The Relationship between Pain Neuroscience Education, Chronic and Acute Pain and Attention to Pain in Patients undergoing Total Knee Arthroplasty: A Randomized Controlled Trial

Georgia L. Walet
Faculty of Social and Behavioral Sciences, Utrecht University

201500819: Thesis clinical psychology

Supervised by Dr. Sibe Doosje, PhD

Pilot study for "Effectiveness of Pain Neuroscience Education on Pain after Total Knee Arthroplasty: A Randomized Controlled Trial" METC number: NL67769.041.18

July 17, 2020

Student number:	5615275
Word count:	4990
Research conducted at:	Tergooi Hospital in Hilversum
External supervisors:	Dominique Baas, PhD and Hanneke van Aalderen

Abstract

Promising results have been found for the effectiveness of Pain Neuroscience Education (PNE) in reducing several types of pain. The current study aims to investigate the effectiveness of PNE in reducing acute knee pain following total knee arthroplasty (TKA) and attention to pain, as well as investigating the relationships between attention to pain and chronic and acute knee pain. Lastly, this study aims to identify risk factors for high levels of acute pain after TKA. The current randomized controlled trial (RCT) is a pilot study for a larger RCT. A total of 27 participants, of which 19 female and 8 male, (age M = 68.6, *SD* = 7.55) received either the standard care after TKA or standard care plus two individual PNE sessions. The results indicated no effectiveness of PNE in reducing acute knee pain or attention to pain. Also, the results found no correlation between attention to pain and chronic pain or acute pain and could not identify risk factors for high levels of acute pain. However, the current study provides a conceptual model and indications which can be used in future research.

Keywords: pain neuroscience education (PNE), total knee arthroplasty (TKA), chronic pain, acute pain, attention to pain

Pain Neuroscience Education, chronic and acute pain and attention to pain

Osteoarthritis is a leading cause of disability worldwide (Chu et al., 2014) and the most common joint disorder in the United States (Lawrence et al., 2008). Knee osteoarthritis (KOA) is the most common type of osteoarthritis (Oliveria et al., 1995). Total knee arthroplasty (TKA) is considered an effective surgical treatment to reduce knee pain and improve function in people with severe KOA (Carr et al., 2012). Despite the fact that many people experience alleviation of knee pain after TKA, one in five patients are dissatisfied due to remaining knee pain even more than a year after TKA (Baker et al., 2007). Given the considerable number of patients experiencing long-term pain after TKA, it is important to investigate which methods are most effective in reducing post-surgical chronic knee pain. Acute pain is a factor which predicts chronic pain in the months and years following surgery (Katz, & Seltzer, 2009). This makes it necessary to investigate methods to directly reduce chronic pain and indirectly reduce it by targeting acute pain.

A recently developed method which reduces various types of pain is Pain Neuroscience Education (PNE; Moseley, & Butler, 2015). PNE refers to a range of educational interventions which aim to teach individuals about the biological and physiological processes involved in the experience of pain. Educating people about these processes leads to a change in the way that people conceptualize pain. People no longer interpret pain as a direct marker of tissue damage or disease, but rather interpret pain as a marker of the perceived need of the brain to protect the body, even in absence of any actual damage. The effect of PNE on pain has been studied in chronic pain samples and in patients undergoing several types of surgery.

Promising results have been found for the effectiveness of PNE in reducing chronic pain, despite some studies failing to find an effect of PNE on chronic pain. In their case series of twelve patients, Louw and colleagues (2019a) found no difference in chronic knee pain scores before and after a 30 minute group PNE session. In their randomized controlled trial (RCT), Andias and colleagues (2018) investigated the effect of four weekly PNE sessions in combination with exercises as compared to no intervention for adolescents with chronic neck pain. They reported a larger decrease in pain scores for the group receiving PNE and exercises than the control group, but this difference did not reach statistical significance. Moreover, in another case series, Louw and colleagues (2015) detected an increase in pain intensity immediately after PNE in patients experiencing chronic lower back pain. However, they also found that PNE does reduce chronic lower back pain one month after PNE. This promising finding is further substantiated by RCT's, in which PNE has been found to be effective in reducing chronic knee pain in patients with KOA (Lluch et al, 2018), pain in fibromyalgia patients (Van Oosterwijck et al, 2013), chronic spinal pain (Malfliet et al, 2018a) and a collection of chronic pain types (Louw et al, 2016b). One systematic review including eight studies, of which six high quality RCT's, found that PNE is effective in reducing chronic musculoskeletal pain (Louw et al, 2011). The same result was found in another systematic review including 13 RCT'S (Louw et al, 2016a) and in a systematic review and meta-analysis (Watson et al, 2019). Two systematic reviews and meta-analyses including two studies (n=122) and eight studies (n=615), respectively, found that PNE in addition to usual physiotherapy may decrease chronic lower back pain in the short-term (Clarke et al, 2011; Wood, & Hendrick. 2019).

