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Original article

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 ($F(3, 218.18) = 13.56$, $p < .001$, $\omega^2 = 0.059$). 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 ($F(6) = 2.597$, $p = .017$, $\omega^2 = 0.012$). 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.

1. 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 (Sebbag et al., 2019). 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 (American Physical Therapy; Smith-Bindman et al., 2019; Murray et al., 2013; Kenan et al., 2012; Foster et al., 2018; Lewis et al., 2020; Culvenor et al., 2019). The majority of persistent MSK pain cannot be adequately explained from an impairment of a peripheral structure (Foster et al., 2018; Lewis and O'Sullivan, 2018; Coronado and Bialosky, 2017). 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 (Duncan, 2000). This model is insufficient for explaining chronic MSK pain and forms a barrier for optimal biopsychosocial assessment and management (Delitto et al., 2012; Oliveira et al., 2018; Bekkering et al., 2003; Koes et al., 2010; Pincus et al., 2007; Foster et al., 2003; Sullivan, 2011; Gardner et al., 2017; Nijs et al., 2013; Poitras et al., 2012).

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

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(Gardner et al., 2017; Nijs et al., 2013; Poitras et al., 2012; Setchell et al., 2017; Darlow, 2016; Darlow et al., 2012; Foster and Delitto, 2011; Domenech et al., 2011; Parsons et al., 2007; Rainville et al., 2000; Houben et al., 2005; Ostelo and Vlaeyen, 2008). 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 (Coronado and Bialosky, 2017; Nijs et al., 2013; Bialosky et al., 2010, 2018). Additionally, manual therapists need to be able to apply the biopsychosocial model (Nijs et al., 2013; Hush et al., 2018; Oostendorp et al., 2015; Smith et al., 2019). 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) (Lewis et al., 2020; Lewis and O'Sullivan, 2018; Sullivan, 2011; Bialosky et al., 2018; Smith et al., 2019; Puentedura and Flynn, 2016; Kolb et al., 2020; Louw et al., 2016a; Moseley and Butler, 2015; Malfliet et al., 2018). PNE is a cognitive-oriented intervention that teaches people about pain biology and physiology and de-emphasises the issues associated with the anatomical structures (Foster et al., 2003; Butler and Moseley, 2013; Louw et al., 2016b; Ryan et al., 2010a; Nijs et al., 2014). 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 (Hush et al., 2018; International Association for the Study of Pain (IASP), 2018).

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 (Gardner et al., 2017; Nijs et al., 2013; Darlow et al., 2012; Foster and Delitto, 2011; Domenech et al., 2011; Parsons et al., 2007; Rainville et al., 2000; Houben et al., 2005; Ostelo and Vlaeyen, 2008; Cottrell et al., 2017; Macdonald et al., 2018). 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 (Morris et al., 2012; Adillón et al., 2015; Kennedy et al., 2014; Ryan et al., 2010b; Leysen et al., 2017; Talmage et al., 2020; Bareiss et al., 2019). 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) (Rushton et al., 2016). 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 (Beetsma et al., 2020). 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?

2. Methods

2.1. 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 (Rushton et al., 2016). These standards containing learning outcomes based on the biopsychosocial framework (Engel, 1978). 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 (Vandenbroucke et al., 2007).

2.2. 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 min $\pm$ 5. For two third-year groups, the survey was sent by email because of graduation and completion of the program.

2.3. 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.

2.4. Measures

2.4.1. Primary measure

Knowledge and attitudes toward pain were measured with the 30-item Rasch modified KNAP (Beetsma et al., 2020). 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)(Beetsma et al., 2020).

2.4.2. 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 (Ung et al., 2016) 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) (Fitzgerald et al., 2018). 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) (Eland et al., 2016). Higher scores on a subscale indicate a stronger orientation. The PABS-PT showed fair methodological quality scores on the COSMIN criteria (Eland et al., 2016; Mutsaers et al., 2012). The internal consistency for the bio-psychosocial subscale was Cronbach's $\alpha = 0.62$–0.68 and, for the biomedical subscale, Cronbach's $\alpha = 0.77$–0.84. Test-retest reliability for the biomedical subscale was ICC = 0.81 and ICC = 0.65 for the biopsychosocial subscale (Mutsaers et al., 2012).

The NPQ contains 12 items relating to the neurophysiology of pain (revised 12-item NPQ) (Catley et al., 2013). 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 (Meeus et al., 2010).

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.

2.5. 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 (Parrinello et al., 2016). 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 (Welch, 1951). 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 (Field, 2018): 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 = 0.0125 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 ≥0.01, medium ≥0.06, and large ≥0.14. 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, 0.30 to 0.50 as medium, and 0.50 to 1.00 as large (Cohen, 1988; Kirk, 1996).

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 (Vandenbroucke et al., 2007). 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.

3. Results

3.1. 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.

3.2. 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, $\omega^2 = 0.059$). The difference between baseline and year 1 was small, t(364.55) = 3.89, p < .001, r = 0.20 and medium between baseline and year 3, t(81,19) = 4.36, p < .001, r = 0.44. Small non-significant differences were determined between year 1 and 2, t(351.65) = 1.58, p = .116, r = 0.08 and between years 2 and 3, t(89.95) = 0.71, p = .480, r = 0.07. Researchers can use the MIC as the smallest change in what is measured that is considered to be important (Haley and Fragala-Pinkham, 2006; Lee et al., 2013). Mean difference did not exceed the MIC (Beetsma et al., 2020).

