. Content of pre-registration, undergraduate physical therapy pain curricula, however, are highly variable.

Objective: This study aimed to develop a list, by consensus, of essential pain-related topics for the undergraduate physical therapy curriculum.

Methods: A modified Delphi study was conducted in four rounds, including a Delphi panel (N=22) consisting of in pain experienced lecturers of pre-registration, undergraduate physical therapy of Universities of Applied Sciences in the Netherlands, and five Validation panels. Round 1: topics were provided by the Delphi panel, post-graduate pain educators and a literature search. Round 2-4: the Delphi panel rated the topics and commented. All topics were analyzed on importance and degree of consensus. Validation panels rated the outcome of round 2.

Results: The Delphi panel rated 257, 146 and 90 topics in rounds 2, 3 and 4, respectively. This resulted in 71 topics judged as "not important," 97 as "important" and 89 as "highly important." In total, 63 topics were rated as "highly important" by the Delphi panel and Validation panels.

Conclusions: A list was developed and can serve as a foundation for development of comprehensive physical therapy pain curricula.

Keywords: Physical therapy curriculum, pain curriculum, education, pre-registration, undergraduate

Introduction

The widespread prevalence, and also the large global burden (four musculoskeletal-related diseases in top 11 ranking among 354 diseases) of MSK pain demonstrates the need for comprehensive education in pain for all Health Care Professionals (HCP) (Briggs, Carr, and Whittaker, 2011; Goldberg and McGee, 2011; International Association for the Study of Pain [IASP], 2011; Institute for Health Metrics and Evaluation, 2019; Jackson et al, 2015; Rice, Smith, and Blyth, 2016). The major deficits in knowledge, attitudes and skills of (student) HCPs about the mechanisms and management of pain is one of the reasons that pain management is inadequate worldwide (Giordano and Boswell, 2011; IASP, 2010; Johnson, Milligan, and Briggs, 2018; Miles, Kellett, and Leinster, 2017; Thompson, 2009). To counteract this, education in pain is one of the cornerstones advocated in the National Pain Strategies of the International Association for the study of Pain (IASP, 2011). Education in pain for HCPs in general is, interestingly, often limited, fragmented, inadequately addressed and inconsistent in pre-registration, undergraduate health curricula of medicine, nursing and physical therapy (Briggs, Carr, and Whittaker, 2011; Doorenbos et al, 2013; Gallagher et al, 2000; Institute of Medicin, 2011; Jones, 2009; Shipton et al, 2018). The documented content of these pain curricula is highly variable, often dominated by the biomedical model (Briggs, Carr, and Whittaker, 2011; Briggs et al, 2015; Doorenbos et al, 2013; Ehrström, Kettunen, and Salo, 2018; Giordano and Boswell, 2011; Hoeger Bement et al, 2014; Leegaard, Valeberg, and Haugstad, 2014; Mezei and Murinson, 2011; Murinson, Mezei, and Nenortas, 2011; Pöyhiä, Niemi-Murola, and Kalso, 2005; Shipton et al, 2018; Thompson, Johnson, Milligan, and Briggs, 2018; Watt-Watson et al, 2009) and often lacking essential content related to current pain (neuro)science (Briggs, Carr, and Whittaker, 2011; Briggs et al, 2015; Ehrström, Kettunen, and Salo, 2018). Education about pain tends to ignore the biopsychosocial framework; despite being advocated in clinical guidelines, cognitive-behavioral methods and multidisciplinary management receive limited or no attention (Ehrström, Kettunen, and Salo, 2018; Loeser, 2015; Scudds, Scudds, and Simmonds, 2001; Sessle, 2012).

Whereas IASPs Curriculum Outline on Pain for Physical Therapy targets all levels of physical therapy training, the European Pain Federation (EFIC) targets postgraduates (European Pain Federation [EFIC], 2019; Fishman et al, 2013; Hoeger Bement et al, 2014; IASP, 2018). Additionally, most research is into the postgraduate area (Hush, Nicholas, and Dean, 2018). Although the IASP core curriculum is helpful for curriculum designers of physical therapy programs, the outline is limited to describing competences and learning objectives and guidance is lacking on the specific content (Hunter et al, 2008; Jones, 2009; Watt-Watson et al, 2004). Considerable variation exists in the content of

education about pain for physical therapy between countries (Hoeger Bement and Sluka, 2015; Scudds, Scudds, and Simmonds, 2001). An unpublished pilot inventory of the pain content in physical therapy courses on Universities of Applied Sciences (UAS) in the Netherlands, revealed substantial differences in content, volume and competence level even within a country.

Even though increasingly more physical therapists recognize the multidimensional nature of chronic pain and the importance of self-management, systematically and adequately addressing psychological factors remains challenging (Cowell et al, 2018; Denneny et al, 2020; Singla, Jones, Edwards, and Kumar, 2015; Verwoerd et al, 2022). Given that physical therapists are frontline clinicians in pain management (Beswick et al, 2012; Edgerton et al, 2019; Kehlet, Jensen, and Woolf, 2006; Pendergast, Kliethermes, Freburger, and Duffy, 2012; Van Gorp et al, 2015; Wylde et al, 2015) pre-registration, undergraduate courses must integrate specific knowledge and skills and contain the latest evidence to prepare them to manage pain effectively (Briggs, Carr, and Whittaker, 2011; Cowell et al, 2018; Hoeger Bement et al, 2014; IASP, 2011; Synnott et al, 2015). Because the importance of education in pain is widely recognized, a description based on consensus of required content on a pre-registration, undergraduate level is needed.

This study aimed to identify a widely consented set of essential topics of a pre-registration, undergraduate pain curriculum of the Dutch physical therapy program by consulting experts in the field of higher education and pain. The research question was: "What are the essential pain-related topics in pain evaluation and management that should be integrated within the curriculum of pre-registration, undergraduate physical therapy students to enable them to treat patients with pain according to applicable guidelines?"

Methods

Design

A modified Delphi study was administered online from February 2020 to May 2021. Four rounds were used to generate consensus between experts (Becker and Roberts, 2009; Hasson, Keeney, and McKenna, 2000; Keeney and Mckenna, 2005; Okoli and Pawlowski, 2004; Skulmoski, Hartman, and Krahn, 2007; Thompson, 2009; Wilson, Averis, and Walsh, 2003). Feedback was collected and was forwarded to the next round, including a summary of comments and statistical measures (Murphy et al, 1998). In order to prevent group bias, national bias and bandwagon effects, five

special interest group Validation panels were used in a single round. The results of the Validation panels were combined with the results of the Delphi panel to compose a consented set of essential pain-related topics for the pre-registration, undergraduate curriculum of physical therapists. Formal ethical review was not needed as judged by the medical ethics committee at the University Medical Center of Groningen (M21.289289). All participants provided written informed consent prior to the beginning of the survey. Guidance on Conducting and Reporting Delphi Studies (CREDES) was followed (O'Brien et al, 2014).

Participants Delphi panel

The Delphi panel experts were recruited from pain experienced physical therapy lecturers of all UAS in the Netherlands. Participants were eligible if they met the predetermined criteria: 1) have a minimum of five years of professional educational experience on the topic of pain; 2) involvement in pain related curriculum development and teaching in it; and 3) willing and able to dedicate the time required for Delphi rounds. We aimed to form a panel of at least 20 experts to include sufficient expertise and diversity to cover pain's multidimensional aspects and derive representative results (Jorm, 2015). The potential participants were informed by email about the purpose and procedure to contribute as experts.

Participants Validation panels

Five special interest group Validation panels were used as a bias reducing filter: panel 1) early career physical therapists; fourth-year Bachelor physical therapy students (with minimally 20 weeks internship experience) and physical therapists up until one-year work experience (reference for prospective curriculum "consumers"); panel 2) physical therapists with a minimum of five years working experience (reference for the broader work field of physical therapy); panel 3) non-pain lecturers in the field of higher education of physical therapy (reference for less pain oriented, but higher education focused lecturers); panel 4) post-graduate pain educators; educators of accredited post-graduate pain courses that are commercially accessible (including general practitioners, physician assistants, psychologists, occupational therapists, psychosomatic physical therapists, pediatric physical therapists, and manual therapists); and panel 5) IASP and EFIC representatives; physical therapy pain curriculum committee members (international reference and content experts in the field of pain curricula). The national Validation panels were recruited by the Delphi panel members, the associated UAS, social media and by a message in the online newsletter of the Dutch Physical Therapy Association (KNGF). Pain educators of post-graduate pain courses were recruited using the database of accredited courses

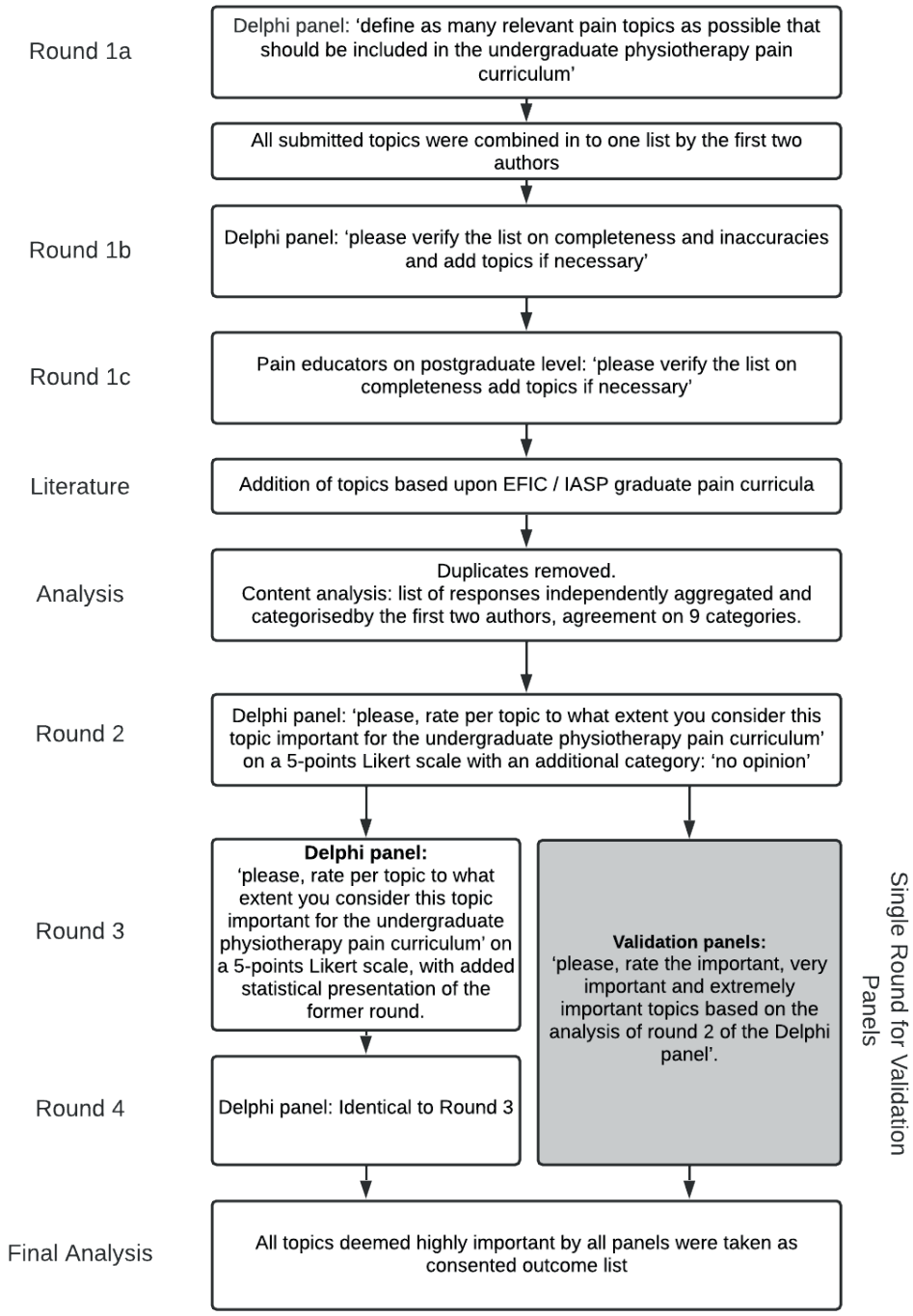


Figure 1. Flowchart of the Delphi process.

IASP; International Association for the Study of Pain, EFIC; European Pain Federation.

of the Dutch Physical Therapy Association. The EFIC and IASP representatives were contacted by email.

Procedures, Rating and Analysis

A web-based survey (Survey Monkey Company, Palo Alto, CA) was used for all four rounds of the Delphi panel and the single round of each Validation panel. The invitation included instructions to take in mind preceding participation in the round; a) the general level of competence of physical therapy education is on a pre-registration, undergraduate level, b) what is minimal necessary (the curriculum space is limited) and c) indicate the importance of the pain topic itself free of competence sublevel (i.e. degree of expertise) within the undergraduate level (Bergsmann et al, 2015). All members had four weeks to fill in the survey in every round, and a reminder was sent halfway. All Delphi panel members participated independently and anonymously. A total of four rounds was determined a priori (Figure 1).

Delphi Panel

First round (1a-c). The aim was to collect and define as many relevant pain topics as possible. The first round was an open consultation round in three steps. First, a) the Delphi panel was asked to liberally list as many pain topics as possible. The topics submitted by the individual participants were taken together and combined into one list by the first two authors (RR&AB). Second, b) the Delphi panel was asked to verify the list and add topics if necessary. Third, c) the list was provided to pain educators of accredited post-graduate pain courses (Validation panel 4), which were asked to add omitted topics (Keeney and Mckenna, 2005; Trevelyan and Robinson, 2015; Wilson, Averis, and Walsh, 2003). For completeness, existing IASP and EFIC curricula literature was screened to identify any additional topics. After data collection, duplicates between b) and c) were removed and the first two authors categorized all topics.

Second round. The aim was to rate and possibly reduce the number of first-round topics. Participants of the Delphi panel were asked which topics are important for a starting physical therapist to treat patients with pain in daily practice according to applicable guidelines and state of the art knowledge. For each topic, the panelists were asked: "Rate per topic to what extent you consider this topic important for the pre-registration, undergraduate physical therapy pain curriculum." Participants rated each topic on a 5-point Likert scale; 1. very unimportant, 2. unimportant, 3. important, 4. very important, 5. extremely important. There was an additional "no opinion" option, which could be used when the participant could not judge it to prevent uninformed response bias (Becker and Roberts, 2009; Trevelyan and Robinson, 2015). To avoid ceiling effects, a five-point Likert scale was used with three positive choices

(extremely important, very important, important) and two negative choices (very unimportant, unimportant) (Crow et al, 2002; Lozano, García-Cueto and Muñiz, 2008; Moret et al, 2007). For each category, comments could be left.

Third round. The aim was to reach consensus on second round topics, emphasizing those topics on which no consensus had been reached. Summarized comments per cluster were presented together with statistical information (percentages and bar charts), to inform the Delphi panel on topics that have gained collective opinion (see analysis). The Delphi panel members were asked to rerate the topics based on the group's opinion (statistical information and comments). In this round, Delphi panel members were asked to comment on all ambivalent topics next to general comments.

Fourth round. The aim and organization of the fourth round was identical to the third round and can be seen as a further iteration of the process. Extra information was added when comments revealed a misunderstanding of the ambivalent topics.

Validation panels

In a single round, all Validation panels were asked to judge the topics rated as important, very important and extremely important, based on the analysis of round 2 of the Delphi panel. Unimportant topics were removed to reduce the completion time, consequently increasing the potential number of responses in the Validation panels and reducing attention bias. Incomplete lists (defined as missing three ratings or more consecutively) and lists with a fill-in time smaller than five minutes were excluded to prevent careless responding (Goldammer, Annen, Stöckli, and Jonas, 2020; Huang et al, 2012)

Analysis

A response rate of 70% for each round of the Delphi panel was considered sufficient (Sumsion, 1998). After the first round, the collected topics were content analyzed, duplicates were removed and pragmatically categorized into nine categories, partly overlapping the categorization used in the IASP and EFIC curricula (Table S2) (Keeney and Mckenna, 2005; Keeney, Hasson, and Mckenna, 2010). Authors (RR & AB) independently aggregated and identified responses. A consensus meeting took place to resolve any disagreements. A stepwise procedure was followed in all rounds to analyze the importance based on group position and degree of consensus (agreement or certainty based on group dispersion) of all topics (see Table 1). Criteria for importance was based on the median, whereas criteria for consensus were based on percentage agreement and the interquartile range (IQR), rather than the mean and

standard deviations, to reduce the influence of outliers in judgement (Trevelyan and Robinson, 2015). The choice of "no opinion" was excluded in all calculations.

Table 1. Importance and degree of consensus of topics.

Judgement	Explanation
Highly important, high degree of consensus	Rated "very important" and "extreme important" by ≥75% of the participants or a median within these levels with low dispersion (IQR≤0.75)
Highly important, low degree of consensus	Rated with a median within "very important" and "extreme important" with high dispersion (0.75≤IQR≤2.5)
Important, high degree of consensus	Rated "important" by ≥75% of the participants or a median within this level with low dispersion (IQR≤0.75)
Important, low degree of consensus	Rated with a median within "important" with high dispersion (0.75≤IQR≤2.5)
Unimportant	Rated important by <75% of the participants
Ambivalent	Rated highly important, important or unimportant with very high dispersion (IQR≥2.5)

Judgement of topics is based on importance and degree of consensus using a Likert scale, where the amount (in percentage) and dispersion of ratings is considered. IQR; Interquartile Range.

Initially, all topics with highly variable ratings (IQR ≥2.5) were categorized as ambivalent and remained for the next round for re-evaluation (Hasson, Keeney, and McKenna, 2000; Keeney and Mckenna, 2005; Sumsion, 1998). Then, topics were categorized as unimportant, important or highly important. Unimportant: when rated as important (3 or higher on the Likert Scale) by less than 75% of the participants. Highly important: when rated 4 or 5 on the Likert Scale by minimally 75% of the participants. Further, a topic was categorized according to the median if not categorized by the former steps (1 or 2: unimportant; 3: important; 4 or 5: highly important) (Diamond et al, 2014; Trevelyan and Robinson, 2015; Von der Gracht, 2012). Secondly, consensus was assumed when IQR ≤0.75. Consequently, topics were taken out of the procedure when consensus was assumed or when topics were rated as unimportant, leaving the (highly) important topics without consensus for re-evaluation (Figure 2). After round 4, all topics were categorized according to their importance and degree of consensus. Finally, all topics deemed "highly important" by all panels (Delphi and Validation panels) were presented as consented topics. Judgment of all topics in their respective categories, including the Validation panels' judgments, is presented separately in Table S2.

Comments of Delphi and Validation panels

The first two authors selected the comments, which were mentioned more than once by Delphi panel members, supporting the quantitative data and providing context for a better understanding of the results. These comments were forwarded to the next round as quotes (preserving the original word usage as much as possible, without revealing the commenter's identity due to writing style). The comments are presented in the appendix.

Results

Participants in the Delphi panel

A total of 22 lecturers participated in the Delphi panel. Twelve out of thirteen UAS in the Netherlands were represented. Ten UAS were represented by two lecturers in the Delphi panel and two UAS by one lecturer. In the last round, there was one dropout (not responding). Descriptive characteristics of the participants are presented in Table 2.

Table 2. Sociodemographics of the Delphi panel.

Characteristic	**Delphi panel (N = 22) Median (IQR) or n (%)**
Gender, female	4 (18 %)
Age (years)	52 (40 - 57)
Highest completed education level (%)	
Bachelor's degree	3 (13,6 %)
Master's degree	16 (72,7 %)
PhD	3 (13,6 %)
Work experience as lecturer (years)	12,5 (8 - 22)
Working as lecturer in general (hours/week)	18 (12 - 28)
Working as lecturer in pain (hours/week)	2,5 (2 - 6,5)
Working experience as physical therapist (years)	17 (25 - 31)
Current working hours as physical therapist (hours/wk)	6 (0 - 8)
Work setting as physical therapist (%)[a]	
Private practice	73
Private practice (specialized in (chronic) pain)	32
Hospital	32
Rehabilitation centre (pain rehabilitation team)	23
Rehabilitation centre (other teams)	14
Nursing home / institution	18

[a]Total exceeds 100% due to panellists who work or have worked in multiple settings. IQR; Interquartile Range, PhD; Doctor of Philosophy.

Participants in the Validation panels

In panel 1) the early career physical therapists, a total of 51 out of 91 (55%) completed a single round and were eligible based on their time-to-completion and completeness, and in panel 2) the physical therapists, 122/237 (51%) were eligible. For panel 3) the non-pain lecturers, this was 81/100 (81%), panel 4) the post-graduate pain educators, this was 17/19 (89%) and panel 5) the EFIC / IASP representatives, this was 10/10 (100%). Descriptive characteristics of the Validation panels are shown in Table S1.

First round

After the open consultation round, literature review and duplicate removal, 257 topics were in the initial list (Table S2). All topics were combined into nine categories; a) Taxonomy and defining pain (13 topics), b) Pain assessment and measurement (20 topics), c) Models and theories (Health and psychosocial models, Pain neurophysiology, anatomy and biology models; 77 topics), d) Multidimensional nature of pain (47 topics), e) Management of pain (45 topics), f) Communication (15 topics), g) Beliefs and attitudes of patient & HCP including students (5 topics), h) Health policy & guidelines in pain (10 topics) and i) Pain subgroups/special populations (25 topics).

Second round

Of the total 257 topics rated in the second round, 36 were considered, with a high degree of consensus, as "highly important," 16 as "important," and 59 as "not important." Additionally, 17 were categorized as ambivalent, resulting in 146 topics for the next round. See figure 2 for the overview of judgment per round.

Third and fourth round

In round 3, 146 topics were rated of which 90 remained to be rated in round 4. After round 3, only one topic ("mechanism-based approach") was categorized as "ambivalent." The comments revealed that not all panellists were familiar with this topic; consequently, additional information was given in the fourth round. After round 4, the Delphi panel rated 64 topics as "highly important and with a high degree of consensus," 25 as "highly important with a low degree of consensus," 53 as "important with a high degree of consensus," 44 as "important with a low degree of consensus" and 71 as being "not important." The complete list of topics and judgment by the Delphi panel and Validation panels is reported in Table S2.

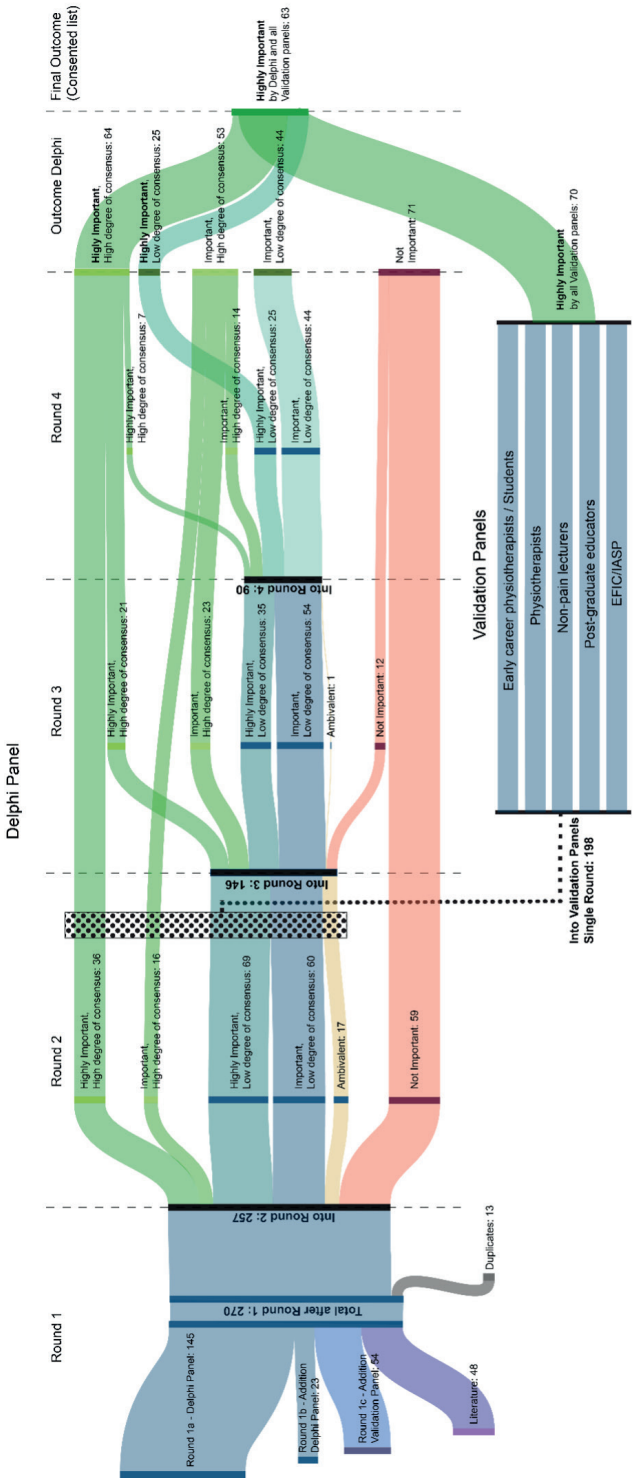


Figure 2. Flowchart of topic analysis after Delphi and Validation panels judgements.

Topics judged as "not important" were taken out of the procedure, as were the topics judged as "highly important" or "important", with a high degree of consensus. Validation panels judged the "highly important", "important", and "ambivalent" topics based on round 2. Finally, all topics judged as "highly important" by both the Delphi and all Validation panels were presented as a consented list. IASP; International Association for the Study of Pain, EFIC; European Pain Federation.

Single round of the Validation panels

All topics rated as highly important, important and ambivalent in the second Delphi round were presented to all Validation panels. Out of these 198 topics, a total of 70 topics were rated as "highly important" by all Validation panels and were used as a filter after the final fourth Delphi round. Summarized ratings of each Validation panel is presented in Table 3.

Table 3. Summarised ratings of the 198 items by the Validation panels.

	Panel 1	Panel 2	Panel 3	Panel 4	Panel 5
	Early career physical therapists	**Physical Therapists**	**Non-pain lecturers**	**Post-graduate pain educators**	**EFIC and IASP representatives**
Highly important	148	89	107	111	163
Important	46	103	79	67	25
Not important	4	6	12	20	10

Validation panellists judgement after their single round. IASP; International Association for the Study of Pain, EFIC; European Pain Federation.

Comments of the Delphi and Validation panels addressed the complexity, relevance, and specificity in judging topics. Representative comments are presented in the appendix.

Final results

After four rounds, the Delphi panel reached consensus on a total of 89 topics as "highly important." After crosschecking this list with the 70 topics rated as "highly important" by the Validation panels, it was determined that collective consensus was reached on 63 topics (presented in Table 4). A complete overview of all ratings of both the Delphi panel and all Validation panels is presented in Table S2.

Table 4. Categories and topics with a collective consensus of Delphi Panel and Validation panels

1. TAXONOMY AND DEFINING PAIN
[2] Chronic Pain
[2] Nociceptive Pain
[2] Acute Pain
[2] Nociplastic pain
[4] Referred pain
[2] Neuropathic pain
[3] Dimensions of pain (sensory, discriminative, affective, motivational, cognitive, evaluative)
2. PAIN ASSESSMENT AND MEASUREMENT
[2] Recognizing psychosocial factors
[2] Symptoms of chronic pain
[2] Evaluation of treatment effects
[2] Prognostics of transition from acute to chronic pain
[2] Pain perception
3. MODELS AND THEORIES **3.1 HEALTH AND PSYCHOSOCIAL MODELS / THEORIES**
[2] Biopsychosocial model
[2] Pain-related mechanisms of physical therapy interventions (psychosocial)
[2] Self Efficacy
3.2 PAIN NEUROPHYSIOLOGY, ANATOMY AND BIOLOGY MODELS / THEORIES
[2] Central sensitization
[3] Plasticity and the brain
[2] Peripheral sensitization
[2] Pain-related mechanisms of physical therapy intervention (physiological)
[2] Neuroplasticity
[3] Neurophysiology of Nociceptive Pain
[4] The autonomic nervous system
[4] Physiology of stress

4. MULTIDIMENSIONAL NATURE OF PAIN

[3] Cognitions
[3] Illness Perception
[2] (Pain) behavior
[3] Influence of emotion on pain
[3] Fear
[2] Stress
[2] Complexity of pain
[3] Coping styles
[3] Influence of pain on movement (motor influence)
[4] Catastrophizing
[4] Risk factors for chronic dysfunction due to pain
[3] Influence of expectation on pain
[3] Contextual factors
[3] Influence of lifestyle on pain
[4] Kinesiophobia
[4] Influence of mood on pain
[4] Motivation

5. MANAGEMENT OF PAIN

[3] Self-management
[2] Physical Exercise Therapy
[4] Behavioral influence on pain
[3] Prevention of chronic pain
[2] Active lifestyle
[2] Graded Exposure/Exposure in vivo
[2] Lifestyle interventions
[2] Patiënt Centered Approach
[2] Graded Activity
[3] Adherence / compliance
[4] Working Interdisciplinary

6. COMMUNICATION
[3] Shared Decision Making
[2] Nocebo in practice
[2] Conversation techniques
[2] Motivational Interviewing
[3] Coaching
[4] Empathy
[4] Dialogue and pain education (lecturing versus Socratic style)
[4] Somatic, Cognitive, Emotions, Behavior, Social (SCEBS) / Pain-SCEBS-Motivation

7. BELIEFS AND ATTITUDES PATIENT & HEALTH CARE PROFESSIONAL INCL.THE STUDENT
[2] Attitude health care professional /student
[2] Health beliefs health care professional/student

8. HEALTH POLICY & GUIDELINES IN PAIN
No topics gained collective consensus

9. PAIN SUBGROUPS / SPECIAL PATIENT POPULATIONS
[3] Musculoskeletal pain
[4] Neck- and back pain

All topics are ordered within the category on percentage agreement on "Highly Important" by the Delphi panel. Number in brackets preceding the topic represents the round when the Delphi panel determined the judgement of the topic.

Discussion

This study resulted in a list, by consensus, of 63 pain-related essential topics that pre-registration, undergraduate physical therapy students should learn in order to adequately treat patients with pain. Eight out of nine at the start of this investigation addressed categories are represented in the final list showing the agreed broadness of pain education. Going more into detail, the results show that the topics should be seen from the perspective of hierarchy. Some topics resemble a broader area and can be considered a parent topic (e.g., "neurophysiology of modulation"), while others relate more in-depth to this topic as a child topic (e.g. "endogenous pain inhibition: conditioned pain modulation"). It is advised that this hierarchy is taken into account when developing a pain curriculum.