Despite the strong evidence that PNE may be effective in reducing chronic pain, only few studies have investigated the effect of PNE on chronic pain after surgery, which is defined as persisting for 3 months or longer after surgery (Treede et al., 2015). No effect of PNE on chronic post-surgical pain has been found in lumbar surgery patients (Louw et al., 2014). Two studies in which the effectiveness of PNE in TKA-patients was investigated yielded mixed results. In their controlled clinical trial Louw and colleagues (2019b) investigated the effectiveness of adding group PNE 1 to 2 weeks before TKA to the traditional hospital educational program for TKA-patients. They found that one PNE-session in group format had no effect on pain at 1, 3 or 6 months after TKA compared to the traditional hospital educational program. Lluch and colleagues (2018) conducted an RCT comparing the effects of PNE combined with knee joint mobilization with the effects of biomedical education with knee joint mobilization on chronic knee pain before TKA and chronic post-surgical pain 3 months after TKA. They found that four PNE-sessions combined with knee joint mobilization significantly reduced chronic knee pain before TKA and chronic post-surgical pain 3 months after TKA. However, they found no difference in effectiveness between the group which received PNE and the group that received biomedical education. This implies that PNE may be an effective method in reducing chronic knee pain both before and after TKA, but is not superior to other educational methods.

As with chronic pain after surgery, only few studies have focused on the effect of PNE on acute post-surgical pain. A quasi-experimental study by Deguchi and colleagues (2019) found no effect of PNE on acute post-surgical pain in knee joint surgery, in which the knee joint is realigned. However, this surgery is less impactful than TKA and may therefore yield less favorable results than studies on TKA. In TKA-patients, Wilson and colleagues (2016) conducted an RCT to investigate the effect of an individualized pre-surgical educational intervention on acute post-surgical pain. This educational intervention is similar to PNE in the sense that provides patients with information about pain, but it differs in content. Whereas PNE focuses on biological and physiological processes involved in pain experience, the educational intervention in this study focused on the importance of pain management and other non-biological information about pain. Wilson and colleagues found no effect of their educational intervention on acute post-surgical pain following TKA. However, no research has yet been conducted investigating the effectiveness of PNE in reducing acute post-surgical pain following TKA. To my knowledge, the current study will be the first to investigate whether PNE is an effective method in reducing acute post-surgical pain, which in turn could reduce chronic pain following surgery (Katz, & Seltzer, 2009).

One factor which may play a role in an individual's pain intensity is attention to pain, which refers to a cognitive state in which patients are more somatically focused and monitor their body for changes in pain sensations and symptoms (Harrison et al., 2016). Many studies have found a positive correlation between attention to pain and chronic pain in fibromyalgia patients (Affleck et al., 1996; Crombez et al., 2004), chronic lower back pain (Crombez et al., 2004) and other chronic pain samples (Crombez et al., 2013; Harrison et al., 2016). The current study aims to further substantiate these findings by investigating the relationship between attention to pain and chronic knee pain before TKA.

Unfortunately, only two prospective longitudinal studies focused on attention to pain in surgical samples. These studies investigated whether pre-surgical attention to pain could predict chronic post-surgical pain following thoracic surgery (Horn-Hofmann et al., 2018; Lautenbacher et al., 2010). These studies found no predictive value of attention to pain for chronic post-surgical pain. However, the patients in these studies had no pre-surgical pain, which may have influenced their pre-surgical levels of attention to pain. Also, the generalizability of these studies is questionable as thoracic surgery and TKA are two completely different surgeries. Further investigation for other surgeries such as TKA is required before a clear relationship (or absence thereof) can be established.

So far, three longitudinal studies have focused on the relationship between attention to pain and acute post-surgical pain. One study examining men undergoing corrective chest surgery found that acute pain in the first few days after surgery predicted patients' attention to pain one week after surgery (Dimova et al., 2013). Lautenbacher and colleagues (2009) also examined males undergoing corrective chest surgery and found that pre-surgical attention to pain did not positively predict acute pain intensity one week after surgery. However, they did find that a broader definition of attention to pain, a definition which includes pain catastrophizing, did predict higher levels of acute pain intensity. This is in line with previous research which has found that pain catastrophizing predicts post-surgical pain intensity (Granot, & Ferber, 2005; Luna et al., 2017; Riddle et al., 2010). Scheel and colleagues (2017) found that pre-surgical attention to pain predicts higher levels of acute pain two to three days after a hysterectomy. An important limitation of these last two studies is that the participants did not undergo surgery due to chronic pain. Therefore, their pre-surgical pain levels were low, which may have influenced the outcome of these studies. The current study investigates both a possible correlation between post-surgical attention to pain and acute post-surgical pain following TKA, as well as the predictive value of pre-surgical attention for acute post-surgical pain following TKA. This knowledge could be used for screening TKA patients at risk of high levels of acute pain and may therefore be in high need of an intervention such as PNE to reduce this pain. If PNE is found to be an effective intervention for reducing acute post-surgical pain, this knowledge can be used to screen which patients could benefit from PNE.