3.3. 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 Fig. 1. The interaction effect was significant on KNAP scores with a small effect size ($F(6) = 2.597$, p = .017, $\omega^2 = 0.012$). A positive difference is visible in knowledge and attitudes toward pain in year 2.

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.

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.

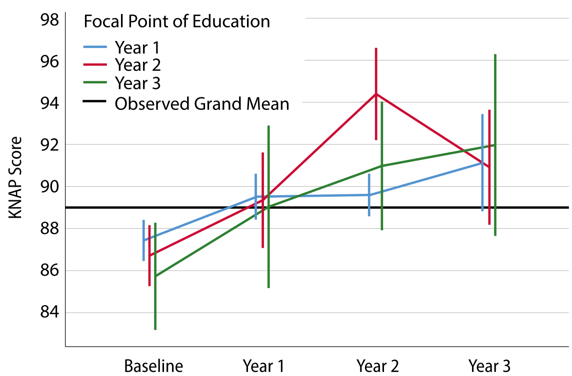

Fig. 1. Interaction of year and focused pain education. KNAP; KNowlegde and Attitude of Pain.

3.4. 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 Fig. 2. There was a significant small effect of education on the PABS-PT/PS scores, $F(3, 212.22) = 2.95$, $p = .034$, $\omega^2 = 0.009$. Differences between years were small and non-significant. On the PABS-PT/BM scores, there was a significant small effect of education $F(3, 222.50) = 4.94$, $p = .002$, $\omega^2 = 0.017$, effect sizes between baseline and year 1 were small, and medium between baseline and year 3. The NPQ scores differed significantly, $F(3, 220.72) = 11.83$, $p < .001$, $\omega^2 = 0.052$), 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 1.

4. 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 (Stevenson et al., 2006; Shuval et al., 2007). The mean overall KNAP difference of 4.1 points did not exceed the SDD (4.99) nor the MIC (4.84) (Beetsma et al., 2020), suggesting that the observed difference may not be sufficient to be educationally relevant (Lee et al., 2013). 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 (Terwee et al., 2007, 2010; De Vet et al., 2001; Briggs et al., 2011). 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 (Rainville et al., 1995, 2000; Houben et al., 2005). 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 (Lakke et al., 2015; Overmeer et al., 2009).

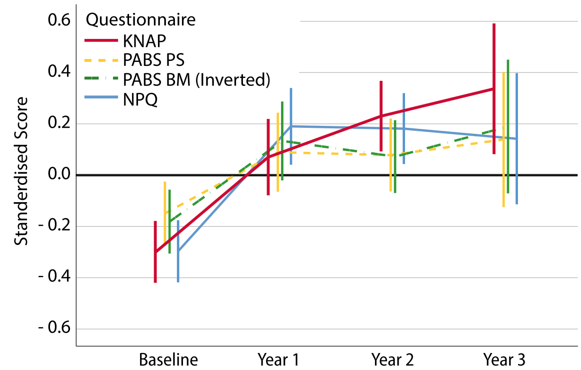

Fig. 2. Sensitivity analyses KNAP, PABS-PT, NPQ. KNAP; KNowlegde and Attitudes of Pain, PABS PS; Pain Attitudes and Beliefs Scale for Physiotherapists Biopsychosocial subscale, PABS BM; Pain Attitudes and Beliefs Scale for Physiotherapists Biomedical subscale, NPQ; Neurophysiology of Pain Questionnaire.

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.

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 h 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 (Ung et al., 2016; Briggs et al., 2011; Pöyhiä et al., 2005). 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 (Briggs et al., 2011; Shumway and Harden, 2003; Beales and O'Sullivan, 2014; Shipton et al., 2018; Briggs et al., 2015). 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 (Bareiss et al., 2019; Abdel Shaheed et al., 2017; Cox et al., 2017; Maguire et al., 2019; Mankelow et al., 2020; Colleary et al., 2017). However, short courses in pain do not elicit the desired long term change with regards to a behavioural shift in pain management (Beales and O'Sullivan, 2014; Cox et al., 2017). Pain education in higher education is facing insufficient curriculum time (Briggs et al., 2011; Shipton et al., 2018; Briggs et al., 2015; Pain Federation EFIC®, 2019). Clearly defined education about pain should be integrated into active integrative learning strategies using a variety of pedagogic approaches (Thompson et al., 2018). 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 (Briggs et al., 2011; EFIC, 2013) and integrated with case study examples that include active clinical reasoning and live patient demonstrations (Briggs et al., 2011; Briggs et al., 2015; EFIC, 2013; Stevens et al., 2009; Murinson et al., 2011; EFIC-Pain-Physiotherapy-Curriculum). 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 are 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 (Nijs et al., 2013; Hush et al., 2018; Morris et al., 2012; Bareiss et al., 2019; Fitzgerald et al., 2018; Beales and O'Sullivan, 2014; Draper-Rodi et al., 2015). 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.

Ethics approval

Written consent was obtained from all participants.

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Declaration of competing interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2021.102350.

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