This study proposed a broad spectrum of biopsychosocial topics that could influence the patients' experience and expression of pain related to current pain science. The agreed topics mainly represent understanding, assessing and management of the complex multidimensional nature of pain. There is also consensus about a patient-centered approach to pain management, active interventions and behavioral principles. In addition, validation panel 5) IASP / EFIC representatives commented to add the use of TENS, heat and cold as part of self-management strategy or manual therapy as a therapeutic strategy.

Topics such as "the biopsychosocial model," "self-management," and "patient-centered approach" are strategies that can be offered generically for several health problems, not only in pain rehabilitation. These general concepts create opportunities in the curriculum to develop competencies in general and more in-depth in specific areas such as pain. As pain is best approached using interdisciplinary collaboration, it has also been argued that students should learn about pain using Inter-Professional Education (Carr and Watt-Watson, 2012; Gordon, Watt-Watson, and Hogans, 2018; Hoeger Bement et al, 2014; Van Lankveld, Afram, Staal, and Van der Sande, 2020). Therefore, cross-profession agreed competencies are needed to allow good collaboration. However, this also requires educators to adopt these strategies in their education and become competent in teaching them.

In "Management of pain," some topics were commented on as "not suitable/too complex" and "knowing the concept but not supportive for practice." For example, low consensus was reached on the topics "cognitive behavioral methods" and "multi/interdisciplinary collaboration." Nonetheless, these strategies may still be relevant for the pre-registration, undergraduate curriculum at a less advanced level. In fact, multiple studies support having competence in delivering psychologically informed interventions in physical therapy (Ballengee, Zullig, and George, 2021; Denneny et al, 2020; Main and George, 2011). At a pre-registration, undergraduate level, it is key that the student recognizes these management strategies as an option in chronic pain, with a starting level of competence (Denneny et al, 2020). Comments of Delphi panellists supported this: "Several concepts can at least be provided; they do not all have to be discussed with the same depth" and "Inter- and multidisciplinary management; it is important to know when you have to work together and what the boundaries are."

The current study results enable building curriculum outlines for education in pain, which shows considerable overlap with curriculum content described in earlier studies (Briggs, Carr, and Whittaker, 2011; Doorenbos et al, 2013; Hoeger Bement et al, 2014; Shipton et al, 2018) and by the IASP, EFIC and the British Pain Society (EFIC, 2017; IASP, 2018; The British Pain Society, 2018). However, this study had a different focus: identifying content for education in pain for uniprofessional physical therapy education at a pre-registration, undergraduate level. The IASP provides a Curriculum Outline on Pain for Physical Therapy on competences and learning objectives (4). This study supplements this outline by providing guidance on the advised content required for treating patients with pain adequately.

Strengths

The composition of the Delphi panel was representative of the target population of lecturers in pain in higher education. Additionally, a near-complete representation of all UAS in the Netherlands was achieved. Further, the liberal reporting of topics, added topics from the IASP and EFIC literature and the verification of completeness by a Validation panel, resulted in a complete and content valid list of topics. Also, a complete response was obtained in the first three rounds, and only one was missing in round 4, resulting in a consistent share of each Delphi panel member's judgment in all rounds.

Importantly, since the outcome of Delphi studies relies heavily on the quality of the judgement of the panellists, multiple methodological steps were taken for bias reduction. First, the multitude of topics could lead to rating topics less known to the rater as less important (recognition heuristic) (Erdfelder, Küpper-Tetzel, and Mattern, 2011). To address this, an option of "unknown topic" was added. Second, a social-desirability responder bias was mitigated by the anonymity of responses: raters were able to hide unfamiliarity with a topic (Edwards, 1953). Based upon the frequent usage of the "unknown topic" option in all panels, we postulate that this form of bias is not dominantly present. Additionally, in every subsequent round, an explanation of unknown topics (based upon the ratings and comments) or misunderstood topics (based upon comments) was given to increase the familiarity with the topic and thus the validity of each panel members rating. Third, to avoid contrast effects, where two topics are judged compared to one another and therefore rated increasingly higher, topics were sorted based upon the importance obtained in the former round to reduce the actual contrast between topics (Sumer and Knight, 1996). Additionally, all topics were clustered in categories and presented as one cluster per page to avoid comparison with more extremely rated topics of other categories. Fourth, our results show many topics rated as important by most raters. An overestimation of importance

could be addressed to the acquiescence bias (Lavrakas, 2008). To counter this, the positive importance of ratings was divided into three scales, which was also used to prevent ceiling effects. Fifth, national bias, which could limit the generalizability to a national level, was reduced by including the ratings of the Validation panel consisting of EFIC and IASP representatives. Sixth, using different clusters of experts of non-equal level of expertise may enhance the validity and comprehensiveness of the consensus (Sorooshian, 2018). Seventh, group bias and a possible bandwagon effect were minimized using Validation panels. The panels were either potentially more or less biased to the higher importance of pain topics, the post-graduate educators versus the non-pain lecturers in the field of higher education of physical therapy. Finally, different levels of experience and applicability were taken into account by including advanced students, recent graduates and physical therapists. The results of all panels showed usage of the unknown option, reduced ceiling effects and panel differences (e.g., EFIC and IASP representatives rated more topics as highly important). In summary, by applying these strategies, the risk of (serious) bias in this study is reduced, thereby contributing to the robustness of the results.

Limitations

Although many methodological steps were taken to strengthen this investigation, there are still limitations to address. Even though all raters were asked to rate the importance of the pain topic free of competence level, some comments revealed that an ambiguous response was possible while using the same reasoning. Topics were rated as important, but only on a "recognition" level (competence level 1), while the panel used the same reasoning to rate the topic as non-important. Additionally, comments revealed that topics rated as non-important in this study can still be (highly) important on a higher level of competence (e.g., post-graduate courses). In contrast, different reasoning was shown to support an equal rating of importance, reasons based on: complexity, clinical relevance, practical implications, applicability, and the evidence base of a strategy. To address these limitations within reasoning, the degree of consensus was added when analyzing the topics. A larger dispersion resulted in a rerating in the next round, and panellists were asked to comment on the specific topic. Last, global generalizability of the study results is enhanced by using an international Validation panel. Still, direct use of the results could be limited by the differences in educational systems per country and hence varying levels of educational standards (i.e., pre-registration, undergraduate, graduate and postgraduate levels). Consequently, implementation of results needs to be done carefully.

In conclusion, the list of 63 topics could serve as a starting point for (further) development of a comprehensive pre-registration, undergraduate physical therapy

pain curricula and should be taught as part of the development towards the graduate level as IASP and EFIC curriculum outlines. As national biases were reduced, the results could be generalized to other countries while considering the local curricula structure.

Educators can use this study as a benchmark to their own curriculum. If deficits exist, new content can be supplemented to their curriculum. Additional investigation of areas of disagreement will enable educators to consider the scope and depth of content on ideas that should be covered. Further, the level of competence should be considered in curriculum development. In developing these curricula, the following questions should be considered: 1) Dosage: What amount of time should the pain curriculum take?, 2) Timing: Where in the curriculum should pain-related content be incorporated?, 3) Delivery: What educational formats should be used?, 4) Assessment: How should instructors assess the efficacy of the curriculum?, and 5) Teacher competency: How can educators achieve competence in teaching in a pain curriculum?

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Appendix – Comments of the Delphi and Validation Panels

Comments of Delphi panel in the second round addressed different general viewpoints related to multiple topics and the method of judgment:

- Topic importance could be judged based on the prevalence of the type of pain and patient category, even though others mentioned that a total overview of all categories would also help. Topic importance is also judged by the relationship of the topic on clinical relevance;
- Multiple panel members noted that the relevance and a bigger picture of a model or strategy are of more importance for clinical practice than in-depth knowledge, e.g. the depth of neurophysiology and neuro-anatomy topics;
- Panel members judged some topics as unimportant due to not being inside the physiotherapeutic domain, but in the domain of the psychologist or psychiatrist;
- Panel members commented that some interventions are highly valuable for pain, but are too complex for the bachelor program of physiotherapy (e.g. Cognitive Functional Therapy).

Comments of Delphi panel in rounds three and four addressed the level of complexity, relevance and specificity in judgment of topics. Additionally, panel members mentioned that:

- The judgment of a topic was based on evidence from research and the practical implications for physical therapy;
- A specific concept or intervention strategies such as Acceptance and Commitment Therapy (ACT) and Cognitive Functional Therapy (CFT) could be taught without being fully applied by an undergraduate student;
- The importance of influencing factors concerns those that are modifiable for physical therapists;
- Topics were sometimes generic for coping with health complaints, not specifically applicable for education in pain;
- Related to inter- and multidisciplinary management; it is important to know when you have to consult or refer to another discipline;
- ICD-11 as a framework contributes to common terminology and may also help interdisciplinary consultation.

In addition, Validation Panellists comments covered other areas:

- Taxonomy of pain is very important because it improves the understanding of the physical therapist for the request for help;
- Only validated (Patient Reported) outcome measures should have a place in the curriculum;
- The concepts necessary for referring to other disciplines (for example, a physician or a psychologist) are important;
- It might be helpful to look more closely at the underlying treatment principles and mechanisms instead of learning a "trick" (imitating the teacher);
- The most important concept to get across to students at an undergraduate level is a biopsychosocial model and an individualized patient-centered approach. Using a lot more other concepts listed will tend to confuse the main concept;
- One should avoid mixing scientific principles with metaphors, jargon and theories. Basic scientific principles (e.g. principles of transduction, transmission and modulation) and their clinical counterparts (e.g. Exercise-Induced Hypoalgesia, Conditioned Pain Modulation and Temporal Summation of Pain) should not be mixed with (essential), non-measurable theories such as Loeser's model
- For the protective nature of pain concepts, a format as the protectometer could be helpful, but is not necessarily the only way to teach this;
- Passive techniques as TENS, heat and cold (as part of self-management strategies) and manual therapy can be used as part of a treatment regime.

Table S1 – Sociodemographics of the Validation panels.

Characteristics	Early Career Physical therapists / Students	Physical therapists	Non-Pain Lecturers	Post-graduate Pain Educators	IASP / EFIC representatives
Groupsize	51	122	81	17	10
Gender, female	35 (68,6%)	60 (49,2%)	31 (38,3%)	9 (52,9%)	9 (90%)
Age (years)	22 (21-25)	39 (32 - 55)	43 (34-55)	46 (39-55)	54(32-64)
Highest completed education level (%)[a]					
Bachelor's degree	-	48 (39,3%)	7 (8,6%)	2 (10,5%)	-
Master's degree	-	72 (59,0%)	66 (81,5%)	11 (57,9%)	-
PhD	-	2 (1,6%)	8 (9,9%)	6 (31,6%)	10 (100%)
Work experience as lecturer[a] (years)	-	-	7 (3-14)	10 (5 - 16,5)	20(9-32)
Working as a lecturer in general (hours/week)[a]	-	-	24 (16 - 32)	60 (32 - 90)	24 (1-40)
Working experience as physical therapist (years)[a]	-	14 (9 - 32)	15 (9-23)	-	20 (3-40)
Actual working hours as physical therapist, being a lecturer (hours/week)[a]	-	-	10 (0-20)	24 (8 - 26)	1 (0-6)
Work setting as physical therapist (%)[a]					
Private practice	94	62	70	-	-
Private practice (specialised in (chronic) pain)	2	7	1	-	-
Hospital	12	9	26	-	-
Rehabilitation center (pain rehabilitation team)	8	10	5	-	-
Rehabilitation center (other teams)	22	3	15	-	-
Nursing home / institution	14	7	7	-	
Other	4	2	34	-	-
Attended a pain course (% yes)	-	61	28	-	-

Demographics of Validation panels. IASP; International Association for the Study of Pain, EFIC; European Pain Federation, PhD; Doctor of Philosophy. aNot all questions were sent to all panels, since not all were applicable (due to differences in the composition of the panels).

Table S2 – Complete list of topics and judgment by Delphi panel and Validation panels.

1. TAXONOMY AND DEFINING PAIN

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[2] Chronic pain[a]	**2**	**2**	**2**	**2**	**2**
[2] Nociceptive pain[a]	**2**	**2u**	**2**	**2**	**2**
[2] Acute pain[a]	**2**	**2u**	**2**	**2**	**2**
[2] Nociplastic pain[a]	**2**	**2u**	**2u**	**2**	**2**
[4] Reffered pain[a]	**2**	**2u**	**2**	**2u**	**2**
[2] Neuropathic pain[a]	**2u**	**2u**	**2u**	**2**	**2**
[2] Pain definition International Association for the Study of Pain (IASP)	1u	1u	2u	2u	2
[3] Dimensions of pain (sensoric, discriminative, affective, motivational, cognitive, evaluative) [a]	**2**	**2u**	**2**	**2**	**2**
Important / High Consensus					
[3] Recurrent pain	2u	2u	2u	1u	2
Unimportant					
[2] Breakthrough pain					

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
-					
Important / Low Consensus					
[4] Primary and secondary pain	2u	2u	2	1u	1u
[4] Widespread Pain	1u	1u	1u	2u	2
[4] International Classification of Diseases (ICD-11) (pain as a "disease")	1u	1u	1u	2u	2

2. PAIN ASSESSMENT AND MEASUREMENT

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[2] Recognising psychosocial factors[a]	**2**	**2**	**2**	**2**	**2**
[2] Symptoms of chronic pain[a]	**2**	**2**	**2**	**2u**	**2**
[3] Prognostics of chronic pain	2u	1u	2u	1u	2
[2] Evaluation of treatment effects[a]	**2**	**2u**	**2**	**2u**	**2**
[2] Pain perception[a]	**2**	**2u**	**2**	**2**	**2**
[4] Type and location of pain	2u	1u	2u	1u	2
[2] Prognostics of transition from acute to chronic pain[a]	**2u**	**2u**	**2u**	**2u**	**2**
Important / High Consensus					
[3] Pain intensity schales (VAS/ NPRS/ Ladder/Faces Pain Rating Scale	2u	1u	2u	1u	2
[3] Indications for referring to pain specialized physical therapist	1u	2u	1u	1u	2
[3] Questionnaires in general	1	1u	1u	1u	2u
[4] Startback Screening Tool	1u	0	1u	0	2u
Unimportant					
[2] Brief Pain Inventory					
[2] Mc Gill Pain Questionnaire					
[2] Pressure Pain Threshold/Tolerance					
[2] Quantitative Sensory Testing battery					
[2] Thermal Threshold/Tolerance					

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Measuring physical activity	2u	1u	2u	2u	2
[4] Measuring outcomes irt ICF, Disability and Health / World Health Organisation (WHO)	1	1u	2u	1u	2
Important / Low Consensus					
[4] Measuring the social domain (e.g. supportive social network, Pain Disability Index)	1u	1u	2u	1u	2
[4] Interprofessional/ multifactorial pain problem analysis	1u	1u	1u	2u	2

3. MODELS AND THEORIES
3.1 HEALTH AND PSYCHOSOCIAL MODELS / THEORIES

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[2] Biopschosocial model[a]	**2**	**2**	**2**	**2**	**2**
[2] Pain-related workingmechanisms of physical therapeutic interventions (psychosocial) [a]	**2**	**2u**	**2u**	**2u**	**2**
[2] Fear Avoidance model	1u	2u	2u	1u	2
[2] Common Sense Model (Leventhal)	1u	1u	2u	1u	0
[4] Self Efficacy[a]	**2u**	**2u**	**2u**	**2u**	**2**
Important / High Consensus					
[4] Common Factors Model	1u	1u	1u	0	0
[3] Classical Conditioning	1u	1	1u	1	2u
[2] Social models of social support					
[4] Body Self Neuromatrix	2u	1u	1u	1	0

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Influence of passive interventions on locus of control and coping	2u	2u	2u	2u	1u
[4] Positieve Health	2u	2u	2u	1	1u
[4] Balance Load-Load Capacity	2	2u	2	1	0
Important / Low Consensus					
[4] Reconceptualisation	1u	1u	1u	2u	2u
[4] Operant conditioning	1u	1u	1u	1	2u
[4] Stages of Change	1u	1u	1u	1u	2u

Unimportant					
[2] Philosophy of Health					
[2] Cartesian vs Embodied Cognition/ Bayesian Processing					
[2] Sawtooth phenomenon of recovery					
[3] Neglected feelings and emotions as causes of pain	2u	1u	1u	0	2u
[2] Modified / Bottum-Up Consequences model (Zonneveld)					
[2] New Consequences model gevolgenmodel (Van Rood & De Roos)					
[2] Avoidance Endurance Model (Hasenbring)					
[2] Neurophilosophical views					
[3] (dis)Embodiment en ownership	2u	1u	0	0	1u
[2] Complexity science: principals, concepts and methods					

3. MODELS AND THEORIES
3.2 PAIN NEUROPHYSIOLOGY, ANATOMY AND BIOLOGY MODELS / THEORIES

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[2] Central sensitisation[a]	**2**	**2**	**2**	**2**	**2**
[3] Plasticity and the brain[a]	**2u**	**2u**	**2u**	**2u**	**2**
[2] Periferal sensitisation[a]	**2**	**2u**	**2**	**2**	**2**
[2] Pain-related working mechanisms of physical therapeutic interventions (physiologic)[a]	**2u**	**2u**	**2u**	**2u**	**2**
[2] Neuroplasticity[a]	**2u**	**2u**	**2u**	**2**	**2**
[3] Neurophysiology of nociceptive pain[a]	**2u**	**2u**	**2u**	**2u**	**2**
[2] Neurophysiology of nociplastic pain	2u	1u	1u	2u	2
[3] Neurofysiology of placebo & nocebo	2u	2u	1u	2u	2
[3] Neurofysiology of neuropatic pain	2u	2u	1u	2u	2

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Endogeneous pain inhibition: Exercise-Induced Hypoalgesia	2u	2u	1u	2u	2
[4] Brain changes after secondary sensitization	2u	1u	1u	1u	2u
[4] Fysiology of stress[a]	**2**	**2u**	**2**	**2u**	**2**
[4] Autonomic nervous system[a]	**2u**	**2u**	**2u**	**2u**	**2**

Important / High Consensus					
[4] Neurophysiology of modulation	2u	1u	1u	2u	2
[4] Neuro-anatomy of the nociceptive system	2u	1u	1u	1u	2u
[4] The somatosensory system	2u	1u	2u	2u	2u
[3] Neurofysiology of transmission (spinal cord)	2u	1u	2u	1u	2
[4] Neuro-anatomy of spinal cord and different tracts	2u	1u	1u	2u	2u
[3] Neurophysiology of conduction	1u	1u	1u	1u	2u
[3] Loesers' Model	2u	1u	2u	0	1u
[3] Facilitation: Temporal Summation (Wind-Up)	2u	1u	1u	1u	2

Important / Low Consensus					
[4] Pathophysiology of wound healing	2u	2u	2u	0	2u
[4] Neurophysiology of referred pain	2	2u	2u	1u	2u
[4] Neurophysiology of hyperalgesia (primary and secondary)	2u	1u	2u	2u	2
[4] Limbic system and pain	2u	2u	2u	2u	2u
[4] Neurophysiology of interpretation (in the brain)	2u	2u	2u	2u	2
[4] Neurophysiology of allodynia	2u	1u	1u	1u	2
[4] Hypothalamic–Pituitary–Adrenal axis	1u	1u	1u	1u	1u
[4] Neurotransmitters (and their role in endogenous pain inhibition)	2u	1u	1u	2u	2
[4] Endogeneous pain inhibiton: Conditioned Pain Modulation	1u	1u	1u	1u	2
[4] Gate Control Theory	2u	1u	2u	1u	2u
[4] Neurophysiology of transduction (sensor)	2u	1u	1u	1u	2u
[4] Neural Signatures / Neurotags	2u	2u	0	1	0

Unimportant					
[2] Neuro-inflammation					
[2] Allostasis					
[2] Model of Hodges and Tucker ((mal) adaptive movement behaviour and chronic pain relation)					
[2] Cortical "top-down" tracts (including cortical-subcortical brainstem tracts)					
[2] Systemic inflammation					
[2] Physiology of the hormonal/ endocrine system					
[4] Mechanism-based approach	1u	1u	1	0	2u
[2] Perception - Predictive coding & processing					
[2] Neural and non-neural cell interactions concerning pain					
[2] Facilitation: Spatial Summation					
[3] Endogeneous pain inhibiton:: Offset analgesia	1u	1u	1u	0	1u
[2] Mature-organism model					
[2] Opioid and GABA systems (Periaqueductal Grey- Rostral Ventromedial Medulla (PAG-RVM) tracts)					
[3] Neuro-immunology	1u	1u	0	0	2u
[2] Perception - Free energy principle					
[2] Adrenergic tracts (including Locus Coeruleus (LC) tract)					

4. MULTIDIMENSIONAL NATURE OF PAIN

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[3] Cognitions[a]	**2u**	**2u**	**2u**	**2**	**2**
[3] Illness Perception[a]	**2**	**2u**	**2u**	**2u**	**2**
[2] (Pain) behavior[a]	**2**	**2**	**2**	**2**	**2**
[3] Influence of emotion on pain[a]	**2**	**2**	**2u**	**2**	**2**
[3] Fear[a]	**2**	**2u**	**2u**	**2**	**2**
[2] Stress[a]	**2**	**2u**	**2**	**2**	**2**
[2] Complexity of pain[a]	**2**	**2u**	**2**	**2**	**2**
[3] Copings styles[a]	**2**	**2u**	**2**	**2u**	**2**
[3] Influence of pain on movement (motor influence)[a]	**2**	**2**	**2**	**2u**	**2**
[4] Catastrophising[a]	**2u**	**2u**	**2u**	**2u**	**2**
[4] Risk factors for chronic dysfunction due to pain[a]	**2u**	**2u**	**2u**	**2**	**2**
[3] Influence of expectation on pain[a]	**2u**	**2u**	**2u**	**2**	**2**
[3] Contextuelal factors[a]	**2u**	**2u**	**2u**	**2**	**2**
[3] Influence of lifestyle on pain[a]	**2u**	**2u**	**2u**	**2**	**2**

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Kinesiofobia[a]	**2**	**2u**	**2**	**2**	**2**
[4] Influence of mood on pain[a]	**2u**	**2u**	**2u**	**2u**	**2**
[4] Health Literacy	2u	1u	1u	2u	2u
[4] Motivation[a]	**2u**	**2u**	**2u**	**2u**	**2**
[4] Somatisation	2	2u	2u	1u	2u
[4] Influence of culture on pain	1u	1u	2u	2u	2
[4] Depression	2u	1u	1u	2u	2

Important / High Consensus					
[3] Hypervigilance	1u	1u	1u	2u	2u
[3] Influence of comorbidity	2u	1u	2u	1u	2
[4] Influence of family on pain	1u	1u	1u	2u	2u
[4] Optimism	1u	2u	1u	2u	2
[2] Influence of age on pain	1u	1u	1u	1u	1u
[2] Influence of gender on pain	0	0	0	0	1u
[3] Addiction of pain medication	2u	1u	1u	2u	1u
[3] Influence of nurture on pain	1u	1u	0	0	2u
[3] Attention/Distraction bias	1u	1u	1u	2u	1u
[3] Self Acceptance	2u	1u	1u	2u	1u
Unimportant					
[2] Anxiety Sensitivity					
[2] Institutional influence on pain					
[2] Influence of genetecs / heridity					
[3] Misdirected problem-solving	2u	1u	1u	0	0
[2] Influence of early traumatic events on pain					
[2] Pain interruption interference and identity-distorting effects of pain					
[3] Influence of religion on pain	0	0	0	0	1u
[2] Psychiatric/Psychopathology					
[3] Influece of regulations on pain	0	0	0	0	0
[2] Splitters vs Lumpers					

Important / Low Consensus					
[4] Misconceptions – existing dated knowledge in pain	2u	2u	2u	2	2u
[4] Influence of society on pain	1u	1u	1u	2u	1u
[4] Resilience	1u	1u	2u	2u	2
[4] (Primary) Disease Gain	2u	1u	2u	1u	0
[4] Influence of work on pain	2u	2u	2u	2u	2
[4] DIMs' & SIMs (Danger in Me & Safety in Me)	2u	1u	1u	2u	0

5. MANAGEMENT OF PAIN

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[3] Self-management[a]	**2**	**2**	**2**	**2**	**2**
[2] Physical exercise therapy[a]	**2**	**2u**	**2**	**2**	**2**
[4] Behavioural influence on pain[a]	**2u**	**2u**	**2u**	**2**	**2**
[3] Prevention of chronic pain[a]	**2u**	**2u**	**2u**	**2u**	**2**
[2] Active lifestyle[a]	**2**	**2**	**2**	**2u**	**2**
[2] Graded Exposure/Exposure in vivo[a]	**2**	**2u**	**2u**	**2u**	**2**
[2] Lifestyle interventions[a]	**2u**	**2u**	**2u**	**2u**	**2**
[2] Patiënt Centered Approach[a]	**2u**	**2u**	**2u**	**2**	**2**
[2] Graded Activity[a]	**2**	**2u**	**2u**	**2u**	**2**
[3] Adherence / Compliance[a]	**2u**	**2u**	**2u**	**2u**	**2**
Important / High Consensus					
[4] Goal setting	2	2u	2u	2	2
[4] Decatastrophising	2u	1u	1u	2u	2
[4] Exposure with Control/Cognitive Functional Therapy (CFT - O'Sullivan)	2u	1u	1u	1u	1u
[2] Post surgery pain protocol	2u	1u	0	1u	2
[3] Pacing	1u	1u	0	1u	2
[3] Treatment of Neuropathic pain	2u	1u	1u	1u	2

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Pain Science Education as therapy	1u	2u	1u	2u	2
[4] Working interdisciplinary[a]	2u	2u	2u	2	2
Important / Low Consensus					
[4] Empowerment	1u	1u	1u	1u	2
[4] Working multidispilinary	2u	2u	2u	2	2
[4] Education strategies (educational science andragogy)	2u	1u	2u	1u	2u
[4] Relaxation therapy	1u	1u	1u	2u	2
[4] Digital health /pain (education) sources	2u	1u	1u	2u	2
[4] Cognitive behavioural therapy	2u	1u	1u	2u	2

Unimportant					
[2] Stress management					
[2] Respiratory / Breathing training					
[2] Biofeedback					
[3] Acceptance and Commitment Therapy (ACT)	2u	1u	1u	0	1u
[2] Group education					
[3] Psychology informed physical therapy	2u	1u	0	0	2
[2] zRevitalizing therapy					
[2] Cognitive defuse health beliefs					
[2] Rational Emotional Behavioral Therapy (REBT)					
[2] Sleep management					
[2] Pain management stimulator techniques (e.g. Transcutaneous Electrical Nerve Stimulation (TENS))					
[2] Virtual Reality (VR)					
[2] Pharmacological possibilities; (World Health Organisation (WHO) ladder and neuropathic pain management with anti-epileptics en antidepressives)					
[3] Protectometer	1u	0	0	1u	0
[2] Mindfulness					
[2] Mindfulness-Based Cognitive Therapy (MBCT)					
[2] Meditation					
[2] Anesthesiology pain management					
[2] Mindfulness-Based Stress Reduction (MBSR)					
[2] Effects of complementary therapy					
[2] Body-mentalisation (Spaans)					

6. COMMUNICATION

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[3] Shared Decision Making[a]	**2**	**2u**	**2u**	**2**	**2**
[2] Nocebo (practical implications)[a]	**2u**	**2u**	**2u**	**2**	**2u**
[2] Placebo (practical implications)	2u	1u	2u	2	2u
[2] Conversation techniques[a]	**2**	**2**	**2**	**2**	**2u**
[2] Motivational Interviewing[a]	**2**	**2u**	**2u**	**2u**	**2u**
[3] Coaching[a]	**2**	**2u**	**2**	**2**	**2u**
Important / High Consensus					
[2] Narratives of pain	2u	1u	1u	2u	2u
Unimportant					
[2] Expertise by experience (the patients' voice)					

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Empathy[a]	**2**	**2**	**2u**	**2**	**2**
[4]] Dialogue and pain education (lecturing versus Socratic style)[a]	**2**	**2u**	**2u**	**2**	**2u**
[4] Assessment model; Somatic, Cognitive, Emotions, Behavior, Social (SCEBS)[a]	**2**	**2u**	**2u**	**2**	**2u**
[4] Use of metaphors	2u	1u	2u	2u	2u
[4] Therapeutic alliance	2u	1u	1u	2	2
Important / Low Consensus					
[4] Orchestra model (Explain Pain)	2	2u	1u	1u	1u
[4] Teach Back method	2	1u	1u	0	2u

7. BELIEFS AND ATTITUDES PATIENT & HEALTH CARE PROFESSIONAL (HCP) INCL.THE STUDENT

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[2] Attitudes health care professional /student[a]	**2**	**2**	**2**	**2**	**2**
Health beliefs health care professional/student[a]	**2**	**2**	**2**	**2**	**2**

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
-					

Important / High Consensus	Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
-	[4] Student's own experience of pain	1u	1u	1u	1u	1
	[4] Student's own experience of pain from acquaintances who have pain	2u	1u	1u	1u	1
	[4] Self-reflection impact of patient on therapist	2u	2u	2u	2u	2u

Unimportant
-

8. HEALTH POLICY & GUIDELINES IN PAIN

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[2] Guidelines of the Dutch Physical therapy Association (KNGF)	2u	1u	2u	2u	2u
Important / High Consensus					
[2] Impact of pain on society (social, ethical and economic)	2u	1u	1u	1u	2
[3] Organization of care (first, second and third line health care)	1u	1u	1u	1u	2u
[3] Epidemiology of pain	1u	1u	1u	1u	2u
[2] Dutch College of General Practitioners (NHG); Standards of Pain	1u	1u	1	1u	2
[2] History/evolution of thinking about pain	0	0	1	0	1
Unimportant					
[2] Dutch Dataset Pain Rehabilitation					
[2] Legislation; Work and Income according to Work Capacity Act (WIA) / Gatekeeper Improvement Act (WvP)					

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
-					
Important / Low Consensus					
[4] Standard of care chronic pain	2u	1u	1u	2u	2
[4] Standard exercise intervention for chronic pain	2u	1u	2u	1u	2
[4] Standard of care Somatic/ Medically Inadequately/ Unexplained Physical Complaints (MUPS)	2u	1u	1u	1	1