As attention to pain may be an important psychological factor in predicting and/or maintaining pain, it is important to investigate how to reduce patients' attention to pain. Three RCT's have investigated the effectiveness of PNE in reducing attention to pain, yielding mixed results. Malfliet and colleagues (2018b) found that PNE has no effect on attention to pain in patients experiencing chronic spinal pain. Another RCT found that adding cognition-targeted motor control training to PNE did reduce attention to pain in a chronic spinal pain sample (Malfliet et al., 2018a). Another RCT found that PNE decreased attention to pain in fibromyalgia patients (Van Oosterwijck et al., 2013). However, no research has yet been done on the effectiveness of PNE on attention to pain in a surgical sample.

Lastly, it is interesting to screen individuals for an elevated risk for acute knee pain after TKA, as these individuals may possibly benefit most from an intervention such as PNE. Previous research has found that higher levels of chronic preoperative pain predict higher levels of acute pain following TKA (Brander et al, 2003; Lunn et al, 2013; Martinez et al, 2007; Singh et al, 2008; Sullivan et al, 2009). A cohort study including over 5000 participants identified female gender as another possible risk factor (Singh et al, 2008), despite an observational study finding no gender differences in pain after TKA (Lingard et al, 2004).

The main aim of this study is to investigate the relationship between PNE, chronic knee pain, acute knee pain after TKA and attention to pain and to form a conceptual model. This study also aims to identify risk factors for worse acute post-operative pain.

The following research questions will be studied:

1) Does PNE influence acute knee pain after TKA?
2) What is the relationship between pre-surgical attention to pain and chronic knee pain before TKA?
3) What is the relationship between post-surgical attention to pain and levels of acute knee pain after TKA?
4) Do pre-surgical attention to pain, chronic knee pain and gender predict levels of acute knee pain after TKA?
5) Does PNE influence patients' attention to pain?

The following hypotheses have been formulated:

1) Due to the lack of previous research investigating the effect of PNE on acute knee pain following TKA, no evidence-based hypothesis can be formulated for this research question. However, as many studies indicate that PNE may be effective in reducing chronic pain (Clarke et al, 2011; Lluch et al., 2018; Louw et al., 2011; Louw et al., 2015; Louw et al., 2016a; Louw et al., 2016b; Malfliet et al., 2018a; Van Oosterwijck et al., 2013; Watson et al., 2019; Wood, & Hendrick, 2019) and even chronic pain after TKA (Lluch et al., 2018), one may expect similar findings for acute pain. Based on extrapolation of previous findings, it may be expected that PNE can also reduce acute knee pain following TKA.
2) Based on previous findings that attention to pain is positively correlated with various types of chronic pain (Affleck et al., 1996; Crombez et al., 2004; Crombez et al., 2013; Harrison et al., 2016), a positive correlation between pre-surgical attention to pain and chronic knee pain before TKA may be expected.
3) Due to the lack of knowledge about the relationship between post-surgical attention to pain and acute post-surgical pain following TKA, no evidence-based hypothesis can be formulated for this research question. However, many studies have found that attention to pain and chronic pain are positively correlated (Affleck et al., 1996; Crombez et al., 2004;

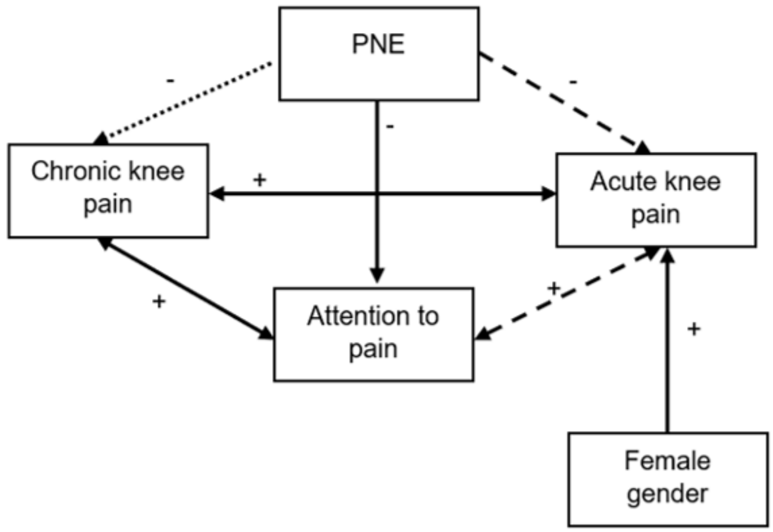
Crombez et al., 2013; Harrison et al., 2016). Due to logical reasoning it may be presumed that attention to pain and levels of pain are positively correlated, regardless of whether the pain is chronic or acute. It is therefore expected that a positive correlation between post-surgical attention to pain and acute pain following TKA will be found.

4) Despite the finding of Lautenbacher and colleagues (2009) that pre-surgical levels of attention to pain do not predict acute pain intensity following corrective chest surgery, it is hypothesized that pre-surgical attention to pain can predict acute knee pain following TKA. The participants in the current study experience pain before surgery, contrary to the participants in the study of Lautenbacher and colleagues. Their participants' low levels of pre-surgical pain may have decreased their levels of attention to pain pre-surgically (Crombez et al., 2004; Crombez et al., 2013; Harrison et al., 2016), which may have led to an underestimation of the predictive value on acute pain. Also based on the findings of Scheel and colleagues (2017), in which pre-surgical levels of attention to pain predict acute pain following a hysterectomy, it is expected that attention to pain predicts acute knee pain following TKA. It is also expected that worse chronic pain before TKA and female gender predict more acute knee pain (Brander et al, 2003; Lunn et al, 2013; Martinez et al, 2007; Singh et al, 2008; Sullivan et al, 2009).
5) Based on previous findings, a negative effect of PNE on attention to pain is expected (Malfliet et al., 2018a; Van Oosterwijck et al., 2013).

The empirical evidence and formed hypotheses are depicted in a conceptual model (see figure 1).

Figure 1

Conceptual model of PNE, chronic and acute knee pain, attention to pain and gender



Note. The continuous lines represent correlations and effects for which empirical evidence currently exists. The dashed lines represent yet undetermined correlations and effects which are expected to be found. The dotted line represents an empirically based effect which will not be investigated in the current study.

Methods

Design

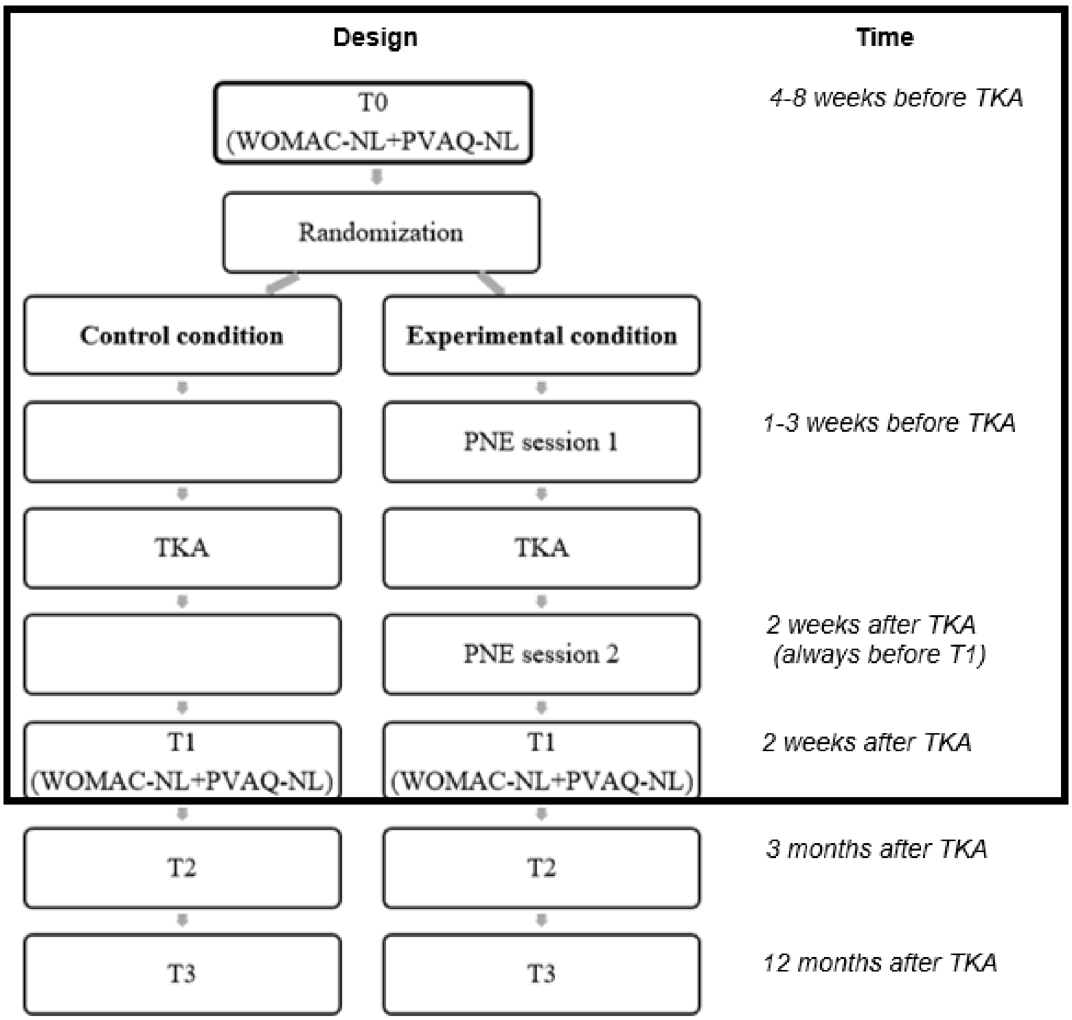
The current study is a pilot for a larger RCT which investigates the relationship between PNE and chronic pain 3 months after TKA and includes several secondary outcome measures, including chronic pain 12 months after TKA, physical functioning, stiffness, health related quality of life, as well as exploring the influence of attention to pain, pain catastrophizing, anxiety and depression on treatment outcome.