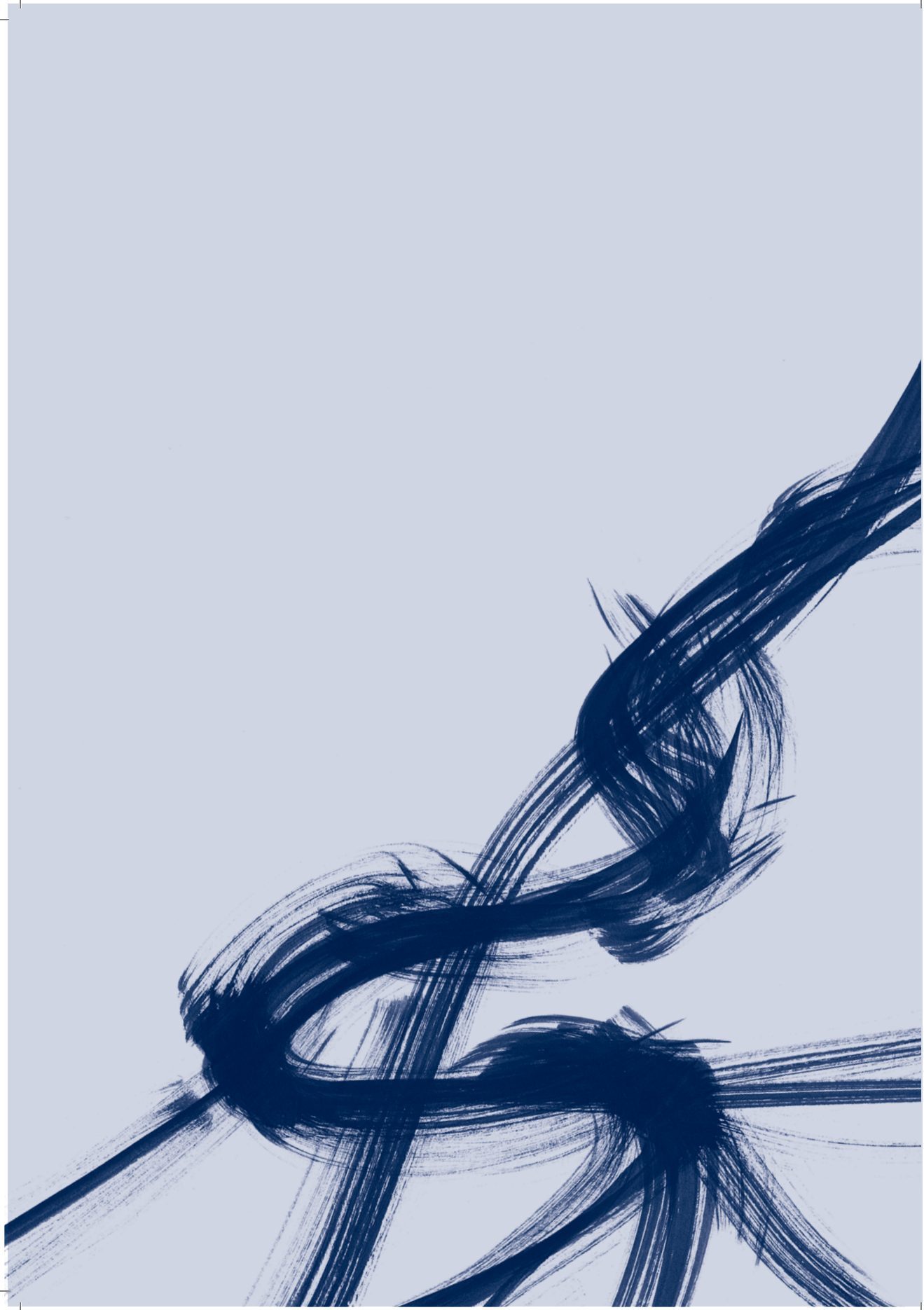
9. PAIN SUBGROUPS / SPECIAL PATIENT POPULATIONS

Highly Important / High Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[3] Musculoskeletal pain[a]	**2**	**2u**	**2**	**2u**	**2**
Important / High Consensus					
[2] Vulnerable populations	2u	1u	1u	0	2
[2] Peripheral Neuropathies	2u	1u	1u	1	2u
[3] Headache	2u	1u	2u	1	2u
[3] Arthritis/inflammatory arthropathies	2u	1u	1u	1u	2
[2] Pain in neurological diseases	2u	1u	1u	1	2u
[3] Oncological pain	2u	1u	1u	1u	2
[2] Post-surgical pain	2u	1u	1u	1u	2
[3] Fibromyalgia	2u	1u	1u	2u	2
[2] Phantom limb pain	1u	1	0	1u	2u
[3] Pelvic pain	1u	1u	1	1u	2u
[2] Migraine	2u	1	1	1	1u

Highly Important / Low Consensus	Early Career Physical therapists	Physical therapists	Non-Pain Lecturers	Post-graduate Educators	IASP / EFIC
[4] Neck- and backpain[a]	**2**	**2u**	**2**	**2u**	**2**
[4] Medically Unexplained Physical Symptoms (MUPS)	2	1u	1u	1u	2
Important / Low Consensus					
[4] Eldery	2u	1u	2u	1	2
[4] Radicular syndromes	2u	2u	2u	1u	2
[4] Tendinopathies	2u	1u	2u	1u	2
[4] Whiplash Associated Disorder (WAD)	2u	1u	1u	1u	2

Unimportant					
[3] Functional pain syndrome	1u	1u	1u	1	1u
[3] Complex Regional Pain Syndrome (CRPS)	1u	1u	1u	1u	2
[2] Children					
[2] Visceral Pain					
[2] Orofacial Pain					
[2] Post Traumatic Stress Syndrome (PTSS)					
[2] Irritable Bowel Syndrome (IBS)					

All topics are placed in bins by the judgement of the Delphi panel and ordered within the bin by percentage agreement of "highly important" on the Likert scale. Validation panel judgements represent bins (2 = "highly important," 1 = "important," 0 = "unimportant," u = uncertain due to high dispersion (0.75 ≤ Interquartile Range ≤ 2.5). Topics deemed unimportant in round 2 by the Delphi panel were not judged by Validation panels. The number in brackets preceding the topic represented the round when the Delphi panel determined the judgement of the topic. [a]Topics (in bold) with a collective consensus of both Delphi panel and Validation panels.



CHAPTER 6

Meaningful contributions of rehabilitation for people with persistent pain; a reflexive thematic analysis

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Abstract

Purpose: This study aims to explore the meaningful contributions of rehabilitation for participants living with persistent pain.

Materials and methods: A phenomenological methodology was used. Thirteen purposefully selected participants, who self-identified as substantially improved from persistent pain due to rehabilitation, were interviewed in-depth. Data were analyzed using reflexive thematic analyses.

Results: Participants included three men and ten women, age ranging from 22–69 years, pain duration was 2-30 years. Seven interconnected themes were developed: 1) indication of negative pain and health care experiences, 2) supporting working alliance with healthcare professionals, 3) Pain Dialogue, 4) improved self-awareness and self-regulation, 5) different view on pain, 6) autonomy and personal growth and 7) hope and new perspective. Integration of these themes provided a framework for understanding meaningful contributions of rehabilitation from the participants' perspective.

Conclusions: The study identified seven interconnected themes enhancing meaningful contributions of rehabilitation for participants who have substantially improved from persistent pain. These findings provide a novel conceptual understanding of how rehabilitation can foster recovery. The themes strongly support person-centred care, an understanding of Pain Dialogue and personal growth through the lens of the lived experience. The quality of the therapeutic relationship is considered a central vehicle for improved health outcomes.

*Keywords***:** Chronic pain, Rehabilitation, Lived experience, Person-centred care, Thematic analysis.

Introduction

Persistent musculoskeletal (MSK) pain is a leading cause of disability worldwide, placing unsustainable strain on health systems(1) and imposing a significant burden on those affected by persistent MSK pain.(2–5) This burden demonstrates the need for effective person-centred care in pain rehabilitation. Although the International Association for the Study of Pain (IASP) defines pain as a complex health condition and acknowledges its personal nature,(6) many health care professionals (HCPs) find it challenging to integrate personal aspects in the management of persons with persistent pain.(7–14) In pain rehabilitation, self-management support is an overall approach to managing persistent musculoskeletal pain,(15,16) which is seen as essential to providing person-centred care.(17,18) Self-management support is defined as 'supporting the individual's ability to manage the symptoms, treatment, physical and psychosocial consequences and lifestyle changes inherent in living with a chronic condition'.(15) Pain Education (PE) is a common component of self-management support, that has been associated with clinically relevant benefits.(19–23) Patients' unhelpful beliefs regarding MSK pain have been associated with higher levels of pain-related fear and avoidance behaviors.(24–27) Identifying patients' beliefs is relevant due to their influence on reconceptualizing pain as safe and non-threatening.(28) PE generally aims to align an individual's pain experience and knowledge with modern pain science, thereby developing and strengthening their own biopsychosocial understanding of pain, which contributes to the conceptual change.(22,23,29) Conceptual change refers to an integral process of restructuring of existing knowledge and acknowledges the relevance of cognitive, behavioral, and emotional aspects of pain.(30)

PE has been developed top-down by clinicians and researchers, relying largely on conceptual models that lack empirical foundation.(31,32) This top-down approach may not accurately address a person's core problems or views on successful treatment outcomes.(33–35) The current perspective is shifting towards increased awareness of participants' view on PE and embracing (inter)active learning frameworks.(36) However, based on the available evidence, it is impossible to make clear clinical recommendations for PE related to participants' perspective on content and delivery.(29,37)The revised definition of pain by the IASP acknowledges that pain is a personal experience shaped by the unique life experiences of the person with pain.(6) Despite the revised definition of pain and the promotion of person-centred care in rehabilitation guidelines, integrating the lived experience of pain remains a blind spot in PE and pain rehabilitation.(29,38–42) As a result, it remains unknown which aspects of PE and pain rehabilitation patients experience as the main valuable contributions.

Including participants' engagement in pain research(43–45) and education is therefore essential, as they are best positioned to provide context for PE based on their experiences.(41,42,46,47)

Qualitative research is the most suitable method to understand the meaningful contributions of rehabilitation in those who live with persistent pain.(47–51) This study used the theory of 'living well with chronic pain'(48)and the conceptual model of the healing journey(52) as a starting point. However, while these models describe processes for recovery from persistent pain, they do not provide insight into the meaningful contributions of rehabilitation for participants who experienced improvement. Previous qualitative studies have explored the experiences of rehabilitation participants undergoing a transdisciplinary PE program(53) and pain reconceptualization following PE in a single center. In these studies patients were commonly consulted by the same clinician, which may limit the transferability of the findings.(29,54–57) As such, the experiences have not yet been explored in a mix of primary, secondary, or tertiary care. The current study focuses on providing insights into a wide palette of meaningful contributions of rehabilitation in participants with persistent pain, independent of a specific program, clinic, clinician, or center. Moreover, focusing on experiences in improvement may lead to a new conceptual comprehension of how rehabilitation may facilitate participants' healing journey. In addition, this understanding has the potential to improve counselling as well as providing an opportunity to revisit HPC educational curricula through the lens of lived experience.(58) The research question guiding this study is: 'What are the meaningful contributions of rehabilitation for people who have substantially improved in living with persistent pain?' Understanding these contributions is important for improving person-centred care and facilitating better rehabilitation outcomes for those living with persistent pain.

Materials and methods

Design

The study design was based on principles of the 'constructionist paradigm', which involves exploring underlying ideas, assumptions, and conceptualizations, that are fluid and context dependent.(59–61) The design involved iterative data collection and analysis of semi-structured in-depth interviews, focussing on facilitating meaning-making, interpreting and theme development.(62) The findings were co-constructed by participant and researcher, with the researcher acting as a 'subjective instrument'. Additionally, an interpretive phenomenological approach was used to gain a deeper

understanding of the meaningful contributions in pain rehabilitation.(60,63–65) The Standards for Reporting Qualitative Research guided the reporting of this study.(66)

Participants

Between June 2021 to December 2022, participants were purposefully selected to encompass a wide range of characteristics.(65) Eligibility criteria included self-identification as substantially improved from persistent pain (defined as pain persisting for more than three months)(67) a history of treatment or currently treated for persistent pain in primary, secondary, and/or tertiary care settings, PE was part of pain management program or treatment, age of at least 18 years, proficiency in Dutch communication and writing, living independently in their own home. Participants were excluded if they had comorbid conditions (severe medical or psychiatric complaints) significantly interfering with their pain, functioning, or quality of life. Recruitment was conducted in collaboration with the Dutch patient organization 'Pijnpatienten naar 1 stem', a collaboration of 11 pain patient's organizations, and through the researchers' network. Those who considered themselves substantially improved were selected and invited to participate and provided written informed consent. Approval for this study was obtained from the local ethics committees committee at the University Medical Center Groningen (M21.267098).

Data collection

Participants' demographic information, including sex, age, family status, type of pain problem, education level (primary, secondary, tertiary), duration of pain, level of healthcare (primary, secondary, and/or tertiary care settings: care provided respectively in a private practice or health center, hospital and/or rehabilitation center) and employment status, were obtained directly from the participants. Before the interviews, participants were informed about the research project, and the interviewer's (AJB) professional background, role, and training. Semi-structured in-depth interviews were conducted using theoretical frameworks related to improvement in persistent pain.(48,52) The primary questions were: (a) "Could you share with me the most difficult moment in your life when dealing with persistent pain?"; b) What was the main impact on your life at that time and how is it now?"; (c) "How do you define improving from persistent pain?"; (d) "What were learnings from rehabilitation that significantly contributed to your improvement?" Additionally, participants were asked to reflect on a series of opposing statements regarding pain (e.g., suffering or challenge?; movement or rest?; exercise or pain medication?; and the significance or futility of understanding pain). Furthermore, questions were asked about learning strategies; 'What was the best way for you to learn about pain?' During the interviews, the interviewer was responsive to the participants' narrative,

asking open-ended questions and follow-up probes to elicit in-depth information. The interview questions were developed by the research team, reviewed by an external pain expert (LM), and the Dutch Patient Association, and pilot-tested with three participants. Feedback from the pilot interviews and the interview skills of the primary researcher (AJB) was provided by two experienced health psychologists.(65) All interviews were conducted by the same interviewer (AJB) at a convenient location for the participant.

Following the initial interviews, the interview's focus was changed to better capture participants' broader perspectives on meaningful contributions, with Pain Education (PE) playing an integral role in this framework. Our initial conceptualization centred on PE, with individuals actively engaging in learning about pain neurophysiology to enhance their condition. During the process, we observed that PE alone did not effectively facilitate a shift in participants' perspectives on pain. Interestingly, PE was not at the center of participants' concerns reflecting on their rehabilitation benefits. Participants held explicit and implicit attitudes toward their pain, contributing to ambivalence and inconsistencies in their interpretation of pain experiences and willingness to adopt rehabilitation strategies. It became evident that PE did not address the primary needs of rehabilitation participants seeking improvement.

We incorporated peer-debriefing from the outset of the interviews. The interviewer (AJB) engaged in discussions and reflections on her experiences, impressions, and findings regarding the interviews with the second author (DP).(60,68) Additionally, reflective notes were maintained to ensure ongoing reflexivity regarding the theoretical framework, interview guide, research team meetings, peer debriefing sessions, and data analysis.

Data analysis

All interviews were audio-recorded and transcribed verbatim by the primary researcher (AJB). Transcripts were analyzed using qualitative software (Atlas-ti 9).(69) Reflexive thematic analysis (RTA) was employed for data analysis.(62) This approach underscores the researcher's subjectivity as an analytic resource and their reflexive engagement with theory, data, and interpretation.(70) The coding process was integral to theme development, encompassing inductive and theoretical/deductive coding approaches.(70,71) Themes represent patterns of shared meaning, underpinned by central concepts that provide a coherent narrative related to the research question.(62,70,71) Themes are assumed to be the final outcomes of data coding and iterative theme development.

Researcher characteristics and reflexivity

RTA captures an approach that fully embraces qualitative research principles and acknowledge the subjective expertise the researcher contributes to the process.(70) The study involved interviews conducted by a researcher (AJB) with a background in physiotherapy and human movement science, pursuing a PhD related to improving pain-related knowledge, attitudes, and beliefs of HCP's. The researcher had no prior relationship with the participants. The second author (DP), an experienced researcher, lecturer, and clinician in physiotherapy and pain, collaborated closely with the primary author through peer debriefing. The third author (GP), an experienced health and clinical psychologist with expertise in qualitative research, provided psychological reflections on the development of themes as interdisciplinary surplus. The remaining members of the research team, along with a rehabilitation participant (EdR) serving as a 'partner in research', retained a somewhat distant position to enable a richer reflection on the research process and its outcomes.

Triangulation

The coding process was collaborative, with two researchers (AJB, DP) coding ten transcripts and three additional interviews used for refinement. Discussion and reflection on accuracy of codes took place, with the aim of developing a rich and nuanced reading of the data. For RTA, a six-phase process for data engagement, coding and theme development took place, consisting of 1) data familiarisation, 2) systematic data coding, 3) generating initial themes from coded and collated data, 4) developing and reviewing themes, 5) refining, defining and naming themes, and 6) writing the report.(70) After eight interviews, an authors' group meeting was held to determine the relevance of codes, and the relationships between codes in relation to the overall research question. A rehabilitation participant (EdR) participated in the authors' group meeting and collaborated with the primary researcher during consultations.(43) The results of this meeting provided input for follow-up interviews. In RTA, codes are dynamic, subject to evolution, expansion, rephrasing, merging, or deletion.(62,71) During meetings of GH, DP and AJB, themes were discussed on relevance and quality (information power).(64,72) Conceptual depth was achieved when themes reached richness and diversity for refinement.(71) Quotations from various participants were selected and translated into English to support theme reporting.

Results

Participants

Sixteen eligible participants were invited for an interview, of whom three declined due to either excessive time commitments or unspecified reasons. In total, 13 participants were interviewed (three men, ten women). The age range was 22-69 years. The range of duration of pain was 2-30 years (table 1). The interviews lasted 90-120 min.

Table 1: Characteristics of participants N=13

Part. nr	Age (yrs)	Sex	Pain condition	Duration of pain (yrs)	Education[a]	Working status	Highest level of Care
1	28	M	Low back pain & generalized pain	8	Tertiary	Working	Tertiary
2	53	M	Fybromyalgia	17	Secondary	Working	Secondary
3	39	F	Fybromyalgia	15	Tertiary	Working, student	Secondary
4	42	F	CRPS	8	Tertiary	Not working	Tertiary
5	36	F	Low back pain & generalized pain	10	Secondary	Not working	Secondary
6	34	F	Pelvic & hip pain	4	Tertiary	Working	Secondary
7	22	F	Shoulder& neck pain	6	Tertiary	Student	Primary
8	38	M	Abdominal & groin pain	2	Tertiary	Working	Secondary
9	69	F	Neck pain	3	Tertiary	Volunteer work	Tertiary
10	64	F	Fybromyalgia	14	Tertiary	Early retirement	Primary
11	55	F	Post cancer pain	8	Primary	Not working	Tertiary
12	49	F	Fibromyalgia	30	Tertiary	Working	Tertiary
13	65	F	CRPS	12	Tertiary	Working	Tertiary

CRPS; Complex regional pain syndrome. [a] Education level: Primary, Secondary, Tertiary. Primary: primary school, lower secondary general education, lower vocational education; Secondary: higher secondary general education, intermediate vocational education, Tertiary: Higher vocational education, university.

Meaningful contributions - an overview of themes

In total seven themes were generated. The integration of the seven themes (figure 1) provides a comprehensive framework for understanding meaningful contributions of rehabilitation in participants who have experienced a substantial improvement in living with persistent pain. For readability, numerical identifiers have been assigned to the themes. In practice however, the themes are interconnected and without a

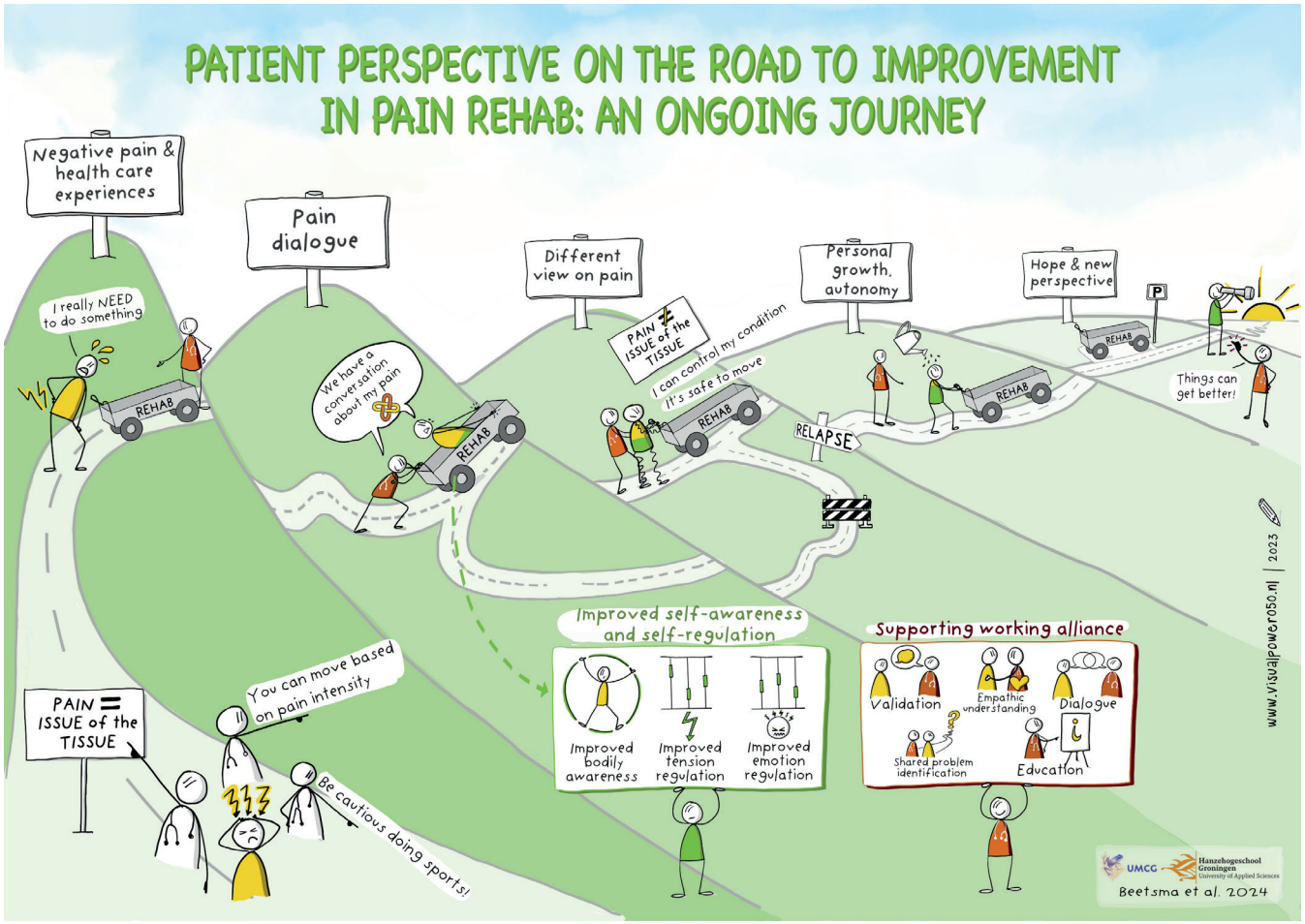


Figure 1. Meaningful contributions of rehabilitation for participants living with persistent pain.

ranking. The first theme focuses on the indication of negative experiences related to HCPs by rehabilitation participants, which has led to a state of earlier hopelessness and sets the foundation for the generation of themes that contributed to the process of improvement. Participants reported feeling distressed due to their past negative experiences, which ultimately led them to seek help in rehabilitation. The second theme focuses on the supporting working alliance with the HCP, in which the validation of the experience of pain was a prerequisite, as well as an acceptable and meaningful explanation for pain. The third theme involves deepening the interaction between the participant and the HCP, by using the supportive and meaningful role of education and communication in Pain Dialogue. Improved self-awareness and self-regulation (fourth theme) relate to the processes contributing to the development of a different view on pain and a helpful adaptive mindset about their body in pain (fifth theme). This ongoing process led to improved self-esteem, autonomy, and personal growth (sixth theme), which in turn facilitated an improved connection with others. The seventh theme concerns experiencing hope and new prospects for change. The processes underlying experienced improvement should be viewed as an ongoing journey of healing, rather than an endpoint of rehabilitation. This journey seemed to require a transition from a pain-centred approach to a more person-centred approach in rehabilitation.

Theme 1: Indication of negative pain and health care experiences

Earlier negative experiences in healthcare and with HCPs were reported by almost all participants, causing distress, negative expectations, and a loss of motivation to seek help and to explore new pain coping strategies (again). The participant's desire for healing and renewed help-seeking was primarily motivated by the accumulation of suffering. The pain itself was also identified as an important negative experience for many participants. For example, participants pushed themselves beyond their limits, ignored bodily signals, or suppressed the pain until it became unbearable. Participants often interpreted the pain as tissue damage and potentially harmful and would return to old thoughts and habits consistent with the biomedical model.

> *"I push myself twice as hard when things get difficult...when I push myself twice as hard, I don't feel the pain anymore." (P1)*

Many participants reported struggling with their pain over extended periods and developed a dysfunctional relationship with their condition. Their pain was viewed as an external adversary, which posed a constant threat. As multiple participants reported receiving advice from their HCP based on a biomedical (i.e., tissue damage) model and provided conflicting advice, contributing to uncertainty, fear, and distress

and for some participants, intensified the search for a medical diagnosis. Common negative learning experiences included beliefs such as "exertion or exercise is detrimental to me", "I need to move based on the pain intensity" and "I am responsible for causing my own pain." Participants reported also protective advice received from their HCPs related to physical activities and sports, suggesting individuals to become more cautious in loading their bodies and potentially developing dysfunctional behavior patterns and bodily protective behaviors.

> *"I started living according to my pelvic and hip trauma... That means I became more careful; I won't go running because my pelvis and hips are not strong enough, or I won't get pregnant again because my pelvis and hips probably can't handle it." (P6)*

Participants consistently highlighted a lack of alignment and agreement in problem identification and problem approach between themselves and their HCPs. They yearned for a holistic and person-centred approach that was often absent. Participants indicated that fragmentation of healthcare contributed to this problem.

The biomedical explanation for their symptoms, and a lack of acknowledgement and comprehension of their conditions left some participants feeling rejected and abandoned, leading to feelings of hopelessness and loneliness.

> *"The rheumatologist basically only said, "You're overweight, you need to lose weight, and then fibromyalgia will disappear on its own". That didn't really help." (P3)*

Theme 2: Supporting working alliance with HCP

A recurring and pivotal concern in the context of experiencing improvement in living with pain is a positive working alliance with their HCPs. This alliance was experienced as essential for effective treatment. Participants consistently indicated that when they felt understood and attentively listened to by their HCPs, they were more likely to actively engage in rehabilitation and embrace novel behaviors.

> *"HCP took me very seriously because she said: 'If you have boundaries, you should respect them. If I can help you with that, you should say so, then we can look together at what you need'...that was the first time I thought, I also have something to say here...that you can learn to set your boundaries in a safe setting." (P3)*

Validation by their HCPs included empathetic understanding, clear explanations about symptoms (e.g., the concept of pain without tissue damage), a safe treatment environment, an individualized assessment of needs, a positive working alliance, and reassurance against abandonment.

Most participants valued a person-centred approach, where HCPs attentively listened to their pain experiences, displayed empathy, and engaged in collaborative problem identification. This approach built trust in both the healthcare provider and the treatment. Some participants felt more secure and understood when their complex needs were addressed by a multidisciplinary team of HCPs, emphasizing the importance of supportive messages conveying a realistic perspective. These messages regulated tension and emotions, offering hope for improvement.

> *"HCPs said: we don't have all the answers, but we can help you discover the solution together." (P1)*

> *"I think information is important because otherwise, you're really a victim of your own life. That's also the case with pain; you lose control, the body you always relied on suddenly doesn't work anymore...what you need is someone who thinks along with you...The most important thing about the HCP is to give someone the experience that they are not alone." (P9)*

Participants also mentioned less successful working alliances. They mentioned that they relied heavily on the HCPs explanations and did not feel ownership of their own health concerns. They faced difficulties in managing their own health and achieving sustainable positive changes. These feelings of dependency towards the HCP prevented them from taking an active role in self-management and hindered their ability to develop the necessary skills and knowledge for long-term self-care.

> *"I notice that I am too dependent on the explanations of the PT. If I have pains in my diaphragm region, I confuse it with heart problems and immediately experience a hypochondriacal attack." (P6)*

Theme 3: Pain Dialogue

This theme underscores a pivotal lesson in rehabilitation, PE effectiveness hinges on acknowledging the role and influences of the other themes and meeting implicit needs. We found that participants' selection of education and communication strategies is shaped by heightened self-awareness and self-regulation, external influences, and past negative experiences. Participants were able to listen, learn, and

explore new strategies, when HCPs adopt a person-centred approach, recognizing participants' expertise and experiences as valuable sources of knowledge. This approach, the so called 'Pain Dialogue' fosters respect, empowerment in self-care, and learning aligned with individual strengths and needs. Much of the learning process was not explicitly programmed, but arises from experiential reception of reassuring, and supportive HCP messages.

> *"What I really appreciated is that the HCPs assumed that we were the experts and that allowed us to learn from our own foundation." (P3)*

One notable positive outcome of Pain Dialogue was the alteration of participants' emotional perception of their illness. They no longer perceived their pain as imaginary or self-inflicted. Moreover, when a message such as "you do not have a pelvic and hip trauma; your pelvic and hip area is strong," was nested in a larger narrative conveying the message, this appears to enhance the strength and credibility of the message.

All participants highlighted the significance of active learning, which involves learning through reflection on personal experiences, supported and facilitated by the HCP.

> *"PT provided an explanation that made me think, 'actually, I'm still doing very well...a lot depends on how he approaches things and how calm he was and listened...he has so much knowledge about pain experiences." (P6)*

The experience of some participants underscored the importance of integrating theoretical knowledge with their own personal pain encounters, a process further facilitated by real-life events. For instance, when confronted with a novel pain experience, one participant encountered difficulties in applying their explicit knowledge about pain to comprehend it. This scenario underscored the participant's need for guidance and support from the HCP to effectively adapt to and attribute meaning to this newfound experience of pain.

> *"Actually, the penny only really dropped when things went wrong. The theory was there, but in practice I got more and more symptoms and then I got stuck, and the PT pointed out to me: look at what's going on in your life, and then I thought and felt, suddenly: aha! That's how it works in practice." (P5)*

One participant reported that explicit PE combined with personal experiences yielded positive learning outcomes. Through reflection on these processes, the participant gained insights into both unhelpful and beneficial thoughts and behavioral patterns.

He perceived these learning processes as instrumental in enhancing their capacity to 'manage pain in a better way.' Furthermore, some participants acknowledged that their negative thoughts had been impeding their progress, and this realization emerged through confrontational dialogues with their HCPs. Such constructive interactions allowed space for doubt, catalyzed change, and ultimately contributed significantly to their recovery.

> *PT: "You go to bed three times a day and you sleep? Did you do that before you got pain? It's not logical that you sleep 12 hours every day." "I had never thought about it that way." (P8)*

HCP-guided education, as Pain Dialogue, empowered participants to structure their daily and weekly routines, employ active coping strategies, and engage in activities with reduced bodily protective behaviors. Many participants discovered satisfaction and relaxation in time-structured training or movement, characterized by clear progression, fostering a sense of achievement, and bolstering self-efficacy. These experiences enhanced their ability to regulate physical exertion and symptom management, reducing fear and nurturing confidence in their physical capabilities. Consequently, participants embraced a more adaptable and diversified approach to managing their pain.

> *"My brain sends the wrong signals, and you can train that...I can be very disciplined...and that gives me a lot of satisfaction...I did the exercises on a time schedule (time contingent), and that's how I set boundaries." (P10)*

> *"My PT said: "I see no reason why you can't run". "That gave me a feeling that I can just do something, while I thought I shouldn't do it, that makes such a difference in your self-confidence." (P6)*

Positioning of Pain Education (PE) as explaining pain neurophysiology

Finally, it was noteworthy that most participants struggled to articulate and reproduce what they learned about pain neurophysiology, including aspects such as the involvement of the central nervous system and the brain. The position of PE, as learning about pain neurophysiology, evolved during the research process, emerging as a subtheme.

Theme 4: Improved self-awareness and self-regulation

During rehabilitation, some participants gained heightened self-awareness and body perception, boosting their confidence, self-efficacy, and the ability to view their pain differently. These improvements led to increased freedom, self-control, and the capacity to prioritize their values, ultimately enhancing self-esteem. Previously, limited self-regulation hindered their ability to adopt new perspectives on their pain problem. For instance, one participant, fearing her neck might detach, demonstrated a profound sense of insecurity within her own body. Trusted HCP-led Pain Dialogue emphasizing that pain does not necessarily indicate tissue damage could alleviate uncertainty and anxiety.

> *"Physiotherapy has had an impact on 'making peace again with my body', 'taking ownership of that entire upper back and neck' and thinking again; this is a part of me." (P9)*

As participants underwent a shift in their self-regulation, their engagement within the rehabilitation program increased. Certain individuals adopted attitudes encompassing respecting their own boundaries, a heightened acknowledgement of pain's significance, increased body awareness, pain acceptance, and the allowance of emotions, resulting in more effective tension regulation.

> *"I have learned that I am allowed to have and show emotions, and I notice that this does me a lot of good physically. It had caused a lot of tension in my body, and I notice that I can relax better now." (P3)*

For some participants, receiving a diagnosis or explanation engendered a sense of security, further reinforced by a trusted HCP. Additionally, Pain Dialogue itself enhanced confidence and contributed to tension regulation, facilitating an improved connection with their inner selves.

> *"The key to success is that it is in my consciousness, that I know what is going on, together with my positive mindset and returning to my own normal as soon as possible, that made the difference." (P8)*

Theme 5: Different view on pain

Our study unveiled intricate and individualized shifts in participants' views on pain. Prior to rehabilitation, many participants believed their persistent pain was caused by physical issues and tissue damage. However, their core beliefs evolved through interactions with their HCP and improved self-awareness and self-regulation. They

learned that movement is safe, and pain does not necessarily indicate tissue damage. These new beliefs contrasted starkly with their previous beliefs, which centred on the idea that pain signaled a severe bodily problem.

> *"What truly altered my perspective was when my physiotherapist (PT) said, you can just move... understanding central sensitization and knowing what's going on in my life right now, there's no cancer or anything were pivotal." (P5)*

For some participants, understanding pain as originating from bodily signals and an overactive nervous system (such as the concept of central sensitization) helped to reduce their perception that "pain is happening to me." In some cases, learning about the multifaceted nature of persistent pain empowered them to identify factors they could control or manage.

> *"My brain is completely unaccustomed to it, so it sounds the alarm. My brain wants to protect me very well. Understanding this was very liberating, enabling better recovery." (P10)*

Participants also recognized the significance of their own behavioral patterns. Our findings showed that understanding the benefits of exercise and physical activity, even in the presence of pain, helped recognize the importance of adopting healthy habits and maintaining a daily structure.

> *"I had long attributed my pain to pelvic and hip trauma, but my PT said; your pelvis is strong, you can go running, that made a significant impact." (P6)*

> *Talking about his rehabilitation process: "My back had only grown stiffer over the past 1.5 years due to excessive rest. I needed to break that pattern. Instead of lying down, a walk in the forest was more beneficial." (P8)*

Several participants emphasized comprehending the adverse effects of persistent dysfunctional behavior patterns and reported heightened awareness of their unhealthy dysfunctional relationship with pain. Some HCPs encouraged them to cease battling pain and view their situation differently, empowering participants to take ownership of their recovery and experience positive physical and mental changes.

> *"I gained insight into my relationship with my pain... which was predominantly adversarial further perpetuated by a diagnosis of pelvic and hip trauma. My PT altered my perspective; from being physically unfit to realizing that I did not have*

a healthy relationship with my pain and that I do have control over it, steering me away from fear and victimization." (P6)

In conclusion, participants' evolving perspectives on pain, shaped by rehabilitation, HCP guidance, and improved self-awareness, encompassed a transition from viewing pain as an external affliction to recognizing their agency in managing and improving their condition. These shifts underscore the complex and individualized nature of pain perception and management.

Theme 6: Autonomy and personal growth

Our findings indicate that, during rehabilitation, a heightened sense of ownership over their pain, increased autonomy, personal growth, and enhanced empowerment are pivotal experiences, although these were usually not explicitly stated as treatment goals. A more positive attitude towards their inner selves correlated with a more positive attitude towards pain, as participants recognized their active role and autonomy in the improvement process. Some also identified the detrimental impact of a victimhood mindset, contributing to this transformative change.

'I used to think that the pain wasn't real, I shouldn't make a fuss, there was nothing physically broken, but now I take that pain very seriously. That was a real eye-opener" (P10)

Furthermore, some participants emphasized significant shifts in their work situations and environments, along with their ability to work without worsening symptoms. These changes held great importance for improved self-esteem, self-efficacy, and identity. For achieving these transformations, gaining insights, and exploring new work strategies such as pacing and adapting tasks or environments, was necessary.

"I can even derive satisfaction from work on bad days, because there are still things I can do, and I no longer have to protect myself constantly." (P1)

"That was a real eye-opener that you can work actively all day without overloading and getting physical complaints." (P2)

Theme 7: Hope and new perspective

Participants gained confidence in their capacity for positive change and improvement of their condition in rehabilitation. They expressed hope and optimism as they developed a different view on pain and a stronger sense of ownership for their recovery. This transformation was particularly pronounced when participants

received encouragement and confidence from their HCPs, validating the possibility of improvement. Experiencing validation and maintaining optimistic recovery expectations, enhanced confidence in the future. Participants valued realistic perspectives and appreciated HCPs explicitly promoting a "growth mindset", emphasizing the potential for learning and change. This shift towards a more positive perspective and increased psychological flexibility, facilitated acceptance of their situation. Additionally, the realization of self-efficacy and improved functioning empowered participants, providing a profound sense of liberation.

> *"I was examined the entire day by a multidisciplinary team and when I got home, tears rolled down my cheeks. Finally, there was a story, which gives an enormous feeling of relief and perspective. This is super relevant for your recovery, and you have a goal together." (P6)*

> *"It was the first time someone said to me, 'You have this, and it can get better.' If she has so much confidence in it, it gives confidence in yourself." (P7)*

Discussion

Our aim was to understand the meaningful contributions of rehabilitation for participants who have substantially improved in living with persistent pain. The interconnectedness of the themes and framing them within the process of meaningful contributions of rehabilitation, provides a novel conceptual understanding of how rehabilitation can enhance recovery. We argue that pain is a personal experience, as such, a person's pain cannot be understood without the lived experience. Consequently, emphasis in pain rehabilitation varies depending on evolving personal needs. These are primarily unconscious and diverse aspects that contribute to individuals' improvement in persistent pain. The themes illustrate the challenges encountered by the participants, as well as the paths they discovered and pursued to transform their perspectives on pain, self-awareness, trust in HCPs, and the necessary steps for their own journey of development. The processes underlying experienced improvement should be viewed as an ongoing journey of healing, rather than an endpoint of rehabilitation.

Regarding meaningful contributions of rehabilitation, it appeared that this process required a shift from a pain-centred approach to a person-centred approach. Many participants experienced a shift in their perspective on pain and personal mindset

after enduring prolonged negative healthcare experiences. This shift was facilitated by establishing a trustworthy and validating working relationship with their HCP, alongside enhanced self-awareness, and self-regulation. Within the alliance, Pain Dialogue played a vital role. It served to validate the participants' perception that their thoughts and feelings were understandable and legitimate, while also contributing to alleviate negative emotions, increased expression of feelings, and facilitated shared decision making and sense of autonomy.(73–77) Effective reception of safe and credible messages depended on the HCP's ability to explain the participant's condition in an understandable manner and the participant's trust in the HCP to provide reassurance. Key elements of successful Pain Dialogue included a focus on the persons' unique circumstances, including perceptions and emotions, the provision of a safe environment, and the contextual relevance of information to the individual's specific situation, rather than the exclusive emphasis on neurophysiological content. Rehabilitation could promote autonomy and personal growth and fostered hope and resilience in participants, empowering them to approach and perceive their own body-mind-processes in a more positive and adaptive manner. Consequently, this growth in capacity for self-regulation,(77) positive self-perception, self-esteem, and autonomy in pain management can meaningfully impact their well-being.

In this study, effective pain management found its foundation in the personal journey of development, where addressing needs was pivotal. Participants reported that when they felt understood and heard by their HCPs, they were more likely to actively engage in rehabilitation and be receptive to confronting the meaning of pain and their way of coping. The existing literature assist the idea that a supportive partnership encourages participants to actively participate in rehabilitation(39,78) and promotes self-management.(79) An HCP who is understanding, empathetic, and acknowledges the unique needs, values, and goals of their rehabilitation participants is considered essential for a person-centred approach in PE and pain management. This approach also involves facilitating Pain Dialogue and supporting and empowering the rehabilitation participant through the development of appropriate person-centred skills. These results appear to be consistent with other research on the topic.(18,38,45,77,80–83) It is within an adequate context, where distrust and anxiety are addressed and overcome, that Pain Dialogue, exploration, and exercise can truly find their grounds. Thus, the quality of the therapeutic relationship is considered a central component for the effectiveness of person-centred care and Pain Dialogue.(84,85) Furthermore, we learned from the participants that previous health care experiences, based on a more biomedical model often lacked alignment and agreement on problem identification, treatment strategies, resulting in negative

expectations, feelings of unsafety and invalidation. In previous research, many of the rehabilitation participants reported that they did not receive what they felt they needed in previous health care settings.(86)

For improvement in self-empowerment and autonomy, a deep conceptual change in understanding their experiences of pain is required.(87,88) For this, HCPs should provide space and opportunity for critical, guided reflection to encourage rehabilitation participants to re-examine their beliefs and attitudes. While participants wished the encounters to be empathetic and individualized, these aspects were often not sufficient to achieve sense of ownership and autonomic agency. A person-centred working alliance led to trust and productive, reciprocal discussions on critical issues that emerged during the rehabilitation process. Previous qualitative research has, similarly, highlighted the importance of a strong working alliance and active involvement of the participants in their own rehabilitation.(89,90)

Many clinicians 'explain pain' or 'apply PE' in a pain-monologue matter focusing on educating modern pain beliefs, not aligned with a person-centred approach. Important limitations of conventional PE have become clear.(36) The learning objectives of PE are only achieved in about 50% of the patients.(29,91) Pain and disability did not improve in those patients who did not undergo conceptual change.(36) This finding is corroborated by qualitative appraisal of patient responses to PE.(54,55) In this study, most participants could not articulate and reproduce what they actually learned about pain neurophysiology in PE. This outcome diverges from our initial expectations of what was perceived important in pain rehabilitation. Rehabilitation participants learn to adopt a different perspective on their pain enabling them to progress, with less emphasis on their ability to articulate the neurophysiological mechanisms behind it. These outcomes align with recent findings of participants who experienced a change in their pain beliefs after PE, which were enhanced by a strong therapeutic relationship.(92) The working alliance with the HCP, the diverse nature of pain conditions, and various factors impacting individual's pain experiences present challenges in participating in rehabilitation and adopting PE. Also, some participants lacked resilience or access to supportive environments, hindering their ability to adopt a helpful perspective towards pain. Even those with extensive knowledge of pain and understanding its victimization aspect reported difficulties managing flare-ups. The existing literature supports the notion that for behavior change, an understanding of capability, opportunity, and motivation constitutes three fundamental conditions for behavior (COM-B model).(93) Participants held explicit and implicit attitudes towards their pain, which can contribute to ambivalence and inconsistencies in their interpretation of pain and what is adopted from rehabilitation. Target concepts taught

in PE(28) could modify core beliefs, however, superficial changes with low learning yields can lead to a relapse into old biomedical thoughts and habits.(29,30) While individuals may experience a perceived overall effect of PE, their sense of ownership over the problem, autonomy and personal growth, functioning, and quality of life may not improve. Conversely, the favorable results of PE may manifest differently, involving a focus on person-centredness and supporting a robust working alliance during PE. This means allocating enough time, attentive listening, delivering a clear explanation, and gaining insight into the patient's symptoms and body awareness. The ultimate goal is to help people to attain self-control(77) and find inner peace. (47,53)

This study introduced a novel concept, termed Pain Dialogue, which integrates personalized PE, as opposed to the conventional HCPs' pain-monologue approach, focusing on educating patients about pain neurophysiology. To enhance the effectiveness of PE, it should go beyond educating about pain neurophysiology and consider participant's broader needs and perspectives.(94–96) Participants conveyed that their inclination to actively participate in Pain Dialogue and adopt new behaviors was heightened when they perceived that their HCPs comprehended and attentively attended to their concerns. When HCPs adhered to a person-centred approach, explicitly conveying, "I might be able to help you, if we collaborate to clarify your pain" and recognizing the participants' expertise and experiences as valuable reservoirs of knowledge, this further facilitated the establishment of a productive Pain Dialogue. Recognizing the influence of pain's threat value on individuals understanding and coping, allowing rehabilitation participants to share their stories can promote readiness for PE.(29,77) In Pain Dialogue, viewing pain as adaptive processes and understanding the biopsychosocial aspects can develop greater resilience to cope with flare-ups.(28) These aspects in Pain Dialogue enhances rehabilitation participants' ability to cope with their condition, leading to active interventions like exercise, pursuing valued life goals, and promoting recovery.(29)

Strengths and limitations

Conceptual analyses of qualitative data, such as reflexive thematic analysis are interpretations of qualitative data. This interpretive process can be considered a strength because analyses rely on a rigorous approach to the data combined with reflexive and creative processes. Through an iterative and inductive approach to theme development, we were able to achieve conceptual depth and refine themes. To strengthen the rigor of our study, we implemented several measures such as extensive peer debriefing, researchers' group meeting and a rehabilitation participant as a partner in research was included. We also consulted with an experienced clinical

health psychologist to prevent researchers from leaning towards certain codes and themes. Additionally, the eligibility criteria were purposely broad to increase the transferability of our findings. We also paid significant attention to elaborating on the experiences of participants to ensure the credibility of the study. Our interviews lasted an average of two hours, which is longer than the typical one-hour duration of such interviews. Despite the researcher who conducted the interviews receiving interview training from an experienced clinical health psychologist and completing a course on qualitative research and analysis during the study, she had no prior experience in interviewing or conducting qualitative research. Despite efforts, individuals with low health literacy are underrepresented in the present study, limiting transferability to this relevant subgroup. It might even be reflective of the worrying observation that fewer people with low literacy benefit from healthcare interventions.(97,98) There are only 3 men included in the study. This could be seen as a limitation although the goal was not to be representative, but rather to have a rich sample. Also, the literature and our data do not suggest that there are differences between men and women regarding this subject. For improvement, we have relied on self-reported progress from a patient's perspective aligned with a person-centred approach and the lived experience. If an appropriate objective measure were available, it could be beneficial to integrate this instrument into our study alongside self-reporting.

Recommendations

The effectiveness of PE is dependent on the presence of a supportive working alliance between the person and the HCP, as well as the fulfillment of the participants' implicit needs. To enhance the effectiveness of PE, a shift from a pain-centred approach to a person-centred one should be considered, thus giving rise to the concept of Pain Dialogue. The themes derived from this study support person-centred care in pain rehabilitation and the pivotal role of Pain Dialogue, viewed through the lens of the lived experience. Consequently, we need to assess the outcomes of rehabilitation in a manner that more accurately aligns with a person-centred approach.(98,99) The quality of the therapeutic relationship is considered a central vehicle for the effectiveness of person-centred care and Pain Dialogue. Insight in the processes leading to new conceptual understanding of participants' meanings, holds an educational potential in HCP training. Providing HCPs with opportunities to listen to participants narratives, creates the opportunity for transformative learning beyond the biomedical to a biopsychosocial, person-centred approach to health care. From this study, it seems very important to explicitly state goals related to a sense of ownership, personal growth, and autonomy in rehabilitation. These aspects in rehabilitation can provide direction and guidance for conversations with people with persistent pain.

Based on the findings of this study, the question arises whether the field of research into persistent pain learns enough from the perspective of the patient, who is an expert by experience. We would recommend learning from individuals with lived experience and incorporating patients as partners in research.(43) Going beyond mere participation in research, individuals with lived experience provide invaluable insights. Their knowledge enriches our understanding of the treatments being studied, facilitates the translation of knowledge into practice, and contributes to achieving more favorable outcomes. For face and content validity of patient reported research instruments, the standard should be to see patients as experts.(100) Future research is warranted to evaluate the impact of pain treatment approaches, incorporating person-centred care, Pain Dialogue, and a supportive working alliance to assess how these changes influence pain rehabilitation. Also, future research is needed in patients with low health literacy and in patients with low socioeconomic status. This patient population may require a different approach with a tailored recruitment method. Perhaps different themes are at play compared to those observed in the current study. Qualitative research can guide the development of educational strategies by examining how patients' values inform treatment and advice.

In conclusion, this study demonstrates seven interconnected themes contributing to meaningful contributions of rehabilitation for participants who have substantially improved in living with persistent pain. These findings provide a novel conceptual understanding of how rehabilitation fosters recovery. The themes strongly support person-centred care, an understanding of Pain Dialogue and personal growth through the lens of the lived experience. The quality of the therapeutic relationship is considered a central vehicle for improved health outcomes.

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Declaration of interest

The authors report no conflicts of interest.

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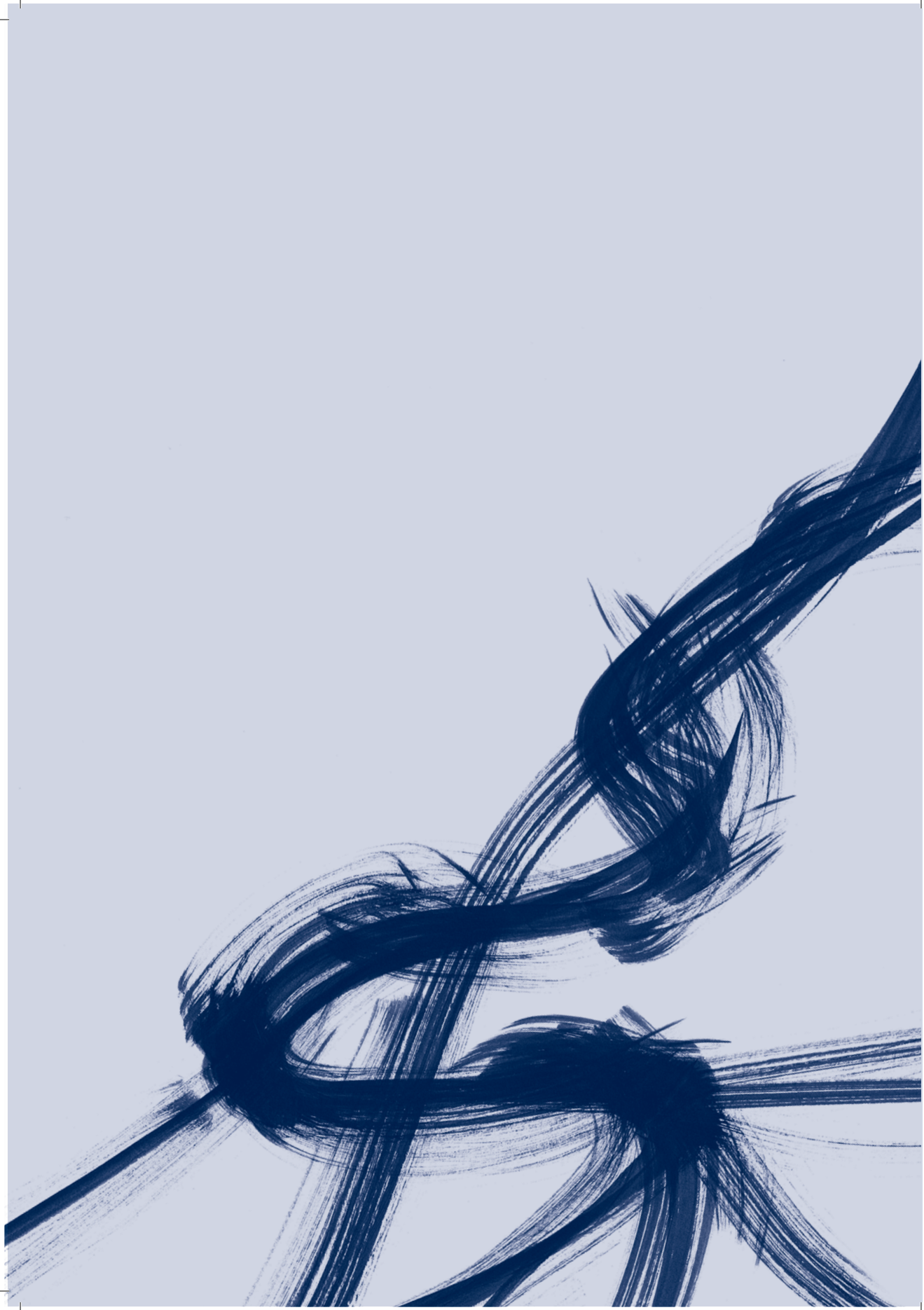
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CHAPTER 7

Benefits of an enhanced educational intervention on biopsychosocial pain knowledge, attitudes and clinical behavior of physical therapist students. A cluster randomized trial

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Abstract

Introduction: It is unknown whether person-centered pain education approaches for physical therapist (PT) students elicit positive guideline-consistent changes in knowledge, attitudes and clinical behavior. This study aims to evaluate the effects of an enhanced educational intervention (EEI) compared to education as usual (EAU) among entry-level PT students.

Review of Literature: Many (future) PTs adhere poorly to evidence-based clinical guidelines and find it challenging to integrate biopsychosocial (BPS) elements in the management of persistent musculoskeletal pain.

Subjects: The eligibility criteria included all first- and second-year students from the Dutch 4-year entry-level PT education program at Hanze University of Applied Sciences in Groningen, the Netherlands.

Methods: A cluster-randomized controlled trial design was used. Primary outcomes were pain knowledge, attitudes, and self-reported clinical behaviors. Intervention duration was 8 weeks. EEI teachers were additionally trained. Students were blinded to group allocation. Data were analyzed using linear mixed models and responder description.

Results: N = 187 students responded at baseline and n = 264 post-intervention, 63% being paired measurements. Both groups improved significantly on all outcomes, with the EEI group demonstrating greater improvement than EAU in 4 out of 5 outcomes: Video Vignette score (p=<.001), Written Vignette score (p=.03), Knowledge and Attitude of Pain (KNAP) (p=.006), Pain Attitudes and Beliefs Scale for Physiotherapists biopsychosocial sub-scale (p=.064), biomedical sub-scale (p=.019). Responder analysis demonstrated greater improvement in EEI than in EAU in all outcomes, with 48% of the EEI group exceeding the Minimal Clinically Important Change for KNAP.

Discussion and Conclusions: Implementation of EEI lead to better guideline-consistent BPS pain knowledge, attitudes, and self-reported clinical behaviors in PT students. These findings could enhance professional PT programs by focusing on improving students' contemporary pain beliefs and clinical behaviors. The natural educational setting facilitated easy implementation of the intervention.

Keywords: Educational intervention; Cluster randomized design; Person centeredness; Pain Science Education; Pain beliefs; Pain clinical behavior.

Introduction

Integrating pain education into the curriculum has improved physical therapist (PT) students' understanding and approach to pain[1,2]. Knowledge of the optimal content and dosage for a person-centered approach in PT education to improve students' clinical behavior is lacking[2,3]. To address these gaps, an Enhanced Educational Intervention (EEI) was developed, based on IASP[4] and EFIC curricula[5] and a consented PT pain curriculum topic list[6].

The present study aimed to evaluate the effects of the EEI compared to education as usual (EAU) among entry-level PT students. The research question was: "To what extent is an eight-week EEI, compared to EAU, beneficial in influencing the biopsychosocial (BPS) pain knowledge, attitudes, and self-reported clinical behaviors of PT students?" We hypothesized that the students in the EEI acquired more BPS pain knowledge, attitudes and better self-reported clinical behaviors compared to the EAU.

Review of Literature

Management of musculoskeletal (MSK) pain conditions require a BPS approach[7,8] but routine clinical pain management frequently fails to comply with this[9]. Many healthcare professionals (HCPs) adhere poorly to evidence-based clinical guidelines[10] and find it challenging to integrate BPS elements in the management of persistent MSK pain[3,11,12].

Non-guideline-based beliefs can result in poor health outcomes[13]. This highlights that HCPs' pain beliefs are important, because they shape patients' beliefs[14,15]. HCP beliefs and accompanying skills are developed during their professional education. Current healthcare training falls short in preparing HCPs for BPS interventions. Becoming a pain-educated clinician requires the acquisition of competencies necessary for providing BPS informed care[2,16,17]. However, education in pain for future HCPs is often limited, fragmented, and lacking essential content related to contemporary pain science [18,19].

The International association for the study of pain (IASP)[20] and the European Pain Federation (EFIC)[21] have provided recommendations for pain education for PT students. A key aim of this education is to understand that most persistent pain should be regarded as a protective response, rather than a sign of tissue damage[22]. Also, this

education is aiming to improve PT students' clinical competencies, particularly in making appropriate functioning recommendations[2,22,23]. Education for PT students should be directed to help align a patient's personal pain knowledge, attitudes and beliefs with contemporary pain science and clinical guidelines. This approach helps develop and strengthen their BPS understanding of pain, thereby contributing to conceptual change in MSK pain management [24–26].

Methods

Design and setting

A cluster-randomized controlled trial was conducted at the Hanze University of Applied Sciences (UAS) Groningen in the Netherlands. Outcomes were measured immediately before and after the 8-weeks intervention (baseline (T0) and post intervention (T1)). The Standards for Reporting cluster randomized trials guided the reporting of this study[27]. A waiver was obtained from the Medical Ethics Committee at the HUAS Groningen (HEAC.2022.04), indicating that formal ethical approval was not required within the Dutch law. Written informed consent was obtained from all students prior to data collection. The outcomes were not traceable to individual students. The study protocol was registered prior to the data analysis (https:/osf.io/3rb98). There were no protocol breaches or amendments, except for the addition of a responder analysis (see data analysis section).

Subjects

The eligibility criteria included all first- and second-year students from the Dutch 4-year entry-level PT education program at Hanze UAS in Groningen, the Netherlands, who provided written informed consent for the use of their educational and sociodemographic data. A convenient sampling approach was employed, intended to include all students in the first year (11 classes, $n \approx 260$ students) and the second year (7 classes, $n \approx 170$ students).

Recruitment, enrollment, allocation and blinding

The PT students were included in clusters when enrolled in the entry-level course, independent of the purpose of this trial. The educational institute administrators as a third party, independently assigned the clusters to teacher's availability. Of the 11 classes in the first year, six participated in the EEI, experimental arm) and five in the EAU, control arm). Of the seven classes in the second year, five participated in the EEI and two in the EAU. Random allocation to the EEI or the EAU was done at the cluster level. A cluster was defined as a group of students within the same class

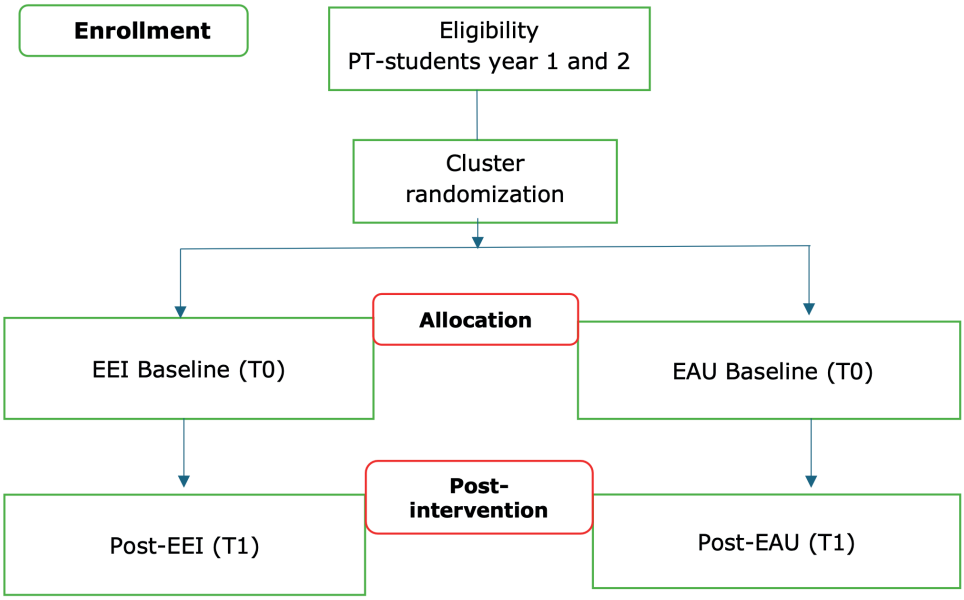


Fig.1 Study protocol. PT; Physical therapist, EEI; Enhanced Educational Intervention, EAU; Education as Usual.