TKA-patients received information about the current study and an informed consent form from their orthopedist. One week after receiving the information, the patients were phoned by researchers to answer any questions patients may have and to ask whether patients wanted to participate. Patients who did, sent the informed consent to the researchers.

After receiving the informed consent participants were called for the baseline measurement (T0). After completing the T0, participants were randomized by a different researcher than the ones providing the questionnaires. Participants were either assigned to the experimental group, in which participants received standard care plus PNE, or the control group, in which participants received standard care only (see figure 2).

Figure 2

Overview of the procedure



Note. Only the questionnaires used for the current study have been depicted in the figure. WOMAC-NL = subscale 'pain' of the Dutch version of the WOMAC. It measures chronic knee pain at T0 and acute knee pain at T0. PVAQ-NL = Dutch version of the Pain Vigilance and Awareness Questionnaire. This measures attention to pain at both T0 and T1.

Control group

Participants in the control group received the standard care for TKA-patients. Before undergoing TKA, patients discussed the procedure with their orthopedist and received information in a booklet. This booklet contains information about the surgery, the risks involved in the surgery and recovery after TKA. On the day of surgery, patients stay in the hospital overnight. The next morning they are seen by a physiotherapist, who mobilizes them (e.g. stretching the leg and walking short distances). After mobilization patients are sent home or to a rehabilitation center to recover. After discharge they may receive further physiotherapy by their own physiotherapist. Approximately 2 weeks after TKA, patients' knee stitches are removed.

Experimental Group

Participants in the experimental group received standard care as described above with additional PNE. The first 45 minute-PNE session took place at 1 to 3 weeks before TKA. The second 30 minute-PNE session took place at 2 weeks after TKA. Both PNE sessions were individual sessions in which a physiotherapist trained in PNE provided the patient with information about pain with the use of a checklist. Copies of this checklist can be requested in either Dutch or English by contacting the author or supervisors.

Participants

In order to be eligible to participate in this study, a patient must be 18 years or older, suffer from KOA according to the American College of Rheumatology classification criteria (Wu et al., 2005), be scheduled for an elective unilateral TKA no sooner than 2 weeks from the time of recruitment, be able to understand and speak Dutch, be willing and able to complete scheduled study procedures and follow-up evaluations and the patient must provide written informed consent. Patients were excluded if they were scheduled for revision arthroplasty, were diagnosed with inflammatory arthritis, were scheduled for TKA because of a fracture, malignancy or an infection, were currently participating in any other surgical intervention or pain management, had a previous TKA or any other lower limb surgery within the past 6 months or had a cognitive impairment.

A total of 27 participants were analyzed in the current study (female = 70.4%). The participants were aged between 50 and 85 years old (M = 68.6, *SD* = 7.55).

Instruments

Demographics

Demographic information (gender and age) has been collected through the medical records of patients at Tergooi Hospital. Also, the medical records provided information on the severity of KOA using the Kellgren Lawrence Grading System. The Kellgren Lawrence Grading system ranges from 0 to 4, in which 0=none, 1=doubtful, 2=minimal, 3=moderate and 4=severe (Schiphof et al., 2008). The American Society of Anesthesiologists Classification (ASA class) determines the fitness of patients to undergo surgery and was also taken from the medical records. According to the ASA class, 1=healthy individual, 2=mild systemic disease not limiting activity, 3=severe systemic disease that limits activity and 4=incapacitating systemic disease which is constantly life threatening. The duration of chronic knee pain (in months) has been asked at T0.