(n≈24). Enrollment and allocation are presented in figure 1. Students were blinded to the intervention, allocation and at T1 to their T0 results. Data analysts were blinded to allocation (EEI of EAU). De-blinding occurred after the data analyses was ended. The EEI was applied by eight teachers, and measures were administered during the first and second years of the PT education program. Teachers were not blinded to the allocation of their classes (EEI or EAU).

Enhanced Educational Intervention (EEI)

The course description and dosage were consistent across both the EAU and the EEI, delivered within the entry-level (PT) education program at Hanze UAS. The EEI was taught by regular teachers who received seven additional training sessions (1–1.5 hours each), led by the primary researcher (AJB), who did not participate in direct teaching.

The EEI, delivered over eight weeks (6 hours of practical and 1 hour of theoretical education weekly), aimed to enhance PT students' knowledge, attitudes, and self-reported clinical behaviors in alignment with clinical guidelines. Central to the EEI was promoting a conceptual change in understanding musculoskeletal (MSK)

pain—from a tissue-damage model to a biopsychosocial, person-centered approach emphasizing 'safety learning'[22]. Pain was framed as a protective response shaped by multiple interacting BPS factors rather than a sign of tissue damage[28–37].

Teaching drew on Cognitive Functional Therapy (CFT)[38] to support experiential and sense-making learning, disrupting a person's unhelpful cognitive representation and behavioral and emotional response to pain. Metaphors such as the 'twin peaks model' [25,28] were used to explain sensitization and the expanded buffer zone. Students practiced applying these concepts through active learning strategies, including case-based reflection and non-threatening pain communication[39,40]. Details of the EEI's content, didactics, and teacher training are reported according to the TIDieR recommendations (Supplemental Digital Content 1), with shared EAU and EEI content provided in (Supplemental Digital Content 2).

Outcome measures

We utilized five outcome measures without establishing a hierarchy a-priori: 1) Video Vignette score (construct: self-reported clinical behavior), 2) Written Vignette score (construct: self-reported clinical behavior), 3) Knowledge and Attitude of Pain (KNAP) score (construct; pain knowledge and attitudes) and 4) Pain Attitudes and Beliefs Scale for Physiotherapists (PABS-PT) score (construct: pain attitude and beliefs), BPS(PS) subscale and 5) PABS-PT score, biomedical (BM) subscale. All five outcome measures were pilot tested prior to the study among students not involved in the study and among PT pain experts. The clarity, comprehensibility, relevance, and likelihood of a positive outcome (feasibility) of the instructions, Video Vignettes and Written Vignette, and questions associated with the measurement instruments were assessed and refined.

1. Behavior regarding practical clinical recommendations was measured by using Video Vignettes (statements and Likert scales). Video Vignettes were developed for this study and were informed by a recent systematic review about pain behavior[34] and by the concept of CFT[32,38]. A professional actor, experienced in medical education with self-experience in persistent low back pain, acted as patient. Students viewed four video clips. Agreement with 18 statements about pain behaviors or preferred movement strategies was measured on a five-point Likert scale, ranging from completely disagree to completely agree were included. Examples of statements were: 'After seeing this video fragment; I recommend the patient reduce the weight of the crate to lift it safely', 'You observe that the patient keeps their back as straight as possible, holds the crate close to their body, and bends their knees while lifting. Statement: I consider this to be a correct movement strategy'. The scoring of items ranged from +2 to -2, indicating the

degree of appropriateness or inappropriateness of the recommendations, in accordance with clinical guidelines. Students could receive +2 or +1 points for an appropriate answer, 0 points for 'no opinion', and -2 or -1 for an inappropriate answer. The total score ranged from -36 to +36 points, with higher scores representing better alignment with current Dutch evidence-based guidelines and recent evidence[32,34,38].

2. Behavior regarding practical clinical recommendations was measured by using a Written Vignette (statements and Likert scales) [41,42]. Students indicated their estimation of the severity of the symptoms and of tissue damage and on clinical recommendations regarding work, daily activities, training, bed rest, education, exercise therapy and use of the back. The questions were adapted from a previous study[43] and has been used in numerous studies[23,44,45]. The scoring of items ranged from +2 to -2 for question 1, 2 and 5 and from +2 to -3 for questions 3, 4 and 6 to 9, indicating the extent to which the recommendations align or deviate from clinical guidelines. There was not a 'no opinion' option. Questions, possible responses and scoring are shown in Supplemental Digital Content 3. The total score ranged from -45 to +27 points, with higher scores representing better alignment with current Dutch evidence-based guidelines.
3. Pain knowledge, beliefs and attitudes were measured by using the validated 30-item Rasch modified KNAP[46] Each participant indicated the extent to which they agreed to the statement on a six-point Likert scale, ranging from completely disagree to completely agree. The total score ranged from 0 to 150 points. A higher score indicated knowledge and attitudes that better reflect contemporary pain neuroscience. Examples of statements were: 'Pain sensitivity can persist, even if there is no longer an injury or tissue damage', 'Correcting poor posture reduces persistent pain'. The measurement properties of the KNAP are adequate[46].

4 and 5. A 14-item Rasch modified version of the PABS-PT[47] was used to measure BPS or a biomedical orientation; seven items belong to the BPS(PS) subscale (score ranged 7 to 32) and seven items belong to the biomedical (BM) subscale (score ranged 7 to 40). Higher scores indicated a stronger BPS or biomedical orientation. The PABS-PT demonstrated fair methodological quality[47,48]

Data collection

Data collection occurred during regular educational activities, immediately before and after EEI and EAU. At baseline, all students received the information letter and consent form via e-mail before the assessment. Additionally, announcements were posted on the intranet to encourage attendance. E-mail invitations, containing a link to the survey, were dispatched shortly before the commencement of the class. After the explanation of the purpose and procedure, the students completed the

survey digitally during a regular class. The students were supervised to ensure that the results reflected their individual responses. A reminder was sent a day after the assessment. The survey remained open for three days after the reminder, for those students who did not complete the survey during class. The completion time was pilot tested and intended to be around 25 minutes. Post-intervention, the retest procedures remained consistent, except for survey administration, which took place during the concluding practical classes. Students who were absent in class were sent a personal e-mail containing the survey link after one week and a reminder was sent two weeks following the retest.

Data analysis

First, all data was analyzed for completeness and careless responses. Careless responders[49] were identified (blinded to group, year or individual) based on time to complete the measurement (less than 2 SDs under the average time) and unnatural patterns of responding (near equal responding on all questions, including mirrored answer possibilities). Descriptive statistics were employed to determine the demographic information of the students and their knowledge, beliefs, attitudes, and behavior related to contemporary pain science at T0.

A missing data analysis was performed. The components of the questionnaire that were completed were included in the analysis. To determine whether the degree of dropout influenced the outcomes on the four components of the questionnaire, a one-way ANOVA was performed. Based on the extent to which the questionnaire was completed, four groups were compared: 1) only Written Vignette, 2) Written Vignette and Video Vignettes, 3) Written Vignette, Video Vignettes, and KNAP, 4) all the components of the questionnaire. Imputing the median was performed on missing data per component separately. Missing data did not exceed 10%; therefore, no additional analysis was conducted.

Intraclass correlation coefficient (ICC) were calculated for the observations within a cluster (class). To get insight into the time-group effect of each outcome measure a Linear Mixed Models (LMM) analysis was performed. Fixed effects were year of education (year 1 vs year 2), time (T0 - T1) and interaction effect of "group status (intervention vs control) * time". The interaction term equals the effect of the intervention, representing our primary aim. Further, as random effects based on the clustering of the data, random intercepts for person and class were added, using an unstructured covariance structure[50]. Random slopes were not added due to the randomization of the intervention on class level[51].

The EEI was considered beneficial when the EEI-students acquired more BPS pain knowledge, attitudes and clinical behavior compared to the EAU-students: operationally defined as significant groups differences. Statistical significance was considered when p = .05. An individual responder analysis was applied on all outcome measures. The percentage of students who improved, remained the same, or declined was calculated for EEI and EAU. Additionally, for the KNAP measures, the percentage of students whose improvement in the mean difference exceeded the Minimal Clinically Important Change (MCIC) of 4.84 was assessed[46].

Results

3.1 Participants

In total, N = 361 students were enrolled in the curriculum year 1 and 2 of the entry-level PT education program. Of them, n = 187 responded at baseline and n = 264 post-intervention. N = 28 (6.3%) were excluded because they did not fully complete the questionnaires. The final analysis included a total of 451 measurement points, with 63% consisting of paired baseline and post-intervention measurements. In total n = 142 participated in both measurements, (n = 54 in year 1, n = 88 in year 2), resulting in 108 respectively 176 datapoints (284 in total). N = 167 were single measures (pre-single measure n = 46, post-single measure n = 121). Table 1 depicts the characteristics of the study participants. Approximately half of the students in both groups experienced persistent pain personally and (had) received treatment. The one-way ANOVA for missing data analysis was not significant, indicating that the level of completing the questionnaire was not related to the outcome and missing data was completely at random.

Table 1: Characteristics of participants

Characteristic	EEI Mean (SD) or n (%)	EAU Mean (SD) or n (%)
N	307	144
Sex, n (% female)	144 (46.9)	73 (50.7)
Age, y	20.2 (2.6)	20.1 (2.1)
Personally experiencing persistent pain at present (n/% yes)	156 (50.8)	65 (45.1)
Treated for persistent pain (n/% yes)		
Now	34 (11.1)	25 (17.4)
In the past	170 (55.4)	70 (48.6)
Having family or friends with persistent pain (n/% yes)	198 (64.5)	83 (57.6)

EEI; Enhanced Educational Intervention, EAU; Education as Usual.

3.2. Differences in pain knowledge, attitudes, and clinical behaviors

The results on all five outcomes are presented in figure 2. The lines represent mean outcomes with 95% confidence intervals, shown separately for EEI and EAU groups. In Supplemental Digital Content 4, trajectories are presented at cluster level. Overall, both groups had improved BPS pain knowledge, attitudes and self-reported clinical behaviors from baseline to directly after the educational intervention, where the EEI group progressed more than the EAU group.

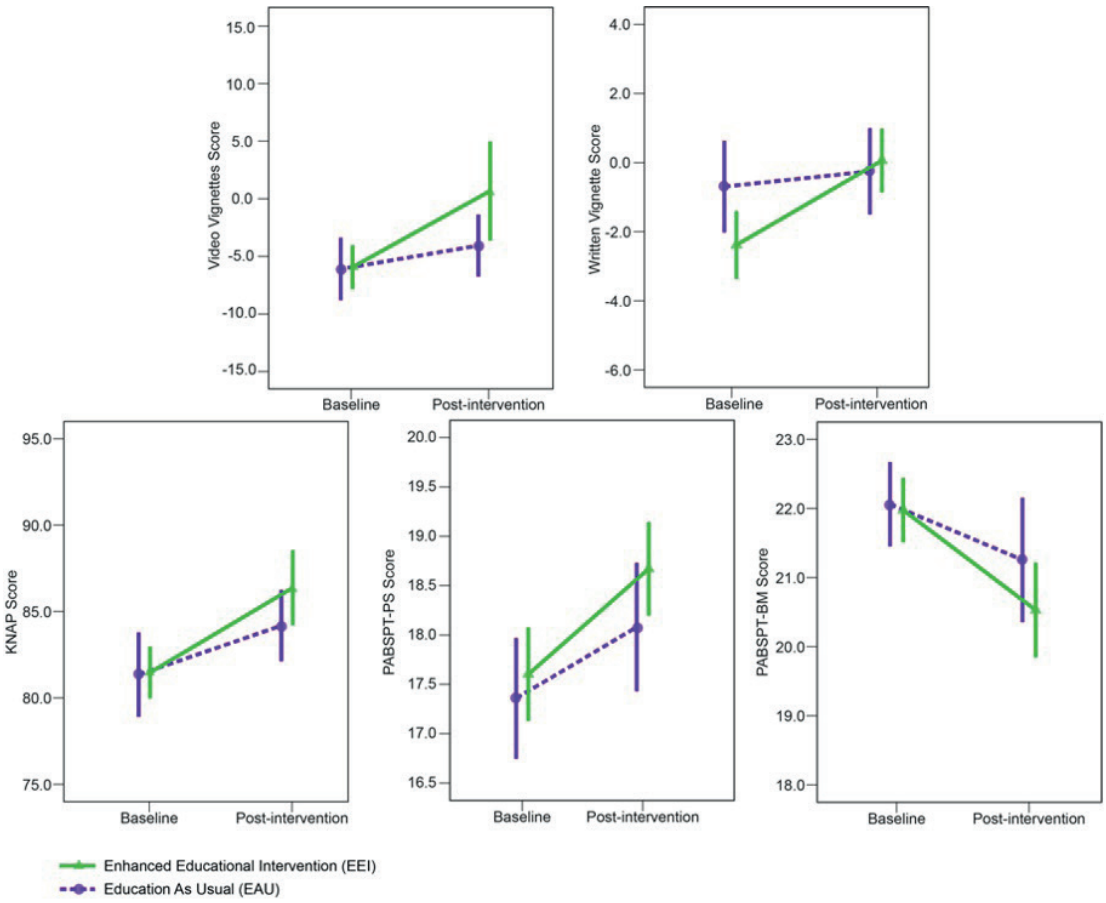


Fig. 2 Results of Video Vignettes, Written Vignette, KNAP; Knowledge and Attitude of Pain, PABSPT; Pain Attitudes and Beliefs Scale for Physiotherapists, PS; biopsychosocial subscale, BM; Biomedical subscale (reversed). Enhanced Educational Intervention (green line), Education as Usual (purple line) (N = 451 measurement points).

The results of the linear mixed method analyses are presented in Table 2 and Table 3. All ICC values were > .400, confirming the choice of LMM as method. The factor time (T0-T1) contributed significantly to 4 of 5 models, showing that students score improve on all outcome measures, except for the Written Vignette. The interaction term Time*Group ('Group' is the allocation status (EEI vs EAU)) was significant for all outcomes, showing that EEI students improved more than EAU students, except for the PABSPT-PS. The year of education (year 1 vs year 2) contributed significantly to the model only for the KNAP. Based on the clustering of the data, we allowed the intercepts to vary over classes and persons.

Table 2: Linear mixed method outcomes Video Vignettes & Written Vignette

Measurement	Parameter	Estimate (95% CI)	Std. Error	df	t	p
Video Vignettes	Intercept	-7.25 (-1.42; -13.08)	2.78	18.62	-2.61	0.018
	Year	0.63 (4.51; -3.25)	1.84	16.61	0.34	0.736
	Time	2.23 (4.20; 0.26)	1.00	221.73	2.23	0.027
	Group*Time	5.12 (7.43; 2.80)	1.17	202.81	4.36	<.001#
Written Vignette	Intercept	-3.83 (-1.70; -5.95)	1.01	17.80	-3.78	0.001
	Year	1.36 (2.76; -0.04)	0.65	14.70	2.08	0.056
	Time	0.93 (1.93; -0.06)	0.504	221.21	1.85	0.065
	Group*Time	1.26 (2.40; 0.13)	0.58	149.88	2.19	0.03#

Intercept; outcome of the measurement, with all other factors being zero, CI; confidence interval, Std.; standard, Df; degrees of freedom, Time; moment in time (T0 - T1), Year; year of education. Group*Time: interaction effect of group allocation and moment in time. #; significant.

Table 3: Linear mixed method outcomes KNAP, PABSPT-PS & PABSPT-BM

Measurement	Parameter	Estimate (95% CI)	Std. Error	df	t	p
KNAP	Intercept	77.42 (80.80; 74.03)	1.62	19.25	47.85	<.001
	Year	2.71 (4.93; 0.49)	1.04	16.01	2.58	0.02
	Time	2.76 (4.18; 1.33)	0.72	210.70	3.81	<.001
	Group*Time	2.30 (3.94; 0.66)	0.83	162.55	2.76	0.006#
PABSPT-PS	Intercept	17.03 (17.91; 16.15)	0.43	29.69	39.50	<.001
	Year	0.32 (0.87; -0.23)	0.26	19.74	1.22	0.236
	Time	0.61 (1.15; 0.07)	0.27	190.47	2.24	0.026
	Group*Time	0.55 (1.13; -0.03)	0.29	100.65	1.87	0.064
PABSPT-BMΦ	Intercept	22.66 (23.83; 21.49)	0.56	20.09	40.35	<.001
	Year	-0.42 (0.34; -1.19)	0.36	16.19	-1.17	0.259
	Time	-0.84 (-0.31; -1.36)	0.27	192.01	-3.12	0.002
	Group*Time	-0.73 (-0.12; -1.33)	0.31	142.10	-2.37	0.019#

ΦReversed score. KNAP; Knowledge and Attitude of Pain, PABSPT; Pain Attitudes and Beliefs Scale for Physiotherapists, PS; biopsychosocial subscale, BM; Biomedical subscale, Intercept; outcome of the measurement, with all other factors being zero, CI; confidence interval, Std.; standard, Df; degrees of freedom, Time; moment in time (T0 - T1), Year; year of education. Group*Time: interaction effect of group allocation and moment in time. #; significant.

3.2.1 Responder analysis

The results of the responder's description are presented in figure 3. Differences in percentage improved were all in favor of EEI, with differences ranging from 10% to 29%. For the KNAP 48% of the EEI students exceeded MCIC. The decline ranged from 15.5% to 28.6% in the EEI and from 31.7% to 50.0% in EAU.

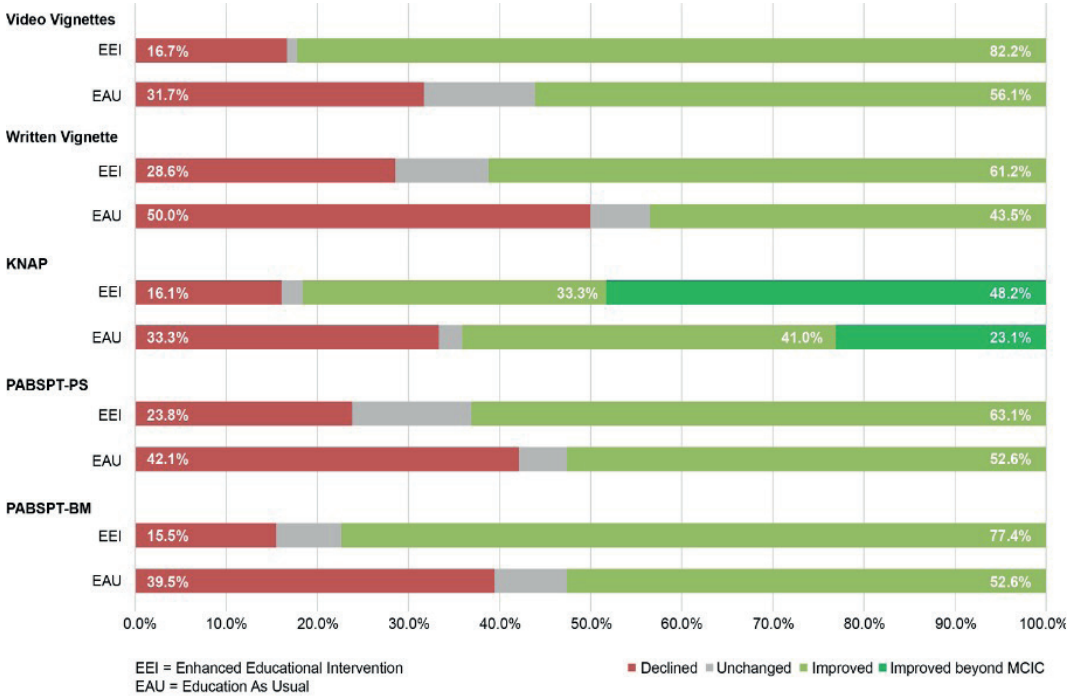


Fig. 3 Responders analysis of Video Vignettes, Written Vignette, KNAP, PABSPT-PS & PABSPT-BM per group allocation. KNAP; Knowledge and Attitude of Pain, PABS; Pain Attitudes and Beliefs Scale for Physiotherapists, PS; biopsychosocial subscale, BM; Biomedical subscale, MCIC; Minimal Clinical Important Change. Number of responders per outcome measure: Video Vignette: EEI (n = 90), EAU (n = 41), Written Vignette EEI (n = 98), EAU (n = 46); KNAP: EEI (n = 87), EAU (n = 39); PABSPT-PS: EEI (n = 84), (n = 38); PABSPT-BM EEI (n = 84), EAU (n =38).

Discussion and Conclusion

This study indicates that the EEI, compared to the EAU, resulted in significant improvements in PT students' contemporary understandings of pain, BPS attitudes, and the ability to make recommendations aligned with clinical guidelines. After completing education with an enhanced BPS focus, students reported lower ratings of symptomatology and pathology and provided less conservative advice regarding work, physical activity and moving the back. Additionally, they reported providing fewer conservative movement strategy recommendations during walking, lifting, and exercising, along with demonstrating more BPS pain knowledge, beliefs, and attitudes. Moreover, students in the EAU group were approximately twice as likely as those in the EEI group to experience potentially negative outcomes. These outcomes

included reinforcing maladaptive beliefs, which could result in pain management recommendations that do not align with clinical guidelines. Although progression occurred in both groups, the EEI group significantly improved more on most outcome measures. Also, substantially more students in the EEI responded on all outcome measures, compared to the EAU. On the KNAP about half of the students in de EEI exceed the clinical meaningful improvement. In the absence of an established estimates for the smallest relevant effect in an educational context, the results for educationally relevant improvements on the other outcome measures are not reported[52].

Our findings align with other studies showing that practical skill training improves the integration of BPS knowledge and skills into context-specific practice[16,53]. The multicomponent nature of the EEI curriculum, such as lectures and tutorial classes could be influential toward competency development, as confirmed by other studies[54]. The EEI was based on principles of CFT, an exposure-based PT-led approach that has yielded positive outcome for chronic low back pain[31,55,56]. The EEI was augmented within PT practical classes, which provided the teacher with more didactic opportunities, such as experiential learning and collaborative reflective practice[16,54,57]. Evidence from CFT learning journeys indicate that PTs felt graduate exposure with feedback and self-reflection were fundamental to clinical behavior change[54,58]. Additionally, by using collaborative reflective practice to explore PT students' own underlying unhelpful pain beliefs were explicitly included in the EEI, highlighted in other behavior change literature[59,60].

This study indicates that implementing a 'train the trainer' program, without changing the dose of PT education, effects can be sorted at the student level. Also, by utilizing minimal resources and adaptations, education in entry-level PT education program can be enriched without the need to adjust the number of teaching hours or incur significant costs. Other studies show that a brief BPS pain education session can improve students' contemporary knowledge and attitudes towards pain, a shift in clinical behaviors is unclear[2,44,45]. In this study, we observed a significant improvement in clinical recommendations, which may be regarded as a determinant for clinical behavior.

Strengths and limitations

The strength of this study lies in the cluster-randomized controlled trial design, whereby participants, examiners, and analyzers were blinded to the aim of the study. Students were also blinded to the intervention, and their T0 results at T1 to prevent recall bias. Also, clusters were identified and recruited before randomization and

allocation was concealed for participants, minimizing the risk of selection bias. This design can deliver level 1 evidence[61] regarding the attribution of the intervention to the observed changes. A nuance can be introduced in the implementation, which might compromise the maintenance of level 1 evidence, particularly with respect to minimizing bias and implementing controls to account for confounding variables. The results were analyzed and graphically presented at group level, cluster level (class), and individual level (responder analysis). We have also presented the cluster and individual levels to demonstrate that, while progress is occurring at the group level, results at cluster and individual levels vary even to the extent of a decline. With this, we challenge the assumption that a student inevitably progresses through education. The reasons why some students declined are unknown. We cannot rule out that the decline was due to measurement error or less than MCID (rule of thumb 30%), however, these are unknown in an educational context. Therefore, further research is warranted to explain why the intervention did not have a visible favorable effect on some students.

Because the study was conducted in a natural educational setting, contextual factors were considered. Therefore, the findings could be more readily implemented in PT curricula, addressing criticisms about the applicability of randomized controlled trial designs[62]. The EEI was accurately described in the TIDieR recommendations, and the common content of EAU and EEI was documented to highlight their differences. Another strength of this study was the homogeneous sample of participants in age and in the type and quality of education they received. All students were exposed to the same content description throughout their entry-level education, provided by teachers who were all physiotherapists by training. This could imply that the results of group allocation were not biased by different educational backgrounds and thus more accurately reflected the effects of the educational module. The EEI was applied by eight teachers, and measures were administered during the first and second years of the PT education program, to mitigate potential teacher bias and control for the influence of study year. The individual students were included in clusters when enrolled in the entry-level PT education program, not for the purpose of the trial. Additionally, five measurements were conducted on three constructs—knowledge, attitudes, and behavior—to enhance the ecological validity of the study's results.

Not all the outcome measures are validated, so tentativeness is regarded in interpretating the study. The use of vignettes to assess participant clinical behavior and reasoning is a proxy measure and it is uncertain if recommendations measured by clinical vignettes represent actual clinical behavior[63,64]. The response options in the case vignettes created noise, leading to regression towards either neutral or extreme

answers (unpublished work). The Video Vignettes were developed specifically for this study, which potentially enhances their specificity, but their measurement properties are unknown. Another limitation that affects the external validity of this study relies on the fact that the observed changes are immediate, and because of the lack of follow-up it is unknown whether the observed changes remain over time. However, recently a study[65] found that KNAP and vignettes showed stable results six months post-intervention, suggesting their potential for measuring improvement over time. Because we only have information on the MCIC for the KNAP, we cannot comment on the clinical relevance of the progress on the other outcome measures. Whether the EEI is sufficient for enhanced BPS practice should be studied subsequently.

Recommendations

The results of this study are of educational relevance and should have an impact on educational practices related to assessing and managing MSK pain. It is recommended that educators and program directors enrich the entry-level PT education program by specifically training teachers, allowing the same number of hours to be utilized more effectively. However, the optimal dose remains uncertain. In our study, the largest mean difference was observed in the Video Vignette assessments. Students may respond more effectively to visual information in comparison to written information[66]. The effort and difficulties required to move, were portrayed by the professional actor non-verbally and realistically. Moreover, the EEI was implemented in a practical setting, with the Video Vignettes closely reflecting this environment, making it a potentially preferred evaluation tool in education. However, without knowing the measurement properties of the Written Vignette and the Video Vignettes, interpretations should be made carefully. Furthermore, longitudinal studies are needed to observe if changes by education remain over time and to determine whether these changes affect the management of the patients' clinical courses. Time for clinical integration with transformative learning experiences is an important consideration for any future training aimed at developing competency and successful clinical application of a BPS approach.

Conclusions

Our study demonstrated a positive impact of implementing an EEI, reflecting stronger guideline-consistent BPS pain knowledge, attitudes, and better clinical behaviors in PT students. These outcomes could lead to changes in the most enduring beliefs and behavior that could then be applied when the students start their professional practice. This study showed improved outcomes in the early stages of PT training, by utilizing minimal resources and adaptations. The results of this study could refine PT entry-level pain training programs to change traditional misconceptions about pain and for more efficient and effective clinical practice into contemporary pain beliefs and clinical behavior.

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Supplemental Digital Content (SDC)

SDC 1: TIDieR checklist

NAME

Teacher training for the Enhanced Educational Intervention (EEI).

WHY

Non-guideline-based recommendations can result in poor health outcomes in Musculoskeletal (MSK) pain. The key aim of EEI is to improve guideline-consistent knowledge, attitudes and clinical behavior in Physiotherapy (PT) students. Clinical behavior is the clinical ability to make recommendations aligned with practical guidelines to patients seeking care for pain. The fundamental concept in our study is going from a pain-centered to a person-centered approach in pain management.

WHAT

Informational materials. The teachers of the intervention group received a 'Teacher training for the Enhanced Educational Intervention (EEI)' that took them through a set of practice-based learning activities as discussion and reflection on conceptual frameworks related to contemporary understandings of pain. A special effort was made to implement these frameworks in practical physical therapy classes. A structured plan for the lessons per week was presented and discussed. Video material was provided to use in the classroom. The content and teaching methods were tailored to the specific year of the curriculum in which the educational intervention occurred. Box 1 provides a more detailed description of the components of the training program.

PROCEDURE

Training sessions for EEI-teachers were conducted by the primary researcher (AJB), but did not teach the classes herself. The primary researchers organized the training, prepared input in PowerPoint slides and took notes. After each training session, the agreements were shared with the EEI-teachers and a standardization of content and didactics per week was shared via a created platform in a Teams-environment. In total eight regular PT teachers in the EEI clusters who expressed interest in the EEI program, were selected and trained to deliver the EEI. These teachers conduct practical or tutorial classes in the first and second years of the PT Bachelor's program and were willing to undergo the training. The remaining teachers were kept unaware of EEI.

WHO PROVIDED

The primary researcher was an experienced teacher in the PT curriculum and PhD candidate with expertise in contemporary pain science. The teachers in the Intervention group (EEI) were physiotherapists and/or manual therapists by training and were all regular teachers of the PT program with special interest and expertise in assessing and treating contemporary MSK pain.

HOW

The training sessions were held in person, in the group of EEI-teachers.

WERE

The training sessions were held in the educational institute where the teachers worked.

WHEN AND HOW MUCH

In total, teachers received additional training seven times, with sessions lasting between 1 and 1.5 hours. Four training sessions for EEI-teachers were conducted, three preceding the educational period, and one serving as a refresher session just before the commencement of the intervention period. Further on, three reflection sessions for maximal 1 hour were held during the intervention period and one to evaluate at the end of the period.

Box 1: Content and didactics of EEI used in practical PT classes

Content Use of framework, models & theories. References: [1–4,10,13–16,18–20,23,25,27]	• Contemporary pain science. • Pain Science Education (PSE). • Person centered care. • Musculoskeletal Clinical Translation. Framework (MCTF). • P-SCEGS model. • NPQ questionnaire. • Safety learning framework. • Cognitive Functional therapy (CFT). • Common sense model. • Fear avoidance model. • Mechanism-Based Approach to Pain Management. • Body Self Neuromatrix. • Nocebo/placebo concepts and explanations • Maladaptive movement-related pain behaviors. • Reframing guidelines for post-operative care, including use of walking devices, orthoses. • Reframing MRI/X-ray results as common variations rather than cause for concern. • High vs low value care in MSK pain condition • Pain related to amount of exercise or movement/function.

Didactics Use of concepts during PT assessment & treatment. References as above plus: [5–9,11,12,17,21,22,24,26]	• Metaphors for sensitized alarm system: software-metaphor, fire alarm metaphor, burglar alarm metaphor, twin peaks model. • Experiential learning combined with sense-making: 'Sore but safe', 'Hurt not equal harm', 'giving credible explanation' regaining confidence in movement. • Identifying contextual factors from case studies & with help of MCTF. • Providing clinical context-specific practice and decision making. • Active teaching methods through discussion and reflection on personal beliefs and perceptions about the body & pain, alongside practical clinical behaviors, including: o Addressing and generating cognitive dissonance. o Discussing recommendations for work, sports, and preferred treatment options. o Analyzing movement-related pain behaviors. • Communication: Open, stimulating healthy pain behavior, empathic, validating, shared decision making, non-threatening choice of words.

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SDC 2: Common content description EEI and EAU.

Year 1: period 3 of academic year

Wk		Lectures	Small group, theory and practical classes
1	MB	Osteoarthritis (AO) hip and knee, pathophysiology, pathogenesis, phenotyping, roll of Immune system, etiology within biopsychosocial model, AO symptoms, imaging, AO misconceptions, nocebo. European Alliance of associations for rheumatology (EULAR) recommendations, stepped care, exercise therapy, Good Life with osteoarthritis: Denmark (GLA:D).	AO hip and knee: myology, osteokinematics, arthrokinematics, capsular patterns, joint range of motion (ROM), tissue repair, epidemiology, course of complaints, International Classification of Functioning, Disability and Health (ICF), pathophysiology, sign of Drehmann, Kellgren and Lawrence, Pain mechanisms, course of signaling.
	BC	Psychodynamics (Freud & Erikson), Behaviorism (Pavlov, Skinner), Humanism (Rogers & Maslow), Cognitive psychology, Common Sense model of Leventhal, Illness perceptions, Positive health, Self-determination theory.	Communication skills in history taking and assessment of body functions and structures.
	PT	Introduction & overview Musculoskeletal (MSK) conditions lower extremity and lumbar spine, Axial spondylarthritis, overview MSK pain, BioPsychoSocial (BPS)model, Pain neuromatrix, pathway nociception, gait analysis, PT guidelines, methodical acting, Rehabilitation Problem Solving (RPS), ICF.	ICF, Physiotherapy (PT) guideline OA, core sets, measurement instruments, methods of assessment: screening, red flags, history taking, inspection, gait analyses, joint ROM assessment, specific testing, living anatomy, treatment plan, goal setting, choice & dose intervention; informing & advising, manual techniques, pain reduction, muscle functioning, stepped care.
2	MB	None	Education free. Assignment gait analysis
	BC	None	Education free. Assignment gait analysis
	PT	None	Education free. Assignment gait analysis
3	MB	Hip & knee arthroplasty (surgery), types of prothesis, surgical techniques and risks & benefits, process of tissue healing, mobilizing in hospital. Knee: anatomy, arthrokinematics, osteokinematics, (non) traumatic complaints/diagnosis, acute knee, tissue healing principles, tendinopathy.	Tissue & fracture healing processes, different kind of fractures and its surgical treatment in lower extremity, Mueller's classification, arthroplasty, osteotomy, surgical techniques, iatrogenics, comorbidity.
	BC	Pain and history taking/anamnesis. Patient journey (methodical acting), Direct Access Physiotherapy (DAP); Intake, prognostic factors, Illness beliefs, Common Sense Model Leventhal; somatic, cognitive, emotional, behavioral, social (SCEBS) factors, Shared Decision Making (SCM), Communicative skills.	Authenticity, empathy, basics of humanistic psychology, Maslow's pyramid, cognitive psychology, catastrophizing cognitions, history taking, goal setting, frailty.

	PT	Hip live surgery. Gait analysis, gait cycle, Kinematics: Electromyography (EMG), goniometry, ground reaction force, reference values, therapy in gait context.	Acute knee problems: guideline knee, gate-analysis, post operative status: assessment & treatment, goal setting, choice & dose of intervention; informing & advising, transfer training, mobilizing techniques, training of muscle functioning and motor control, gate training with and without walking devices.
4	MB	Knee ACL. Anatomy, arthrokinematics, osteokinematics, (non) traumatic complaints/diagnosis, acute knee, trauma mechanism, signs and symptoms ACL injury, tissue healing principles, surgical treatment, rehabilitation after ACL reconstruction, tendinopathy.	Knee joints; anatomy, arthrokinematics, osteokinematics, myology, active/passive stability, function, acute knee trauma, pathophysiology, tissue repair, osteoarthritis, different knee diagnoses and conditions.
	BC	None	Intercultural communication, ethnocentrism, culture relativism, cultural identity, values and norms, acculturation, stereotyping, prejudices, discrimination.
	PT	Guided human movement behavior, principles of motor learning and motor control, interplay person-environment, dynamic pattern, perspective, cognitions and emotions related to organization of motor behavior, motor control and pain.	Clinical reasoning, RPS, methods of assessment: history taking, inspection, gate-analysis, palpation/living anatomy, ROM, isometric resistance test, specific testing, Treatment; informing & advising, counseling, behavioral change (6 steps model), Attitude, Social Influence and Self-Efficacy (ASE) model, pain modulation, mobilizing techniques, communication skills, thermotherapy.
5	MB	Muscle ruptures and injuries, muscle anatomy, red flags, muscle contusion, pathophysiology, etiology, biomechanics, risk factors, classification muscle injuries, signs and symptoms, muscle pain conditions, phases of recovery, treatment-optimal loading. Jumpers' knee, Osgood Schlatter.	Anterior cruciate ligament (ACL): biomechanics, osteokinematics, arthrokinematics, motor control, anatomy, unhappy triad, reconstruction anterior cruciate ligament, indication for surgery, surgical procedures, tissue repair & healing, prognosis ACL, rehabilitation & training, tendinosis, tendinopathy, muscle rupture, tissue repair.
	BC	Intercultural communication & competences, cultural differences, cultural identity, cultural dimensions, professional ethics, norms and values, social identity.	Cultural identity and differences, cultural shock, stress.
	PT	Assessment lumbar spine and lower extremity. Clinical reasoning, orthopedic and rheumatoid conditions, models: ICF, BPS, load-capacity, clinimetry, pathology, tissue status vs functional status, Musculoskeletal Clinical Translation Framework, PT guidelines OA, knee conditions, axial spondylarthritis, acute knee injury, ALC injury, ankle complaints, Ottawa ankle rules, functional stability, tendinopathy, muscle injuries.	Trauma ACL; RPS, Screening, history taking, knee assessment: inspection, palpation/ living anatomy, ROM, specific testing, Q-angle, measurements for pain and functional status, treatment plan, goal setting, informing & advising, treatment protocol post-operative, ASE model, training motor control, mobilizing techniques, Knee brace, motor learning.

6	MB	Ankle complaints and conditions; anatomy, osteology, motor control, stability, signs and symptoms, PT assessment & treatment. Ankle strain and sprain, PT guideline, preventive exercises, ankle brace, tape-application.	Muscle anatomy and function, muscle innervation, muscle contraction, muscle rupture, nociception, inflammation, muscle tone, antalgic postures and motor behavior, phases of tissue repair.
	BC	None	Physical work-related factors, work-stress, stress related complaints, cognitions and perceptions.
	PT	Treatment lumbar spine and lower extremity, Clinical reasoning for exercise prescription, orthopedic and rheumatoid conditions, shared decision making, therapeutic alliance, PT guidelines, education, exercise therapy, Frequency, Intensity, Time, and Type (FITT) factors, treatment techniques; stretching, mobilization, strength therapy, motor control, working mechanisms exercise therapy & massage therapy, mobilization with movement (MWM), eccentric training, heavy slow resistance, treating muscle injuries.	Lower leg complaints: screening, history, assessment ankle/lower leg, diagnostics, clinical reasoning, conclusion in ICF-terms, RPS, treatment: informing & advising, pain modulation, excentric training, heavy slow resistance, mobilizing techniques.
7	MB	Diagnostics and Classification Spondylarthritis, axial and peripheral manifestation, clinical signs and symptoms, spondylarthritis central and peripheral, X-ray features, screening of Spa, pathophysiology, PT guideline, measurement instruments, (medical) treatment. Tendinopathy achilles.	Talocrural and subtalar joint, osteokinematics, arthrokinematics, motor control (impairment), anatomy, gate analysis, ankle function, ankle trauma acute and persistent, muscle, rupture, Ottawa Ankle Rules, giving way, phases of tissue repair, functional loss of stability, ankle laxity, brace/tape, treatment: conservative and surgery.
	BC	Distress definition, complaints. Stress related to dimensions of biopsychosocial model, distress & recovery, Karasek & Theorell, Life events theory Holmes & Rhabe, Transactional model of Lazarus & Folkman, types of distress, flight, fight, freeze response, Selye's model, General Adaptation Syndrome (GAS), physiological (psychological) response, treatment, distress & illness.	Distress, (work) stress, Karasek's model, Holmes & Rahe's table, life-events, psychosocial factors.
	PT	Assessment & Treatment Ankylosing spondylitis, classification, pathophysiology, signs and symptoms, PT guideline, risk factors, measurement instruments, High Intensity Exercise (HIT), education, passive mobilization, contra indications, restrictions, optimal exercise behavior.	Ankle guideline, assessment and clinical reasoning; screening, Ottawa ankle rules, history taking, ankle assessment, diagnostics, specific testing, physiotherapeutic conclusion, treatment; informing & advising, pain modulation, mobilizing techniques.
8	MB	None	Pathophysiology Ankylosing spondylitis (Bechterew's disease), hyperalgesia, peripheral & central sensitization, modulation of nociception, attention, cognition, emotion, pain medication (different levels), anti-inflammatory medication.

	BC	None	History taking and related communication skills (verbal and non-verbal) on pain, question for help, patient expectations, personal factors/personality traits (big five), SCEBS-model, coping style, locus of control, way of attributing.
	PT	Thermotherapy & pain, pain modulation & its explanation, place of thermotherapy in methodical acting and ICF model, evidence base (PT guidelines) of thermotherapy, Heat therapy, Cold therapy, working mechanisms physiological and biochemical effects, (contra) indications. Modulation & pain by PTs: neurophysiology overview: peripheral sensitization, wind-up, Descending controls: Conditioned Pain Modulation (CPM), mobilization/manipulation, exercise induced hypoalgesia, supraspinal (cognitions), nocebo, placebo, words, context, explaining the mechanisms.	Ankylosing spondylitis (Bechterew's disease) RPS, measuring instrument (NASS Bath Indices) assessment: history taking, assessment of spine & lower/ upper extremities, treatment: goal setting, informing & advising, mobilizing techniques, improving muscle functioning, correction poor posture, pain modulation, functional training, therapy adherence.

Year 2: period 1 of academic year

Wk		Lectures	Small group, theory and practical classes
1	MB	Red Flags and specific spinal pain, epidemiology, etiology, comorbidity, prognosis.	Anatomy and arthrokinematics of the spine & pelvis, pain-nociception.
	BC	Common Sense Model Leventhal, Union Model Loeser, expectations, placebo/ nocebo communication.	Experience of pain and suffering, coping mechanisms, (pain) cognitions, pain behavior, stress, Common Sense model (Leventhal), prognostic psychosocial factors, expectations, Rational Emotive therapy (RET), Activating Events, Beliefs, Consequences (ABC scheme).
	PT	Physiotherapeutic (PT) Guidelines, screening, RPS model, Pain - Descending Controls and Body Neuro Self Matrix.	PT diagnostics: Physiotherapeutic Guidelines, BPS model, PT diagnostic process, screening, prognostic/contextual factors, normal/ abnormal course of complaints.
2	MB	Nociplastic pain, central sensitization, descending controls, motor control, red flags and specific spinal pain.	Red flags related to cancer, Tuberculosis, Human Immunodeficiency Viruses (HIV), drugs abuse, Osteoporosis, Rheumatoid arthritis, Cauda Equina Syndrome, Radiculopathy, OA, Spondylolisthesis, Stenose, Ankylosing spondylitis, Meningitis, Labrum defect.
	BC	Yellow flags, SCEBS anamnestic model, orange flags.	Theory of planned behavior, ASE model, four-dimensional complaints list (4-DKL), yellow & orange flags, SCEBS, placebo/nocebo effect, cognitive behavioral therapy.
	PT	A specific spinal pain, victim of medical imaging, variability in asymptomatic populations, clinical presentation low back pain, start back screening tool, treatment-based classification, guideline profiles.	PT diagnostics: SCEBS, movement assessment and outcome measures, differential diagnostics, specific testing of arthrogenic, myogenic, vascular, and neurogenic components, clinical presentation low back pain, screening: red & yellow flags.

3	MB	Acute vs chronic pain, spinal cord / brain anatomy, Lissauer's tract, wide dynamic range (WDR) neurons, sensitization, endocrinal system.	Pain system: central & peripheral mechanism/ neurophysiology, pain medication, radicular pain syndrome.
	BC	Transtheoretical model, therapy adherence, acceptance and commitment therapy (ACT), model of Selye, health literacy, mindfulness.	ACT, history taking (SCEBS), Health belief model, central sensitization, locus of control, attribution style, coping mechanism, illness behavior & cognitions, graded activity.
	PT	Treatment Based Classification, motor control, spinal (in)stability, clinical reasoning.	PT diagnostics: neurological assessment, neurodynamics, assessment MCI, kinesthetic awareness, assessment trigger points, assessment Sacroiliac joint, outcome measures lumbar& cervical spine, STarT Back Tool.
4	MB	Radiculopathy, sciatica, centralization, Derangement (McKenzie), spinal stenosis, trigger points, piriformis syndrome, anatomy and arthrokinematics of the lumbar spine.	Spinal segmental overview, sensibility, sensibility related brain areas, radiculopathy, spinal stenosis, sciatica.
	BC	Equal to week 3.	Central sensitization, Distress model of Selye, motivational model Prochaska & Diclemente, therapeutic alliance.
	PT	Assessment, Patient related outcomes, physical load and capacity, mental load and capacity.	PT treatment process, treatment-based classification, patient education, biomechanical counseling, training correct posture, safe body mechanics, kinesthetic awareness, motor learning, lifting instruction.
5	MB	Mechanical stability / biomechanics, effect of intra-abdominal pressure, disc pressure in different postures, Panjabi stability model, Forces in weight bearing.	Anatomy and arthrokinematics of the spine & pelvis related to global movement possibilities, stabilizing factors of the spine, variation of postures, spinal soft tissue abnormalities.
	BC	Central sensitization (behavior component), contemporary pain management models, biopsychosocial perspectives, catastrophizing, common sense model, coping, Kinesiophobia, metaphors to explain pain.	Therapeutic alliance, compliance/adherence, ACT (pain), communication skills.
	PT	Assessment of pain type, behavior (incl safety seeking behavior) and treatment of different pain types in terms of hands-on, exercise (specific / nonspecific), graded exposure and activity, lifestyle.	PT treatment; MDT (McKenzie) principles, Mulligan concept, active & passive mobilizing techniques, global & local spinal mobilization (angular techniques), motor control.
6	MB	Anatomy and arthrokinematics of the cervical spine.	Anatomy and function of spinal motor control system, spinal postures, discus anatomy and physiology.
	BC	Pain education (PSE), graded activity, graded exposure.	Central sensitization, Stress model of Selye, Work stress related to pain & the limbic system, Pain Science Education (PSE), coaching, graded activity.
	PT	Motor control assessment and therapy (no bracing but controlling).	PT treatment: Motor control retraining, lumbar and cervical spine, Luomajoki's tests, lifting instruction, treatment myofascial trigger points, cognitions/pain education, graded activity.

7	MB	Non-specific vs specific, General practitioner vs PT (and potential conflicts), multiple specific lumbar spine conditions.	Rheumatoid Arthritis, pain medical treatment, neurophysiology of persistent pain, multi-disciplinary pain treatment.
	BC	None	SCEBS-model, RPS form-contextual factors, multi-disciplinary treatment persistent pain, prognostic factors, pain (self)management.
	PT	None	PT treatment: MDT (McKenzie) principles, Mulligan concept, Mobilizations with Movement (MWM), myofascial trigger points, PSE, BPS factors, multidisciplinary approach.
8	MB	None	Clinical reasoning & differential diagnostics spinal problems, Claudicatio Intermittens, Spondylolisthesis, Stenosis, Sciatica, Piriformis syndrome, Radiculopathy, medical treatment options, medical diagnoses upper- and lower extremities & internal organs related to spinal problems.
	BC	None	Influencing factors per case study, clinical reasoning, communication skills.
	PT	None	PT diagnostics & treatment: Differential diagnoses case studies low back & neck pain (related to upper /lower extremities), clinical reasoning related to RPS-form.

Wk; week, MB; medical biological, BC; behavior & communication, PT; physiotherapy.

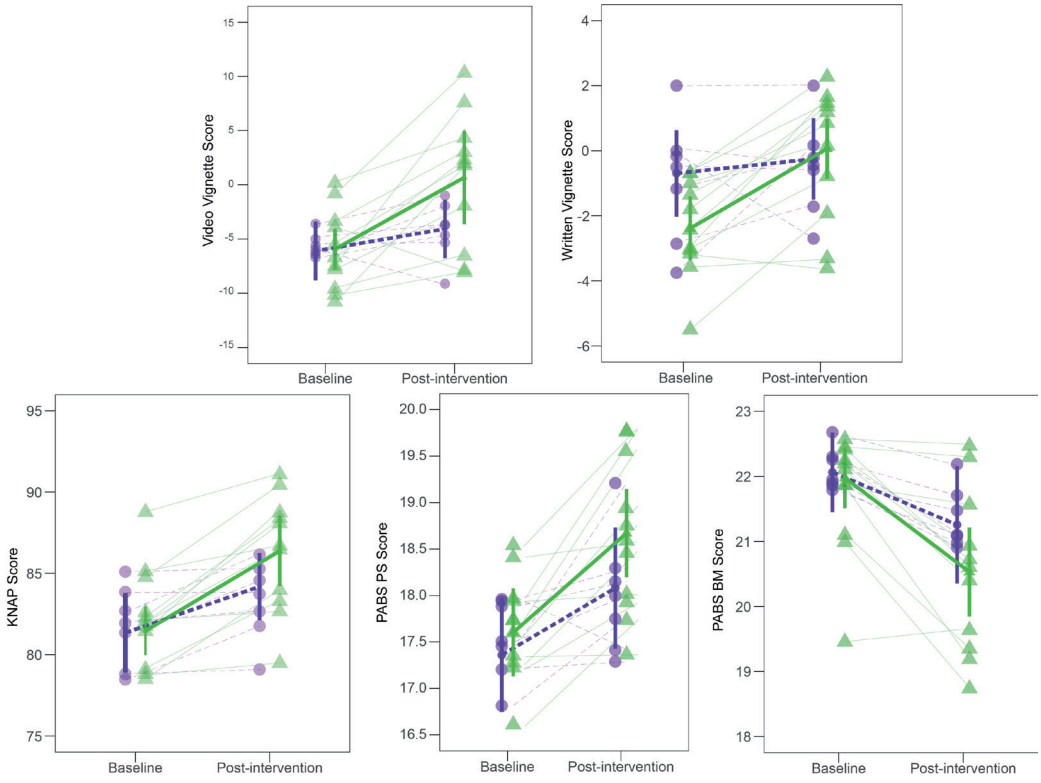
SDC 3: Response options Written Vignette

Question	Response classification + scoring (pnts)	Response option on questionnaire
1. Symptoms		
	1 AR: +2	Very mild
	2 AR: +1	Mild
	3 IR: 0	Moderate
	4 IR: -1	Severe
	5 IR: -2	Very severe
	6 IR: 0	Cannot assess
2.Tissue damage		
	1 AR: +2	These symptoms are probably not originating from tissue damage or disease.
	2 AR: +1	Mild
	3 IR: 0	Moderate
	4 IR: -1	Severe
	5 IR: -2	Very severe
	6 IR: 0	Cannot assess
3.Work **Given the patient's capacity,**		
	1 AR: +2	regular work could be performed
	2 AR: +1	part-time or light work could be performed.
	3 IR: -1	work should be temporarily stopped
	4 IR: -2	work should be stopped until the pain has reduced
	5 IR: -3	work should be stopped until pain has completely disappeared
4.Training		
	1 AR: +2	Return to normal training
	2 AR: +1	Return to gradual build-up of the training
	3 IR: -1	Refrain from training for 1 months
	4 IR: -2	Refrain from training until pain has improved
	5 IR: -3	Refrain from training until the pain has completely disappeared
5.Activities of daily living		
	1 AR: +2	Perform usual activities of daily living
	2 AR: +1	Perform usual activities of daily living within the participants' tolerance
	3 IR: -1	Perform only pain free usual activities of daily living
	4 IR: -2	Limit all usual activities of daily living until pain disappears

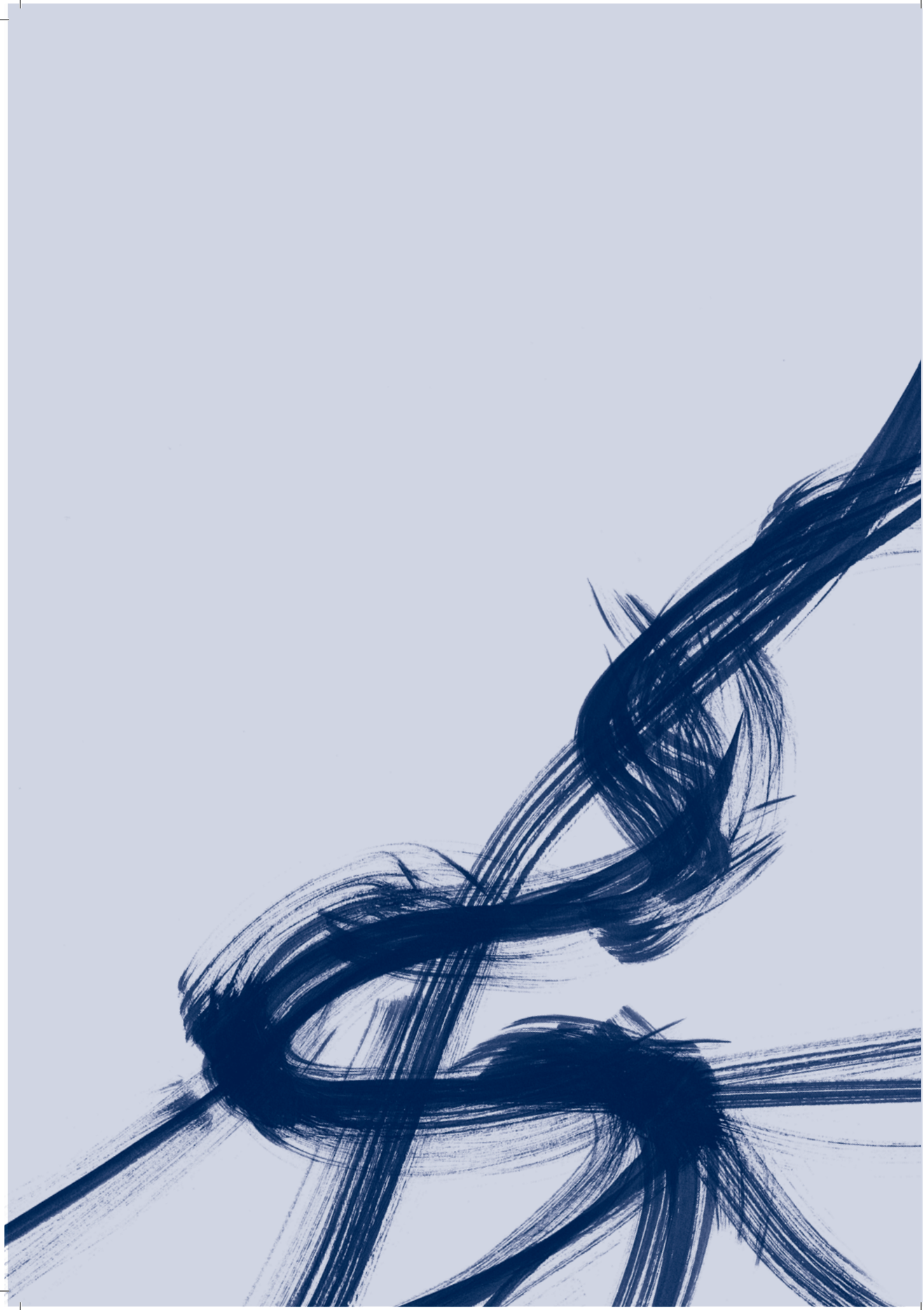
6.Rest in bed or couch		
	1 AR: +2	Avoid resting in bed or couch entirely
	2 AR: +1	Avoid resting in bed or couch as much as possible
	3 IR: -1	Rest in bed or couch only when pain is severe
	4 IR: -2	Rest in bed or couch until pain improves substantially
	5 IR: -3	Rest in bed or couch until pain disappears
7.Education		
	1 AR: +2	Being active is helpful
	2 AR: +1	Being active is helpful, even if it worsens the pain
	3 IR: -1	Being active is helpful but not when it worsens the pain
	4 IR: -2	That the patient should move cautiously
	5 IR: -3	That the patient should bend and lift carefully
8.Exercise therapy		
	1 AR: +2	Performing regular exercise therapy
	2 AR: +1	Gradually building up the exercise therapy
	3 IR: -1	Not performing exercise therapy for a month
	4 IR: -2	Not performing exercise therapy until the pain is reduced
	5 IR: -3	Not performing exercise therapy until the pain has completely disappears
9.Use of the back		
	1 AR: +2	Gradually resume flexion and rotation of the back.
	2 AR: +1	Gradually resume lifting and carrying heavy objects
	3 IR: -1	The patient should pay attention to their posture while sitting and standing
	4 IR: -2	The patient should keep the back straight when lifting and carrying weights exceeding 5 kg
	5 IR: -3	The patient should avoid lifting and carrying weights exceeding 10 kg

Legend: Case vignette options for symptoms and tissue damage and clinical recommendations regarding work, training, activity of daily living, rest in bed or couch, education, exercise therapy and use of the back. The first two responses are appropriate recommendations (AR), the last remaining options are considered inappropriate recommendations (IR) Adapted from Bishop et al. (2008)

SDC 4: Results of Video vignettes, Written Vignette, KNAP, PABSPT-PS & PABSPT-BM at cluster level.



Results of Video vignettes, Written Vignette, KNAP; Knowledge and Attitude of Pain, PABSPT; Pain Attitudes and Beliefs Scale for Physiotherapists, PS; biopsychosocial subscale, BM; Biomedical subscale. (reversed). Enhanced Educational Intervention (green lines), Education as Usual (purple lines) (N = 451 measurement points). Bold lines represent mean scores per outcome score with 95% confidence intervals, thin lines represent the mean scores for each cluster, illustrating the effect of each cluster in relation to the total group. At the cluster level, both progress and decline are visible.



CHAPTER 8

General discussion

Introduction

Professional health education provides an opportunity to develop competencies aligned with current evidence and to prioritize high-value care in musculoskeletal (MSK) pain treatment. (1,2) Health curricula must be realigned to fully incorporate the biopsychosocial (BPS) model, resulting in future physiotherapists (PT) feeling confident and competent in delivering patient-centered pain care. Apparently, there is a discrepancy between what is known from the International Association of the study of Pain (IASP) and European Pain Federation (EFIC) curricula and what is happening in health education. This emphasizes the need for increased efforts to integrate core pain competencies, outcomes and accompanying learning strategies into health education programs. Therefore, the overarching aim of this thesis was to expand knowledge on improving contemporary pain knowledge, attitudes, and clinical behavior among future PTs in the management of individuals with MSK-pain.

In this final chapter the main findings are presented and discussed in a broader educational context. Moreover, the methodological strengths and limitations are considered, as well as educational recommendations of the findings and future perspectives.

Main findings

Part I. Assessing contemporary pain knowledge and biopsychosocial attitudes

The first step towards the overarching aim was to assess contemporary pain knowledge, beliefs and BPS attitudes of PT and Manual Therapy (MT) students. Chapter 2 contains the development of the 30-item KNowledge and Attitudes of Pain questionnaire (KNAP), with extensive testing according to COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) guidelines, demonstrating its adequate measurement properties and sensitivity to consistently differentiate between future PTs. It was concluded that the KNAP is useful in evaluating future PTs knowledge and attitudes of contemporary pain science in the progressing years of the PT curriculum and after completing a pain education course. Chapter 3 provides a systematic overview to assess outcomes of Pain Science Education (PSE). Assessments can target either proximal or distal outcomes. In this chapter 32 proximal assessment instruments were identified that currently target pain understanding, beliefs, and attitudes, with the intent of helping clinicians and researchers using PSE to choose the optimal instruments for their assessment needs. Process and

impact variables have been identified as distal outcomes. More psychometrically robust instruments, guided by frameworks such as the COSMIN guidelines and Item Response Theory (IRT) methods, and tailored to specific populations, would enhance the utility and applicability of PSE-assessments. Combining existing instruments with qualitative interview in a mixed-methods approach may be required to assess conceptual change in depth. Understanding different methods of assessing PSE is essential for designing effective health education. In Chapter 4 the extent to which MT students possess contemporary pain knowledge and BPS attitudes necessary for applying a patient centered approach to patients with MSK pain was explored, using the KNAP as primary measure. The results show that MT students develop more guideline consistent knowledge of and attitudes towards MSK pain during the progressing years of the MT educational program. Moreover, a specific pain education course seemed to have the most positive impact in minimizing students' vacillation between a biomedical and a BPS perspective.

Part II. Adopting and evaluating a biopsychosocial approach towards musculoskeletal pain in health care education

The second step was to identify a consented set of essential pain-related topics that undergraduate PT students should learn to adequately treat patients with pain. In Chapter 5 a Delphi study was presented that identifies 63 BPS topics related to contemporary pain science for Dutch PT programs. The topics reflects the dynamic interaction of multiple factors which contribute to tissue sensitivity and influence how a person perceives and interprets their pain. The agreed topics mainly represent understanding, assessing, and managing the complex multidimensional nature of pain. Competences related to concepts such as "the BPS model," "self-management," "patient-centered approach", and "behavioral principles" can be developed in general and more in-depth in specific areas such as pain. These findings enable building comprehensive pain curricula and should be taught as part of the development toward the graduate level as IASP and EFIC curriculum outlines.

The third step was to understand the meaningful contributions of rehabilitation of participants who have substantially improved in living with persistent pain (Chapter 6). The findings of this qualitative study strongly support person-centered care, an understanding of Pain Dialogue and personal growth through the lens of people with lived experience. The quality of the therapeutic relationship is considered a central vehicle for improved health outcomes. Insight in these processes, provides the opportunity to revisit health education. Explaining pain should not be taught to future PTs as a one-sided pain monologue focused solely on educating patients about pain neurophysiology, but rather as an interactive Pain Dialogue. These insights could

lead to an effective guidance of patients to reconceptualize their pain, improved self-awareness, self-regulation and autonomy that promotes self-management.