Chronic knee pain

Chronic knee pain intensity has been measured one to two months before TKA using the subscale 'pain' of the Dutch version of the WOMAC (WOMAC-NL; Roorda et al., 2004). The subscale contains 5 items, each scored from 0 – 4 points. The total score of the subscale ranges from 0 – 20, with a higher score indicating higher pain levels. The reliability and validity of the subscale 'pain' of the WOMAC-NL has been tested in patients with hip osteoarthritis (Roorda et al., 2004). Researchers found a good intra test reliability (Cronbach's $\alpha = 0.88$) and an excellent test-retest reliability (intraclass correlation coefficient = 0.77). It also has a moderate to strong correlation with the subscales 'pain' of the Dutch Health Assessment Questionnaire and the Dutch Harris Hip Score ($r = 0.69$ and $r = 0.39$ respectively). This makes the subscale 'pain' of the WOMAC-NL a reliable and valid measure of pain.

Acute knee pain

Acute knee pain intensity has been measured at 2 weeks after TKA by also using the subscale 'pain' of the WOMAC-NL (Roorda et al., 2004). See "*chronic knee pain*" above for the scoring and psychometric properties of the subscale 'pain' of the WOMAC-NL.

Attention to pain

Participants' pre- and post-surgical levels of attention to pain have been measured at 4 to 8 weeks before TKA and 2 weeks after TKA respectively, using the Dutch version of the Pain Vigilance and Awareness Questionnaire (PVAQ-NL; Roelofs et al., 2003). The PVAQ-NL contains 16 items, all of which are scored on a scale ranging from 0 to 5. The total range of the PVAQ-NL is 0-80, with a higher score indicating more attention to pain. The internal reliability of the PVAQ-NL is considered good (Cronbach's $\alpha = 0.88$). The PVAQ-NL also has a good convergent validity as it correlates highly with theoretically related constructs, measured by the Pain Catastrophizing Scale ($r = 0.61$) and the Body Vigilance Questionnaire ($r = 0.56$). Overall, this makes the PVAQ-NL a reliable and valid measure of attention to pain.

Data analysis

The data-analysis has been conducted using *SPSS Statistics 25* (IBM corporation, 2017).

Descriptive statistics

In SPSS missing values received a value of 99. Only the missing values of a respondent are deleted, but the rest of the respondents' answers are used for the data analyses, which is called pairwise deletion.

Descriptive statistics were used to describe the baseline characteristics of individuals in each group. Firstly, normality was tested for age, length, weight and duration of knee pain using the Shapiro Wilk's test. The independent samples t-test (for the normally distributed continuous variables), the Mann-Whitney test (for the non-normally distributed continuous variables) and the chi square test (for categorical variables) was applied to determine whether there were baseline differences between groups.

Reliability analyses

Cronbach's alpha has been computed for the subscale 'pain' of the WOMAC-NL and the PVAQ-NL at both T0 and T1. The guidelines of Field (2013) will be used to interpret the reliability of these questionnaires, in which $\alpha < .5$ is insufficient, $.5 < \alpha < .8$ is sufficient and $\alpha > .8$ is good.

Hypotheses

The first and fifth research question have been tested by conducting a between subjects t-test. The Cohen's d will be calculated to interpret the output. Cohen (1988) suggested that an effect size of $d = .20$ is considered small, $d = .50$ is medium and $d = .80$ is large. Before conducting the analysis for the fifth research question, the dependent variable was created by computing the difference between attention to pain at T1 and T0 as a new variable.

The second and third research question have been tested by conducting a correlation analysis. If assumptions are met the pearson's correlation coefficient will be used. If assumptions are violated spearman's rho will be used. The guidelines of Cohen (1992) will be used, in which a correlation of $r = .1$ is weak, $r = .3$ is mediocre and $r = .5$ is a strong correlation.

The fourth research question has been tested by conducting a simultaneous multiple regression analysis.