The fourth step was to evaluate the impact of an educational intervention aimed at influencing BPS pain knowledge, attitudes, and self-reported clinical behaviors of PT students (Chapter 7). The educational intervention is informed by the findings from the KNAP studies (Chapter 2 and 4), the Delphi study (Chapter 5), the qualitative study (Chapter 6), and the guidelines of IASP (3) and EFIC. (4) Both groups improved significantly on all outcomes, with the Enhance Education Intervention (EEI), compared to Educational as Usual (EAU) resulted in greater improvements in PT students' contemporary understandings of pain, BPS attitudes, and the ability to make recommendations aligned with clinical guidelines. It was concluded that these findings could lead to changes in the most enduring beliefs and behavior that could then be applied when future PTs start their professional practice. Figure 1 provides a schematic overview illustrating the connections between the findings of this thesis.

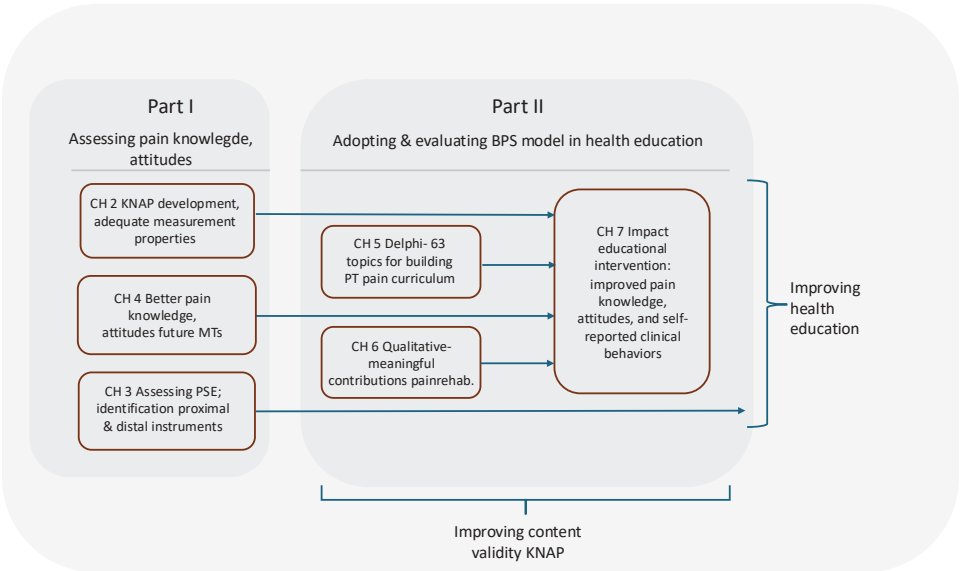


Fig. 1. Connections between the main findings of the thesis

KNAP; Knowledge and attitudes of pain, BPS; Biopsychosocial, MT; Manual therapist, PSE; Pain science education, CH; chapter, painrehab; pain rehabilitation.

Reflecting the main findings

Integrating the findings in a Health Educational Framework

This thesis synthesizes comprehensive findings to enhance the integration of the BPS model in MSK-pain education. KNAP is useful in assessing future PTs and MTs knowledge and attitudes of contemporary pain science (Chapter 2 and 4). When assessing pain reconceptualization (Chapter 3), the literature has predominantly taken a quantitative approach. However, the validity of such measures is challenging to elucidate. This is because pain reconceptualization is a multifactorial phenomenon (5) one tool might be unlikely to access the full scope of someone's 'understandings of their pain'. A person's ideas around pain cannot be fully understood outside of their lived experience and the impact it has on their life (Chapter 6). By mapping the competencies of future PTs, gaps in pain knowledge and attitudes become clear. Also, insights in essential pain-related topics for undergraduate PT students (Chapter 5), knowing the meaningful contributions of rehabilitation (Chapter 6), and the impact of an educational intervention (Chapter 7) allowing PT education and ultimately clinical practice to be adjusted and improved. Reciprocally, the findings from Chapters 5–7 could inform the KNAP to improve its content validity, thereby improving the coherence between educational goals, assessment, and the program. This refers to the 'model of constructive alignment' as an educational framework in higher education. (6–8)

Adopting a biopsychosocial approach towards musculoskeletal pain in health care education

----proposing a way forward----

A patient-centered method and the BPS model are two sides of the same coin. Engel (9) proposed that the BPS model could make medicine and allied health care more scientific, but its use in education, clinical care, and in research remains minimal. Combining existing instruments with qualitative interview in a mixed-methods approach may be required to assess conceptual change in depth. (Chapter 3) As an example, to define the current BPS model using a consistent, agreed-upon, evidence-based, and patient-centered interviewing method—making it both testable and more scientific—teaching and research will be positioned for significant advancement. (10) Similarly, the application of the behavioral change wheel (11) could guide the implementation of the BPS model into musculoskeletal pain care and education. Because these methods focus on emotion and the provider-patient relationship, they also affect regulation as the central dynamic in patient-centered communication, one of our main findings in the qualitative study. (Chapter 6)

Although the BPS model has gone a long way toward focusing on the human experience of pain, there is room to clarify and extend (i.e. modernize) it.(12) Understanding the meaning of pain to those who live with it, is integral to the study of pain.(13) The qualitative study (Chapter 6) used the concepts for recovery from persistent pain, focusing on the subjective lived experience (14,15). The enactive approach as a preliminary embodied pain framework (12,16), can help to better appreciate lived experiences and patients' narratives.(12,17,18) When considering the enactive approach to pain, we move from it being just in the brain or in the back – to it being a process that emerges or unfolds through a whole person who is inseparable from the world.(12,16) The enactive approach can be seen as the underlying framework integrating the findings from Chapter 6 and 7. The individual lived experience of pain can inform cognitive behavioral (CB) approaches, such as Cognitive Functional Therapy (CFT) (19)**.** The principles of an enactive approach align with guided experiential therapies such as graded exposure (20) to feared experiences. Helping a person learn through experience that hurt (pain) does not always mean harm and thereby reducing the threat value of moving, which then becomes the new expectation when moving. The educational relevance of an enactive BPS approach lies in providing in-depth explanatory pain theories and subsequently altering students' approaches to pain. Also, to uncover the multiplicity of factors that may be contributing to a person's pain and many possible interventions across the person-environment system, places an interest in more comprehensive, interprofessional education and pain care. (21)

Future PTs should be aware that healthcare interactions can shape patients' experiences and may unintentionally facilitate nocebo effects, thereby modulating threat and pain.(22–24) This emphasizes training in listening and validation skills with (role-played) patients. (12) The results of the Delphi study (Chapter 5) support the need to integrate psychologically informed approaches, along with appropriate learning strategies, into physical treatments. Psychologically informed practice (PIP) (25,26) is proposed as a clinical framework for integrating management of experience unhelpful psychological responses to pain into standard 'physical' practice (1,2,27–29). A PIP Consultation Roadmap is offered as a guide for clinical implementation to establish a therapeutic relationship, develop patient-centered communication, and guide effective pain self-management. (30) The same insights as individuals with lived experience had on how rehabilitation can support recovery in persistent pain. (Chapter 6) In an interactive pain dialogue, focus can be ensured on the person's unique circumstances, including perceptions and emotions. However, the patient's view on what is needed contrasts with the professional competencies required to meet these needs and evaluate treatment. An integrated approach should become a standardized part of professional PT education programs, to ensure that psychological

factors and pain perception are handled appropriately. Within context-specific pain practice, experiential learning and collaborative reflective practice can facilitate a positive change toward competency in BPS attitudes and skills while challenging previous unhelpful responses to pain among future PTs. (2,31–35) With additional training PT-delivered cognitive behavorial (CB) interventions provides potential for PTs to integrate physical, psychological and social elements and greater benefits for patient outcomes compared to physical techniques alone. (1,2,25,27–29,36,37) A training program with a CB approach for (future) health care professionals (HCP), resulted in improved behaviors, a decrease in their biomedical orientation for pain treatments (38,39) and improved clinical practice and patient outcomes. (26,40)

PTs play a vital role in the treatment of pain and to meet the needs of society. Therefore, Bachelor PT programs must educate students with content that aligns with a modern-day understanding of pain. However, from the Delphi study (Chapter 5) it was observed that there is varying pain content in PT education programs. Worldwide there are no clear curricular elements in PT education program accreditation standards guidelines, sub optimally ensuring that undergraduates are knowledgeable and competent in pain. (41–43) Through integration into existing PT courses and updating content with attention to pain mechanisms/BPS framework without curricular expansion is possible. Implementing modern pain education is about refining, linking, or scaffolding what is currently being taught. (41). Given the significant global impact of MSK-pain and the unsustainable burden on healthcare systems, every investment in health education pays for itself.

Methodological considerations

Strengths

A major strength of this thesis lies in its broad methodology, incorporating both quantitative and qualitative methodologies to gain and evaluate contemporary pain knowledge, attitudes and BPS behavioral of future PTs. Within the positivistic framework diagnostic and evaluative studies were conducted by using cross-sectional designs, a rapid review design and a cluster-randomised controlled trial. Within the qualitative paradigm a narrative review, a modified Delphi study and an interpretive phenomenological approach was used. This thesis employs various research approaches to assess conceptual change in depth, aligning PSE evaluation with a person-centered approach. For the KNAP a robust and extensive procedure for developing and testing measurement properties was provided, surpassing other assessment instruments.

The external validity of the findings in this thesis can be considered high. Several designs were used, recognizing the interconnectedness of the constructs represented in Leventhal's common-sense model.(44) This provided a foundation for generalizing the research findings and supporting their potential application in implementation efforts. Additionally, four of the six studies in this thesis were conducted in an educational setting, while the other two have the potential to inform health education. This ensures that the findings represent a comprehensive reflection of the important competencies necessary for a future PT managing MSK pain.

The Hanze University of Applied Sciences (Hanze UAS) can be regarded as representative of PT education in the Netherlands, supporting the generalizability of the KNAP findings. Furthermore, the comprehensive setting and large sample size in the MT study (over 660 participants) enhance the applicability of the findings to all MT institutions in the Netherlands. In addition, the Delphi study included a near-complete representation of all universities of applied sciences (UAS) in the country, further supporting the generalizability of the findings across Dutch UAS. By minimizing national biases, the results may also hold relevance in international contexts.

Limitations

In this thesis, there was a focus on a mono-disciplinary approach on health education. When health problems arise that transcend the boundaries of a single profession, this singular approach becomes problematic. As an increasing global burden with growing prevalence, 'complex pain' highlights the urgent need for integrated education given the current inadequacies in pain management training. Uni-professional education is inadequate to prepare students to work in teams and can spur competition rather than cooperation between the professions. (45) Complex pain can be seen as a broad, shared problem domain, as it involves multiple different professions, suggesting the need for education that transcends professional silos.

The KNAP addressed responses in future PTs at Hanze UAS and in future MTs at all MT institutions in the Netherlands. However, it is unclear to what extent these results can be generalized to future PTs and MTs outside of the Netherlands. Direct application of these findings may be limited by differences in educational systems and curricula and varying levels of educational standards between countries (i.e., preregistration undergraduate, graduate, and postgraduate levels). Also, education in pain for HCPs in general is highly variable and inconsistent in health curricula even within one country. (46) Consequently, implementation of results needs to be done carefully.

The MCIC of KNAP represents the magnitude of change perceived to be beneficial in the context of educational interventions not in clinical contexts. Whether the effect sizes of the educational intervention are large enough to determine enhanced clinical practice and patient-related outcomes is unknown at present and should be subject for further research. As the MCIC is only available for the KNAP, it is not possible to determine the clinical relevance of changes observed in other outcome measures, such as the clinical vignettes. Stable KNAP results at 6-month follow-up after an interdisciplinary training program (40) suggest a potential relationship between KNAP outcomes and clinical vignette performance. This may allow for a tentative estimation of the MCIC for the clinical vignettes.

The outcomes of KNAP should be interpreted carefully since its content validity is limited. The language used in the KNAP is aimed at HCPs, making the questionnaires unsuitable for a broad audience. Research shows that the questionnaires used in pain management are not suitable for measuring the constructs of pain knowledge and attitude and do not adequately align with the target group of people with low socio-economic status and/or limited Health Literacy (HL).(47) In general, there are gaps in our understanding of how best to capture pain-related knowledge and understanding, attitudes and beliefs, and whether these assessments are relevant in non-affluent, low HL or culturally diverse populations.(47–49) This leaves doubt over the impact of pain educational interventions and how they might work.(50)

Educational recommendations & future research directions

Assessing pain in diverse populations

The content validity of KNAP could be further improved by the insights in essential pain-related topics for an undergraduate PT curriculum, knowing the meaningful contributions of rehabilitation and the impact of an educational intervention. Also, HL considerations are important to ensure instrument accessibility and usability across diverse populations and under-served groups, which are often least well served by health education interventions.(50) To enable deeper understanding of what works for whom, when and in which context and get a tighter understanding of which concepts most directly track to outcomes like pain and disability, instruments considering HL are needed. Progressing from the findings of this theses, the Pain Attitudes Cognitions Knowledge and Actions (PACKA) questionnaire has been developed, incorporating elements from the KNAP and Neurophysiology of Pain Questionnaire (NPQ) (51). To

ensure the content validity of the PACKA, it must be tailored to individuals with limited HL. The first steps have been taken in the Dutch translation and cultural adaptation of the PACKA in a qualitative validation study (unpublished work). Further steps are needed to culturally adapt the PACKA for people with low HL, assess its measurement properties and design tailored interventions for and in collaboration with the target population and ultimately improve patient outcomes. Also, considering the importance of preparing graduates for the challenges of encountering 'real' people with limited HL from diverse sociocultural backgrounds, it is essential to integrate this aspect into their training.

It will be also important to ensure that appropriate outcome assessments, such as PACKA, supported by robust psychometric evidence exist to explore change in this non-clinical context where people with and without pain are targeted. In this 'general public' setting, it will be important to ensure that the items within the instruments are sufficiently generic to accommodate people with pain of any kind, as well as those without pain. Moreover, any assessment will need to be sufficiently brief and simple to administer within a public health setting.

Interprofessional collaboration in education

This thesis focused on a mono-disciplinary approach to health education, but future research should take an interprofessional (IP) direction to enhance pain competencies in future HCPs. Complex pain could be seen as a large, shared problem domain because it involves many different clinical professions, such as nursing and allied health professions, but also integrates social and technical professions.(52,53) A focus on the patient's needs and the competencies required to appropriately meet them with evidence-based techniques is needed. Interprofessional education (IPE) that transcends current professional boundaries, rather than enhancing professional silos, could provide training to competency in 'pain clinician skills' (e.g., emphatic communication, contemporary knowledge about pain, underlying pain processes and maladaptive psychological mechanisms, and guidance in behavior change and making sense of the pain problem), which in turn should improve care for patients suffering disabling pain.(54)

An IP pain curriculum could provide a common basis for different professions to learn the same language, a shared BPS conceptual framework and a basic understanding of pain mechanisms, conditions and principles of management.(52,55) However, IP collaborative practice is not yet an integral part of all health education programs.(56). Research (45,57,58) shows a positive shift in pain knowledge and attitudes toward collaboration through IPE. Recommendations of the World Health Organization (59) calls for education reform that is guided by the desired outcomes of transformative

learning and interdependence in education. Students should be introduced to IPE early and have developmentally appropriate opportunities throughout a curriculum program.(56) In 'Communities of practice' and 'situated learning' students move from learning about their own profession to other professions and members of a team. (60) The IASP Pain Curriculum Outlines (3) provide recommended curricula for several professions. (52,61–63) However, consensus on the content and desired competencies of an interprofessional pain curriculum at an undergraduate level is scarce.(46,64) Also, there is limited evidence on the implementation of IPE in the health education context, especially in MSK conditions.(65) These gaps make it valuable to explore.

Future research and educational practice in pain education should focus on defining and implementing essential content, optimizing competency use, and tailoring educational approaches for future HCPs treating pain. PT curricula need to be designed to support students to develop clinical competencies based on current pain science. A structured integration of pain education into health curricula requires considering healthcare needs, competencies for quality MSK pain management, effective teaching methods, and institutional parameters (66). Pain education in health care can be improved through a curriculum of practically engaging pain scenarios with diverse sociocultural backgrounds, co-created with people living with pain, reflecting the challenges faced in clinical practice.(67,68) Also, to gain a more comprehensive understanding of improved (future) HCP competencies towards persistent MSK-pain management, integrating qualitative evaluations with existing evaluation tools may be required. These evaluations can be integrated into various learning contexts such as lectures, demonstrations and patient simulations.(69) In turn, these insights would provide valuable feedback for refining health training programs regarding training content, teaching methods, and duration of the training.(40)

Also, research is needed to evaluate what changes may occur from educational interventions that are necessary to measure clinically significant changes in HCPs behaviour and how this affects their patients' attitudes, beliefs, behaviour, and better pain management. Also, future studies need to assess the healthcare efficiency (eg, cost-effectiveness). Therefore, research is required to investigate what type and amount of education is the most effective and has long term outcomes. There is a need to train a wide range of HCPs in delivering pain education and behavioral pain care. (70) Aspects of Cognitive Behavioural Therapy should be integrated and evaluated in health education to ultimately be a standardized part of it. Future PTs must understand their professional practice and competencies within newer evidence-based models of pain perception, pain behavior, and disability development.(25)

Conclusions

The aim of this thesis was to expand knowledge on improving contemporary pain knowledge, attitudes, and clinical behavior among future physiotherapists in the management of individuals with musculoskeletal pain. The findings offer a comprehensive reflection on key competencies required for future physical therapists managing musculoskeletal pain and provide guidance to enhance constructive alignment within health education. The findings illustrate that by mapping the competencies of future physiotherapists and manual therapists, gaps in pain knowledge and attitudes become clear, allowing health education to be adjusted and improved. The Knowledge and attitudes of pain (KNAP) questionnaire can evaluate pain competences of future health care professionals. For the KNAP questionnaire a robust and extensive procedure for developing and testing measurement properties was provided. Reciprocally, the findings from the physiotherapy educational program, including pain curriculum content and impact of an educational intervention could inform KNAP improvements. Additionally, the assessment of Pain Science Education (PSE) outcomes can target either proximal or distal outcomes. Understanding different methods of assessing PSE is essential for designing effective health education. Also, insights in the significant role of lived experience, provided a valued contribution to health education by teaching and assessing Explaining Pain as an interactive Pain Dialogue. The educational intervention led to significant improvements in physiotherapy students' contemporary understanding of pain, biopsychosocial attitudes, and their ability to make guideline-consistent recommendations, thereby contributing to the main aim of this thesis.

The findings presented in this thesis provide a foundation for future developments in health education, advocating for a systematic and robust integration of the biopsychosocial model, with the potential to fundamentally transform pain curricula. Future research and educational practice in pain should focus on defining and implementing essential content, optimizing competency use based on current pain science, and tailoring educational approaches for future health care professionals. Developing competencies in behavioral pain care and collaborative reflective practice—particularly through interprofessional education—can further enhance pain management skills in future healthcare professionals. To enable deeper understanding of which concepts most directly track to outcomes like pain and disability, instruments considering health literacy are needed. Ultimately, research is needed to evaluate what changes may occur from educational interventions on patients' attitudes, beliefs, behaviour, and better pain management.

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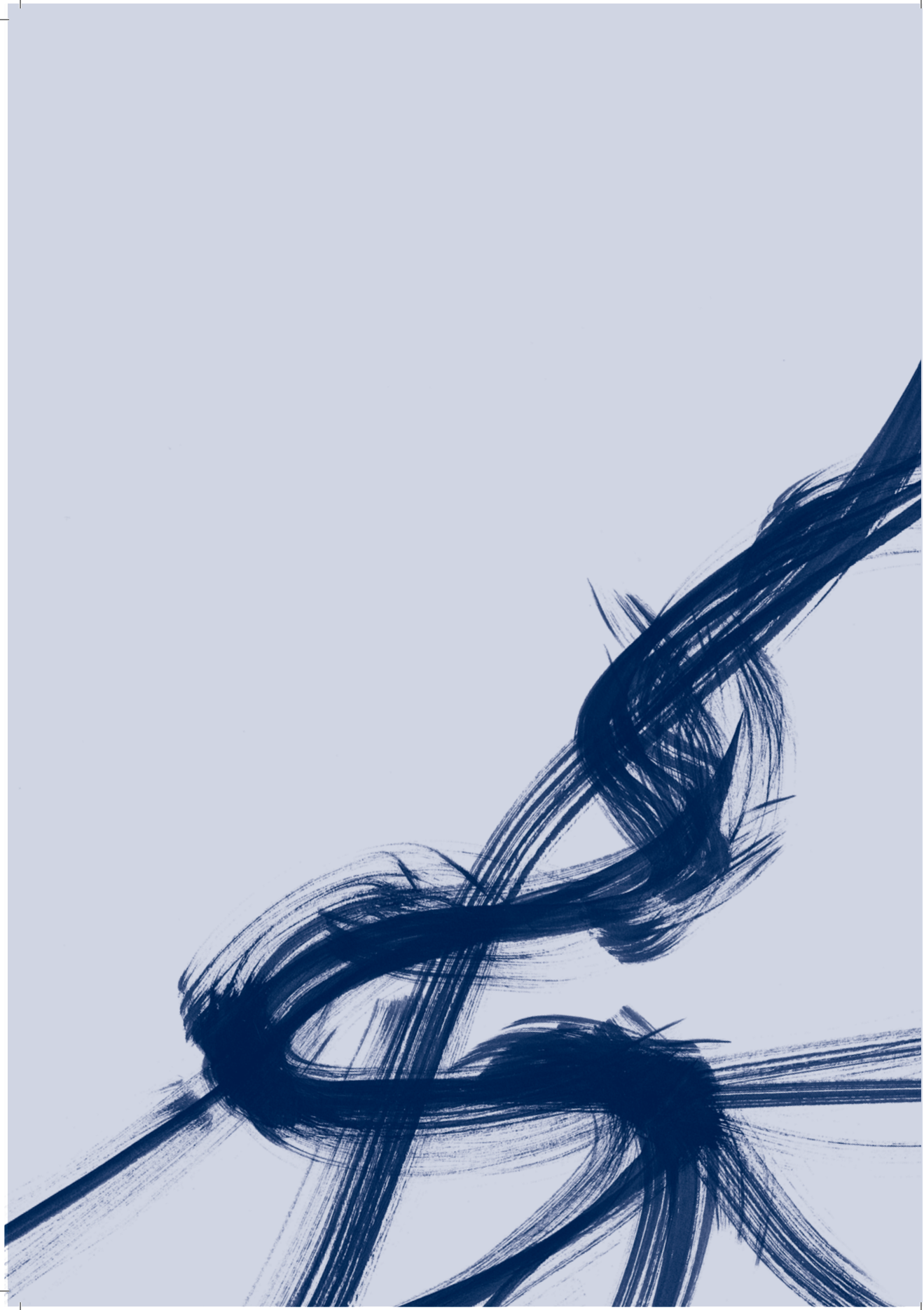
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SUMMARY

Pain Science in Physiotherapy Education

Advancing contemporary pain knowledge, beliefs, attitudes and clinical behavior of future physiotherapists

Introduction

The contemporary understanding and treatment of musculoskeletal (MSK) pain are underpinned by the biopsychosocial (BPS) model, which aligns with the comprehensive model of health education. Health educational programs lay the foundation of future physiotherapists (PT) in terms of helpful beliefs, attitudes and the adherence to clinical guidelines. However, current health educational programs and their traditional educational approaches still tend to focus on a biomedical perspective, thus being insufficient for helping future PTs in feeling confident and competent in delivering person-centered care. Despite the revised International Association of the study of Pain (IASP) definition of pain and the promotion of person-centered care in MSK pain care, integrating the BPS model in limited in PT professional health care training.

Therefore, the overarching aim of this thesis was to expand knowledge on improving contemporary pain knowledge, attitudes, and clinical behavior among future PTs in the management of individuals with MSK-pain. To achieve this, key research gaps were addressed, each aligned with the specific aims of this thesis. The first aim was to assess contemporary pain knowledge and BPS attitudes towards pain of future PTs and to get an overview of instruments assessing outcomes of pain science education (PSE). The second aim was to identify a consented set of essential topics in the undergraduate pain curriculum of the Dutch PT program. The third aim was providing insights into a wide palette of meaningful contributions of rehabilitation for people with persistent pain, providing an opportunity to revisit health educational curricula through the lens of people with lived experience. The fourth aim was to evaluate the impact of an educational intervention aimed at influencing BPS pain knowledge, beliefs, attitudes, and clinical behaviors of PT students.

The thesis is divided into two key parts:

PART I Assessing contemporary pain knowledge, beliefs and biopsychosocial attitudes.

The findings of assessing contemporary pain knowledge, beliefs, and attitudes of PT students and Manual Therapy (MT) students in the Netherlands are presented in **Chapters 2** and **4.** In **Chapter 2** the 30-item Knowledge and Attitudes of Pain

questionnaire (KNAP) was developed in 4 stages, with extensive testing according to COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) guidelines. A cross-sectional survey (n=424) was conducted among all registered students of the bachelor physiotherapy education program at the Hanze University of Applied Sciences in Groningen, the Netherlands. Internal consistency, structural validity, hypotheses testing, and Rasch analysis were examined. Longitudinal designs were applied to analyse test-retest reliability (n=156), responsiveness, and interpretability (n=76). The KNAP demonstrate adequate measurement properties and sensitivity to consistently differentiate between future PTs. It was concluded that the KNAP is useful in evaluating future PTs knowledge and attitudes of contemporary pain science in the progressing years of the PT curriculum and after completing a pain education course.

In **Chapter 4** the extent to which MT students possess contemporary pain knowledge and BPS attitudes necessary for applying a BPS approach to patients with MSK-pain was explored. Self-reported knowledge and attitudes were measured among students (n=662) at baseline and in all years of the MT postgraduate programs in the Netherlands. The KNAP was used as a primary measure. The results show that MT students develop more guideline consistent knowledge and attitudes towards MSK-pain during the progressing years of the MT educational program. Moreover, a specific pain education course seemed to have the most positive impact in minimizing students' vacillation between a biomedical and a BPS perspective.

In **Chapter 3** an overview of assessment instruments to evaluate outcomes of Pain Science Education (PSE) is provided with the intent of helping clinicians and researchers using PSE to choose the optimal instruments for their assessment needs. A two-phase process was used, including expert panel discussions and a narrative and rapid review strategy, to identify and appraise articles reporting on instrument development and psychometric evaluation. The psychometric properties of the instruments were mapped against the criteria of COSMIN. A list of 32 proximal assessment instruments were identified that currently target pain understanding, beliefs, and attitudes. Process variables such as pain self-efficacy, fear of movement and pain catastrophizing and impact variables such as physical activity, emotional wellbeing/distress and fatigue have been identified as distal outcomes. Combining existing quantitative instruments with qualitative interview in a mixed-methods approach may be required to assess conceptual change in depth.

PART II Adopting and evaluating a biopsychosocial approach towards musculoskeletal pain in health care education.

Chapter 5 contains a modified Delphi study conducted in 4 rounds with pain-experienced lecturers from Universities of applied sciences in the Netherlands and validation panels, identifying a consented set of essential pain-related topics that undergraduate PT students should learn to adequately treat patients with MSK-pain. The 63 agreed topics mainly represent understanding, assessing, and managing the complex multidimensional nature of pain. These findings enable building comprehensive pain curricula and should be taught as part of the development toward the graduate level of the IASP and European Pain Federation (EFIC) curriculum outlines.

Chapter 6 outlines the use of a phenomenological research framework and its associated methodology, involving in-depth interviews with thirteen purposefully selected participants who reported substantial improvement from persistent pain following rehabilitation. This chapter offers insights into the meaningful contributions of rehabilitation to their pain recovery and adaptation. Seven interconnected themes were developed: 1) indication of negative pain and health care experiences, 2) supporting working alliance with healthcare professionals, 3) Pain Dialogue, 4) improved self-awareness and self-regulation, 5) different view on pain, 6) autonomy and personal growth and 7) hope and new perspective. The interconnectedness of the themes and framing them within the process of meaningful contributions of rehabilitation, provides a novel conceptual understanding of how rehabilitation can enhance recovery.

Our initial expectation of what was perceived as important in pain rehabilitation was an understanding of pain neurophysiology. However, rehabilitation participants learn to adopt a different perspective on their pain enabling them to progress, with less emphasis on their ability to articulate the neurophysiological mechanisms behind it. This study introduced Pain Dialogue, a personalized, interactive approach to pain education that moves beyond the traditional one-sided pain-monologue. The findings strongly support person-centered care, an understanding of Pain Dialogue and personal growth through the lens of people with lived experience. The quality of the therapeutic relationship is considered a central vehicle for improved health outcomes. Insight in these processes, provides the opportunity to revisit health education.