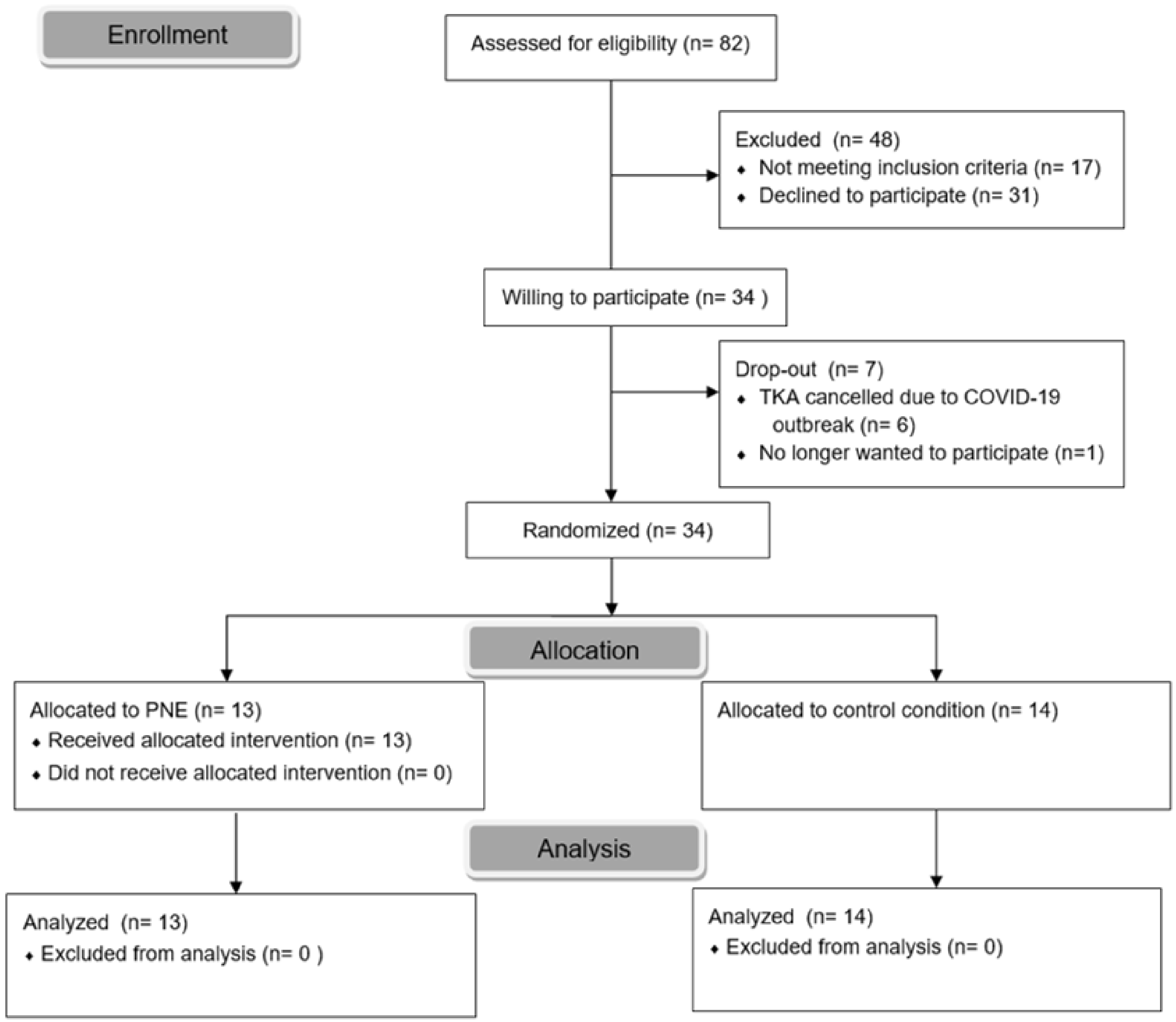
Results

Descriptive statistics

Out of the 82 patients assessed for eligibility, a total of 27 participants have been analyzed (see figure 3).

Figure 3

Consort flow



Age, length and weight were normally distributed across both conditions. However, duration of knee pain was non-normally distributed across both groups.

No baseline differences were found between the two groups (see Table 1).

For the independent samples t-tests, no assumptions were violated. Due to the violation of the assumption of linearity and homoscedasticity for all correlation analyses, spearman's rho will be used. For the multiple regression analysis all assumptions were met.

Table 1

Baseline characteristics of patient groups

	Control group (N=14)	Experimental group (N=13)	*P**
Age (y)	67.0 ± 8.0	70.3 ± 6.9	0.274
Gender (% female)	78.6	61.5	0.420
Height (cm)	170.9 ± 6.6	171.6 ± 8.5	.815
Weight (kg)	81.6 ± 13.7	74.8 ± 10.4	.157
Duration knee pain (months)	54.5 ± 83.5	38.3 ± 36.6	.827
Kellgren Lawrence n (%)			
0	0 (0)	0 (0)	0.922
1	0 (0)	0 (0)	
2	1 (7.1)	1 (7.7)	
3	3 (21.4)	2 (15.4)	
4	10 (71.4)	10 (76.9)	
ASA class n (%)			0.995
1	1 (7.1)	1 (7.7)	
2	11 (78.6)	10 (76.7)	
3	2 (14.3)	2 (15.4)	
4	0 (0)	0 (0)	

Note. Values are presented as mean ± SD.
*P-values refer to potential differences between both intervention groups.