In **Chapter 7** the results of a cluster-randomized controlled trial are presented. The study aimed to evaluate the effects of an enhanced educational intervention (EEI) on

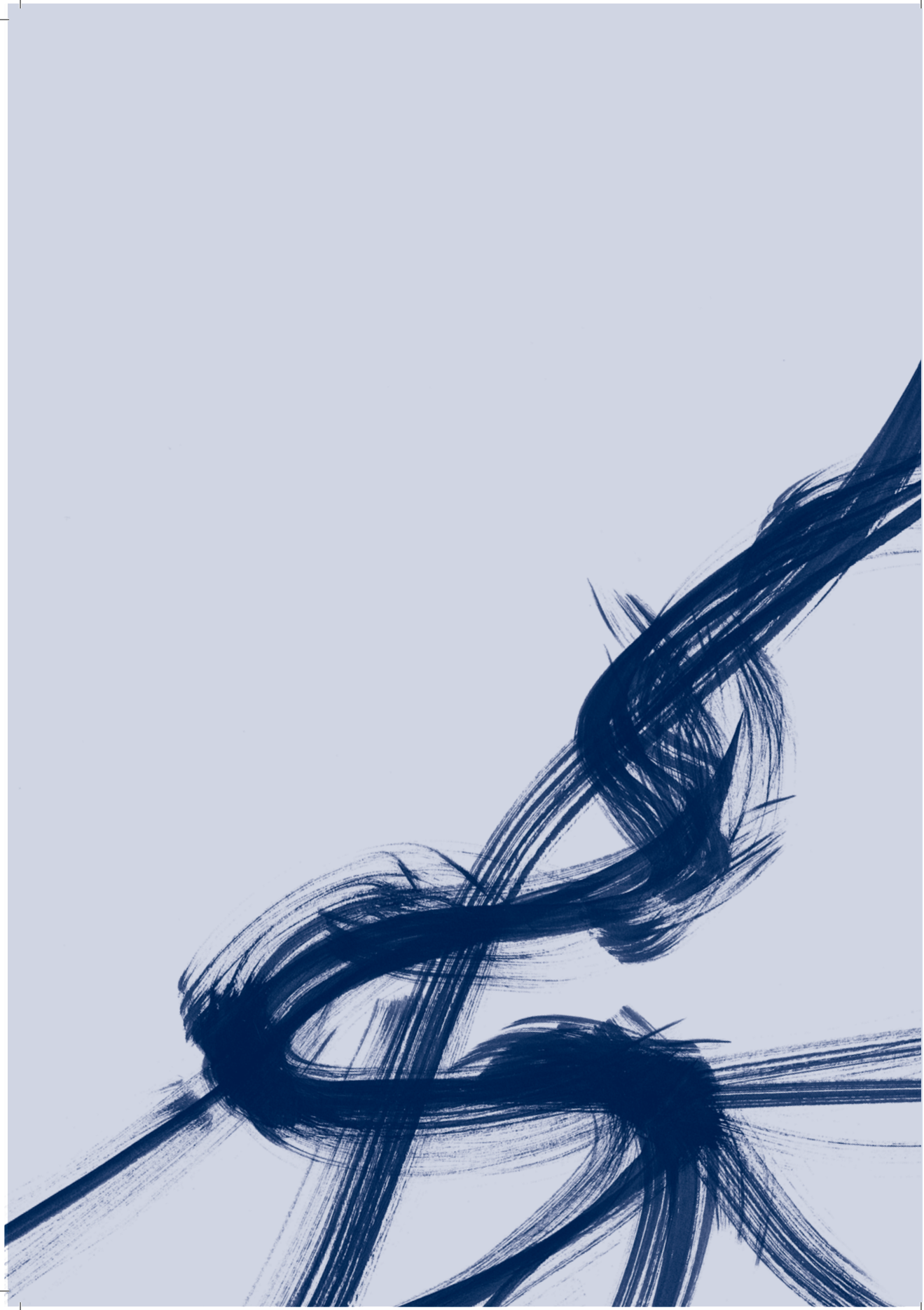
the BPS pain knowledge, beliefs, attitudes, and self-reported clinical behaviors of PT students in the Netherlands. The course description and dosage (standard curriculum content) were consistent across the EEI and Education as Usual (EAU) group and was delivered over 8 weeks. The EEI group received enhanced training during practical PT classes promoting a conceptual change in understanding MSK-pain, based on contemporary pain science. The difference between EEI and EAU lies in the approach and delivery of the assessment and treatment skills during practical PT classes. This was done without extending the duration of the EEI. The EEI was taught by regular teachers who received additional training. The EEI compared to EAU resulted in greater improvements in PT students' contemporary understandings of pain, BPS attitudes, and the ability to make recommendations aligned with clinical guidelines. Substantially more students in the EEI responded on all outcome measures, compared to the EAU. On the KNAP about half of the students in de EEI exceed the clinical meaningful improvement. Moreover, students in the EAU group were approximately twice as likely as those in the EEI group to experience potentially negative outcomes.

This study showed improved outcomes in the early stages of PT training, by utilizing minimal resources and adaptations. Time for clinical integration with transformative learning experiences is an important consideration for any future training aimed at developing competency and successful clinical application of a BPS approach. The natural educational setting facilitates easy implementation of the intervention. The results of this study could help refine entry-level PT pain education programs by addressing traditional misconceptions about pain and promoting more efficient and effective clinical practice aligned with contemporary pain beliefs and behaviors.

Discussion

The studies described in this thesis aimed to expand knowledge on improving contemporary pain knowledge, attitudes, and clinical behavior among future PTs in the management of individuals with MSK-pain. It was concluded that the KNowledge and Attitudes of Pain questionnaire (KNAP) is useful in evaluating contemporary pain knowledge and attitudes of future PTs. The outcomes of KNAP should be interpreted carefully since its content validity is limited. The assessment of Pain Science Education (PSE) outcomes can target either proximal or distal outcomes. Understanding different methods of assessing PSE is essential for designing effective health education. To further contribute to the main aim of this thesis, insights were gained into essential pain-related topics for undergraduate PT students, the meaningful contributions of rehabilitation, and the impact of an educational intervention. These findings have the potential to adjust and improve PT education and, ultimately, clinical practice.

Although this thesis synthesizes comprehensive findings to support the integration of the BPS model in health education, further efforts are needed to clarify and modernize its application. This calls for a systematic and rigorous integration of the BPS model, with the potential to fundamentally transform pain curricula. The findings presented in this thesis provide a foundation for future developments in health education, offering guidance to improve constructive alignment within curricular design and delivery. Developing competencies in behavioral pain care and collaborative reflective practice—particularly through interprofessional education—is needed to further enhance pain management skills in future healthcare professionals.



SAMENVATTING

Pijnwetenschap in Fysiotherapie-onderwijs

Bevorderen van moderne pijnkennis, overtuigingen, attitudes en klinisch gedrag van toekomstige fysiotherapeuten

Inleiding

Het moderne begrip en de behandeling van musculoskeletale (MSK) pijn zijn gebaseerd op het biopsychosociale (BPS) model, dat aansluit bij het integrale model dat wordt gebruikt binnen het gezondheidszorg onderwijs. Gezondheidszorg onderwijs vormt de basis voor het ontwikkelen van actuele pijnkennis, overtuigingen, attitudes en het toepassen van klinische richtlijnen bij toekomstige fysiotherapeuten. Huidig gezondheidszorg onderwijs en hun traditionele onderwijsvormen zijn echter vaak nog biomedisch georiënteerd, waardoor toekomstige fysiotherapeuten niet de competenties en het vertrouwen ontwikkelen die nodig zijn voor een persoonsgerichte zorg bij MSK-pijn. Ondanks de herziene definitie van pijn door de International Association for the Study of Pain (IASP) en het belang van persoonsgerichte zorg bij MSK-pijn, is de integratie van het BPS-model in de fysiotherapieopleiding beperkt.

Het overkoepelende doel van dit proefschrift was daarom het verbeteren van de moderne pijnkennis, overtuigingen, attitudes en het klinisch gedrag van toekomstige fysiotherapeuten bij MSK-pijn. Om dit doel te bereiken werden belangrijke kennishiaten onderzocht en elk kennishiaat werd gekoppeld aan een specifiek doel. Het eerste doel was om de moderne pijnkennis en de BPS-attitudes van toekomstige fysiotherapeuten te meten en daarnaast om de meetinstrumenten in kaart te brengen die worden gebruikt om uitkomsten van Pijn onderwijs (Pain Science Education) vast te stellen. Het tweede doel was om consensus te bereiken over de essentiële onderwerpen binnen het pijncurriculum van de Nederlandse bacheloropleiding fysiotherapie. Het derde doel was het verkrijgen van inzicht in de betekenisvolle bijdrage van revalidatie bij mensen met aanhoudende pijn. Deze inzichten in de doorleefde ervaring bieden kansen om gezondheidszorgopleidingen te herzien. Het vierde doel was het evalueren van de impact van een educatieve interventie gericht op het beïnvloeden van BPS-pijnkennis, overtuigingen, attitudes en het klinisch gedrag van fysiotherapiestudenten.

Dit proefschrift is onderverdeeld in 2 delen.

DEEL I – Meten van moderne pijnkennis, overtuigingen en biopsychosociale attitudes.

In Hoofdstuk 2 en 4 worden de resultaten van de evaluatie van de moderne pijnkennis, overtuigingen en attitudes van fysiotherapie en manuele therapie studenten in Nederland gepresenteerd. In **Hoofdstuk 2** werd de 30-item Knowledge and Attitudes of Pain (KNAP) vragenlijst in vier fasen ontwikkeld en uitvoerig getest volgens de COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) richtlijnen. Een cross-sectionele studie (n=424) werd uitgevoerd onder alle studenten van de bacheloropleiding fysiotherapie van de Hanzehogeschool Groningen. Interne consistentie, construct validiteit, hypothese-toetsing werden onderzocht en een Rasch-analyse werd uitgevoerd. Voor de analyse van de test-hertest betrouwbaarheid (n=156), responsiviteit en interpretatievermogen (n=76) werd gebruik gemaakt van longitudinale designs. De KNAP beschikt over adequate meeteigenschappen en de gevoeligheid om consequent onderscheid te maken in moderne pijnkennis en attitudes van toekomstige fysiotherapeuten. Er werd geconcludeerd dat de KNAP bruikbaar is voor het evalueren van actuele pijnkennis, overtuigingen en attitudes van studenten gedurende hun studie en na afronding van een cursus pijneducatie.

In **hoofdstuk 4** werd onderzocht in hoeverre studenten manuele therapie (MT) beschikken over moderne pijnkennis en BPS-attitudes die nodig zijn voor het toepassen van het BPS-model bij patiënten met MSK-pijn. Zelf-gerapporteerde kennis en attitudes werden gemeten bij studenten (n=662) op baseline en in alle studiejaren van alle MT-masteropleidingen in Nederland. De KNAP werd gebruikt als primaire uitkomstmaat. De resultaten laten zien dat MT-studenten tijdens hun opleiding meer moderne pijnkennis en attitudes ontwikkelen, in overeenstemming met de MSK-richtlijnen. Bovendien bleek een specifieke module pijneducatie de grootste positieve impact te hebben op het verminderen van de ambivalentie tussen een biomedisch en een BPS perspectief.

In **hoofdstuk 3** is een overzicht gegeven van de meetinstrumenten die de uitkomsten van PSE evalueren, met als doel om clinici en onderzoekers te helpen bij het kiezen van een geschikt meetinstrument. Een twee-fase benadering werd gebruikt: 1) discussies met een expertpanel, en 2) een 'narrative and rapid review strategy' om artikelen te identificeren en te beoordelen die instrumentontwikkeling en psychometrische evaluatie rapporteren. De psychometrische eigenschappen van de meetinstrumenten werden getoetst aan de COSMIN-criteria. Er werd een lijst van 32 *proximale* meetinstrumenten geïdentificeerd, die gericht zijn op het begrip van pijn, overtuigingen en attitudes. Daarnaast werden *distale* uitkomstmaten geïdentificeerd;

dit zijn procesvariabelen zoals pijn gerelateerde zelfeffectiviteit, bewegingsangst en pijn-catastroferen en impactvariabelen zoals fysieke activiteit, emotioneel welbevinden en vermoeidheid. Een combinatie van bestaande kwantitatieve meetinstrumenten met kwalitatieve interviews (mixed-methods benadering) werd aanbevolen om diepgaand de conceptuele verandering van pijn te kunnen evalueren.

DEEL II – Implementatie en evaluatie van een biopsychosociale benadering van musculoskeletale pijn binnen het gezondheidszorg onderwijs.

Hoofdstuk 5 beschrijft een aangepaste Delphi-studie, uitgevoerd in vier rondes met ervaren pijn-docenten van Nederlandse hogescholen en validatiepanels. Hieruit kwam een gezamenlijk vastgestelde set van 63 essentiële pijnonderwerpen. Dit zijn de onderwerpen die volgens de experts in de bacheloropleiding fysiotherapie aan bod moeten komen om studenten adequaat voor te bereiden op de behandeling van mensen met MSK-pijn. Deze onderwerpen richten zich vooral op het begrijpen, meten en behandelen van de complexe, multidimensionale aard van pijn. Deze bevindingen vormen een basis voor het ontwikkelen van een integraal pijncurriculum, dat aansluit op de ontwikkeling naar Masterniveau volgens de IASP- en European Pain Federation (EFIC) curricula.

Hoofdstuk 6 beschrijft een fenomenologisch onderzoeksdesign, waarbij dertien deelnemers die substantieel verbeterd waren van aanhoudende pijn na een revalidatiebehandeling, diepgaand zijn geïnterviewd. Zeven onderling verbonden thema's werden ontwikkeld: 1) negatieve ervaringen met pijn en de gezondheidszorg, 2) ondersteunende behandelrelatie met zorgverleners, 3) pijndialoog 4) verbeterd zelfbewustzijn en zelfregulatie, 5) andere kijk op pijn, 6) autonomie en persoonlijke groei en 7) hoop en nieuw perspectief. De onderlinge samenhang van de thema's biedt een nieuw conceptueel inzicht in de betekenisvolle rol van revalidatie in het herstelproces.

De verwachting was dat in pijnrevalidatie het begrijpen van de pijnneurofysiologie vooral belangrijk is. Dit onderzoek toont echter aan dat deelnemers vooral baat hebben bij het aannemen van een ander perspectief op hun pijn, terwijl minder de nadruk lag op het precies begrijpen van het neurofysiologische mechanisme. Dit onderzoek introduceerde het begrip 'pijndialoog': een gepersonaliseerde, interactieve benadering van pijneducatie, die verder gaat dan de traditionele eenzijdige pijnmonoloog. De resultaten van deze studie benadrukken sterk het belang van persoonsgerichte zorg, inzicht in de pijndialoog en persoonlijke groei, vanuit het perspectief van participanten met eigen doorleefde ervaring. De kwaliteit

van de therapeutische relatie wordt beschouwd als cruciaal voor het verbeteren van gezondheidsuitkomsten. Inzicht in deze processen biedt de mogelijkheid om het gezondheidszorg onderwijs te herzien.

In **hoofdstuk 7** worden de resultaten gepresenteerd van een cluster-gerandomiseerde gecontroleerde studie naar het effect van een 'Enhanced Educational Intervention' (EEI) op BPS-pijnkennis, overtuigingen, attitudes en zelf gerapporteerd klinisch gedrag van fysiotherapiestudenten in Nederland. De standaard curriculum-inhoud waren gelijk in de EEI en de 'Education as Usual (EAU) groep en het onderwijs duurde 8 weken. De EEI-groep ontving verrijkte training tijdens de praktijklessen fysiotherapie, gericht op het bevorderen van een conceptuele omslag in het begrijpen van MSK-pijn, gebaseerd op actuele pijnwetenschap. Het verschil tussen EEI en EAU lag in de benadering en uitvoering van de onderzoeks- en behandelvaardigheden tijdens de praktijklessen. Dit werd gerealiseerd zonder de dosering van het EEI-onderwijs te vergroten. De EEI werd gegeven door reguliere docenten die extra training ontvingen. In vergelijking met de EAU-groep liet de EEI-groep grotere verbeteringen zien in modern pijnbegrip, BPS-attitudes en in de vaardigheid om (beweeg)adviezen te geven in overeenstemming met de klinische richtlijnen. Substantieel meer studenten in de EEI-groep boekten vooruitgang op alle uitkomstmaten in vergelijking met de EAU groep. Op de KNAP behaalde ongeveer de helft van de EEI-studenten een klinisch relevante verbetering. EAU-studenten behaalden bovendien tweemaal zo vaak potentieel negatieve uitkomsten.

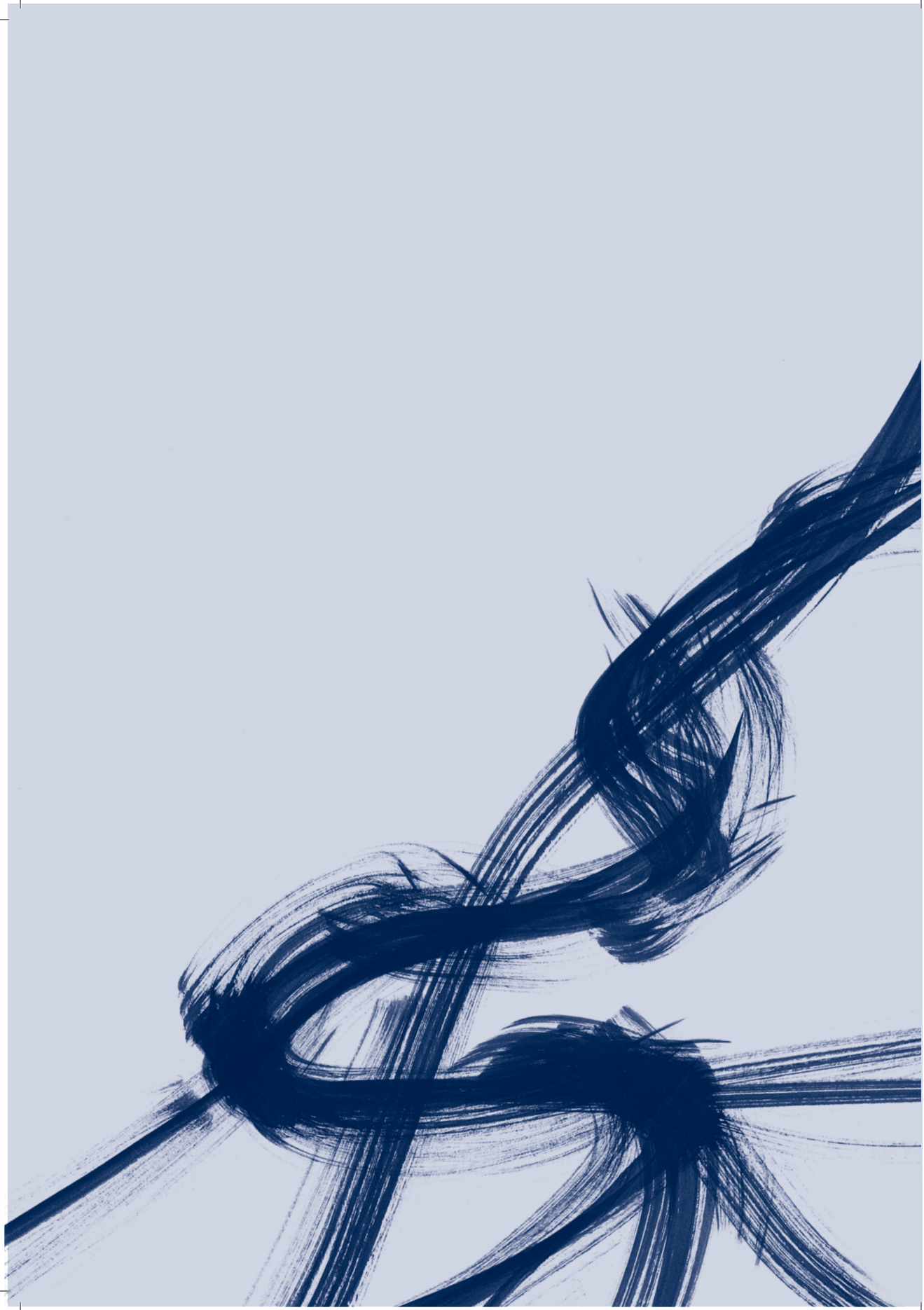
Deze studie toonde aan dat met minimale middelen en aanpassingen, verbeterde uitkomsten mogelijk zijn in een vroege fase van het fysiotherapie onderwijs. Voldoende tijd voor klinische integratie en transformatieve leerervaringen is cruciaal voor toekomstig onderwijs, dat gericht is op competentieontwikkeling en een succesvolle klinische toepassing van het BPS-model. De natuurlijke onderwijssetting in deze studie vergemakkelijkt de implementatie van de interventie. De resultaten kunnen bijdragen aan het verbeteren van het pijnonderwijs voor toekomstige fysiotherapeuten. Door traditionele misvattingen over pijn te adresseren, wordt efficiënter en effectiever klinisch handelen gebaseerd op moderne pijnwetenschap bevorderd.

Discussie

De studies in dit proefschrift hadden als doel om de moderne pijnkennis, overtuigingen, attitudes en het klinisch gedrag van toekomstige fysiotherapeuten bij MSK-pijn te verbeteren. De KNowledge and Attitudes of Pain questionnaire (KNAP) vragenlijst bleek een adequaat instrument om actuele pijnkennis en attitudes

van toekomstige fysiotherapeuten te evalueren. De uitkomsten van de KNAP moeten echter met enige voorzichtigheid worden geïnterpreteerd, aangezien de inhoudsvaliditeit beperkt is. De beoordeling van de uitkomsten van Pain Science Education (PSE) kan gericht zijn op een continuüm van proximale en distale uitkomsten. Inzicht in de verschillende methodes om PSE-uitkomsten te meten, is essentieel voor het ontwerpen van effectief pijnonderwijs. Om bij te dragen aan het hoofddoel van dit proefschrift, is inzicht verkregen in de essentiële pijn-gerelateerde onderwerpen voor bachelor studenten fysiotherapie, de betekenisvolle bijdragen van revalidatie en de impact van een educatieve interventie. Deze bevindingen kunnen bijdragen aan het aanpassen en verbeteren van het fysiotherapieonderwijs, en uiteindelijk aan beter klinisch handelen van fysiotherapeuten.

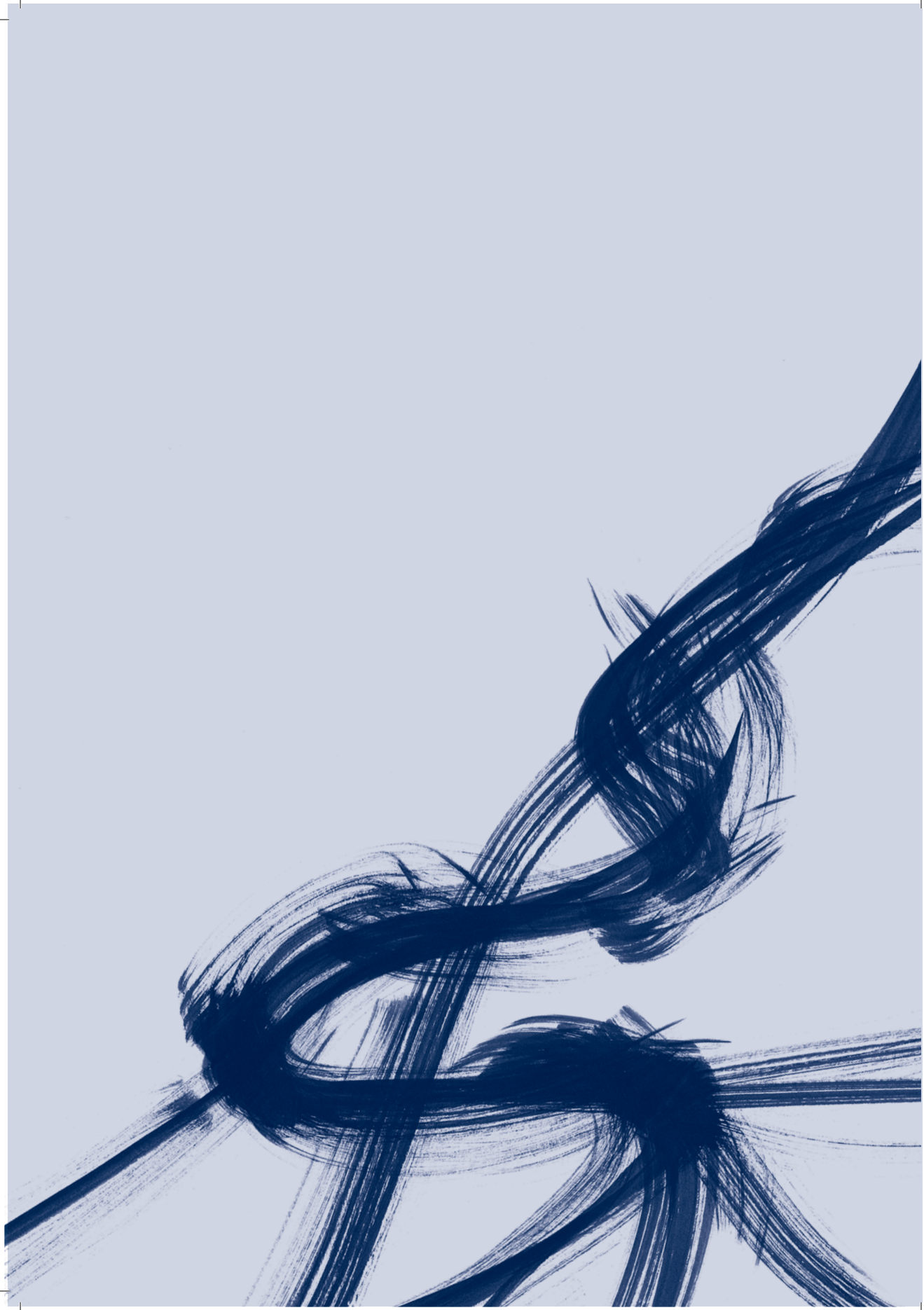
Hoewel dit proefschrift een breed scala aan bevindingen presenteert die een betere integratie van het BPS-model in het gezondheidszorg onderwijs ondersteunen, is verdere uitwerking en actualisering van de implementatie noodzakelijk. Dit vraagt om een systematische en grondige integratie van het BPS-model, die leidt tot een fundamentele hervorming van het pijnonderwijs. De bevindingen in dit proefschrift bieden een fundament voor toekomstige ontwikkelingen in gezondheidszorg onderwijs, met als doel om de afstemming tussen pijn-curriculumontwerp en -uitvoering te verbeteren. Het ontwikkelen van competenties in gedragsmatig handelen bij pijn en reflectieve samenwerking– met name via interprofessioneel leren – is noodzakelijk voor het verbeteren van pijn-behandelvaardigheden van toekomstige zorgprofessionals.



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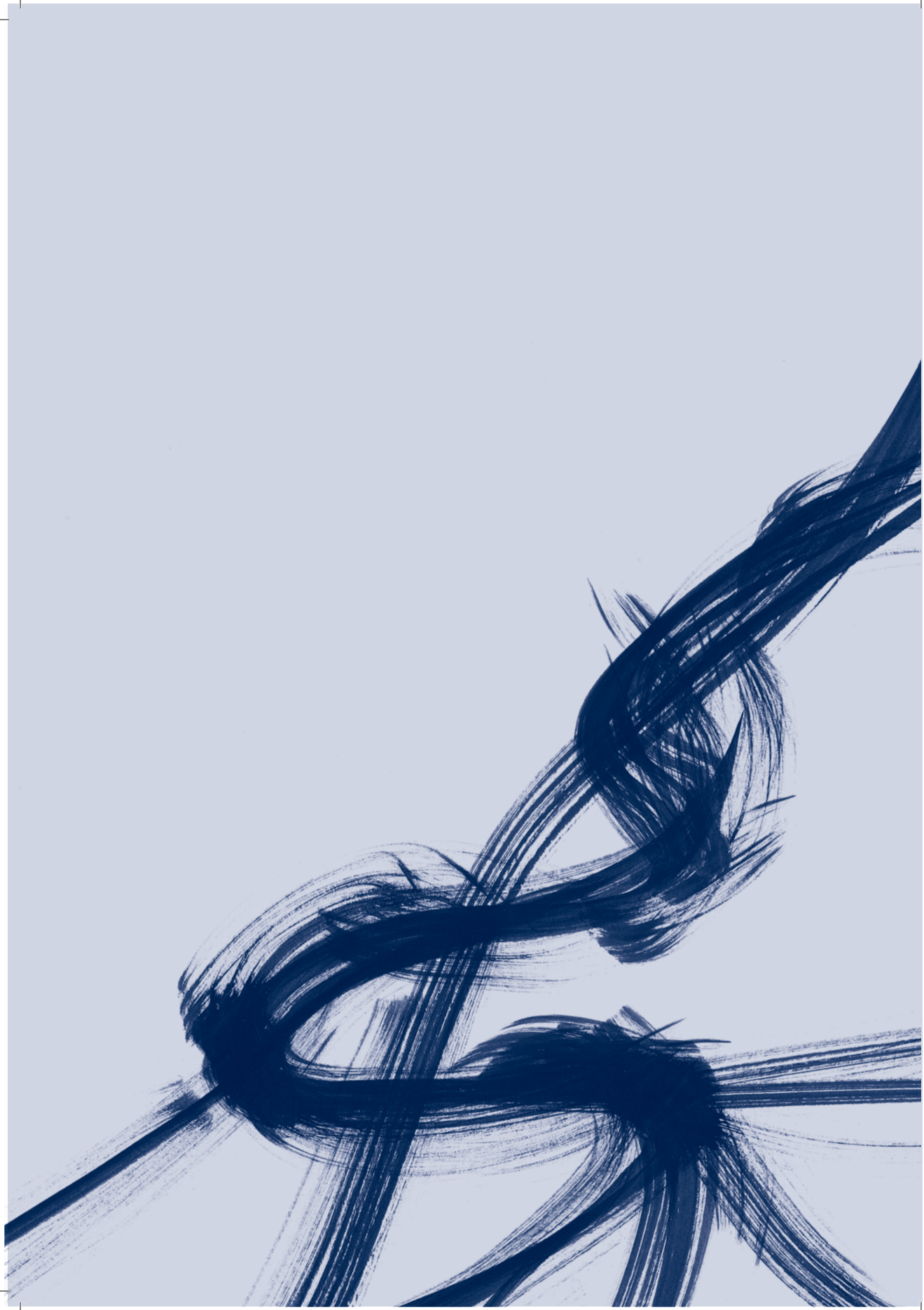
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OVER DE AUTEUR



Anneke J. Beetsma werd geboren op 26 februari 1970 in Leeuwarden. Na de middelbare school studeerde ze fysiotherapie in Enschede, aan de toenmalige Twentse Academie voor Fysiotherapie. Na het behalen van haar fysiotherapiediploma startte ze via de 3-jarige Schopenhauer-route met de studie Bewegingswetenschappen aan de Rijksuniversiteit Groningen, met als differentiatie Revalidatie en Gehandicaptenzorg. Haar afstudeeronderzoek deed ze bij de afdeling Orthopedie van het Universitair Medisch Centrum (UMCG), waar ze samen met Ella Zomerdijk onderzoek verrichtte naar de effecten van het McConnell-programma bij het Patellofemoraal pijnsyndroom bij adolescente meisjes. Als bewegingswetenschappers waren zij pioniers op de afdeling Orthopedie en hebben zij de weg vrijgemaakt voor (bewegings)wetenschappelijk onderzoek. Daarnaast werkte ze als fysiotherapeut in een eerstelijnspraktijk.

Na haar afstuderen werkte Anneke in verschillende eerstelijns fysiotherapiepraktijken in Noord-Nederland. Daarnaast was zij werkzaam bij het Koninklijk Nederlands Genootschap voor Fysiotherapie als coördinator Intercollegiaal Overleg Fysiotherapie en als docent Evidence Based Practice bij de toenmalige Hanzeservice van de Hanzehogeschool Groningen. Sinds 2003 is zij verbonden aan de opleiding Fysiotherapie van de Hanzehogeschool: aanvankelijk als docent en onderwijsontwikkelaar, later als hogeschooldocent met de verantwoordelijkheid voor de musculoskeletale leerlijn. In deze periode ontstond haar belangstelling voor pijn, waarvoor zij diverse scholingen volgde, waaronder 'Explain Pain.' Vanaf 2018 ontving zij een subsidie van de Nederlandse Vereniging voor Manuele Therapie (NVMT), waardoor zij zich intensiever kon inzetten als onderzoeker.

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