Reliability Analyses

The subscale ‘pain’ of the WOMAC-NL has sufficient reliability at T0 ($\alpha = .67$) and T1 ($\alpha = .79$). The PVAQ-NL has a good reliability at T0 ($\alpha = .90$) and T1 ($\alpha = .87$).

Hypotheses

1) No effect of PNE on acute pain after TKA has been found, $p > .05$. Hypothesis 1 is rejected.
2) No correlation between pre-surgical attention to pain and chronic pain before TKA has been found, $p > .05$. Hypothesis 2 is rejected.

3) No correlation between post-surgical attention to pain and acute pain after TKA has been found, $p > .05$. Hypothesis 3 is rejected.
4) In combination, pre-surgical attention to pain, chronic pain before TKA and female gender accounted for a non-significant 14% of the variability in levels of acute knee pain after TKA, $R^2 = .14$, adjusted $R^2 = .02$, $F\ (3,\ 22) = 1.16$, $p = .349$. Unstandardized (*B*) and standardized (β) regression coefficients, and squared semi-partial correlations (sr^2) for each predictor in the regression model are reported in Table 2. Hypothesis 4 is rejected.
5) No effect of PNE on attention to pain has been found, $p > .05$. Hypothesis 5 is rejected.

The results are depicted in Table 3.

Table 2

Unstandardized (B) and Standardized (β) Regression Coefficients, and Squared Semi-Partial Correlations (sr^2) for each Predictor in an Regression Model Predicting Acute Knee Pain after TKA

Variable	*B* [95% CI]	β	sr^2
PVAQ-NL T0	-.00 [-0.09, 0.08]	-.02	.00
WOMAC-NL T0	.33 [-0.08, 0.74]	.35	.11
Gender	.57 [-2.54, 3.67]	.08	.01

Note. *N* = 27. CI = confidence interval.
* p < .05

Table 3

Cohen's d, correlation coefficients and p-values

Hypothesis. Independent variable(s) Dependent variable	Cohen's d	Spearman's Rho	p-value
1. PNE WOMAC-NL T1	.47		.242
2. PVAQ-NL T0 WOMAC-NL T0		.208	.299
3. PVAQ-NL T1 WOMAC-NL T1		.321	.110
4. PVAQ-NL T0, WOMAC-NL T0 and female gender WOMAC-NL T1			.349
5. PNE PVAQ-NL difference T0 and T1	.22		.570

Discussion

The aim of the current study was to investigate the relationships between PNE, chronic and acute pain, attention to pain and gender. This knowledge could be used in practice to screen for patients at higher risk for acute pain following TKA and to provide an effective intervention to reduce this pain. The current study was unable to identify elevated levels of chronic pain and pre-surgical attention to pain or female gender as risk factors for high levels of acute pain after TKA. Also, the current study found no effect of PNE on acute pain after TKA or patients' levels of attention to pain. Lastly, the current study found no correlation between attention to pain and chronic or acute pain, which is in contrast to previous research (Affleck et al., 1996; Crombez et al., 2004; Crombez et al., 2013; Harrison et al., 2016).

The finding that pre-surgical levels of attention to pain cannot predict levels of acute pain are in line with the findings of Lautenbacher and colleagues (2009), but is in contrast to the findings of Scheel and colleagues (2017). However, all three studies examine patients of different types of surgery, which may influence the outcome due to differences in the impact of surgery. Future research could focus on TKA patients only to further investigate the predictive value of pre-surgical attention to pain on acute pain following TKA. The finding that higher levels of chronic pain and female gender cannot predict acute pain is also in contrast to previous research (Brander et al, 2003; Lunn et al, 2013; Martinez et al, 2007; Singh et al, 2008; Sullivan et al, 2009). This may be due to the limitations of the current study, which are discussed below. To my knowledge, this is the first study to examine the effect of PNE on acute pain after TKA and patients' attention to pain. These results therefore cannot conclusively indicate whether or not PNE can be used to reduce acute pain following TKA and patients' attention to pain. Previous research has found promising results in other pain samples for the effectiveness of PNE on chronic pain (Clarke et al, 2011; Lluch et al., 2018; Louw et al., 2011; Louw et al., 2015; Louw et al., 2016a; Louw et al., 2016b; Malfliet et al., 2018a; Van Oosterwijck et al., 2013; Watson et al., 2019; Wood, & Hendrick, 2019) and even chronic pain after TKA (Lluch et al., 2018) as well as attention to pain (Malfliet et al., 2018a; Van Oosterwijck et al., 2013). Therefore, future research with more power should be conducted to further investigate the possible effectiveness of PNE in TKA patients.

The current study has several limitations. Firstly, the small sample size unfortunately decreased the strength of the evidence. This is partially due to the outbreak of the COVID-19 virus, which has negatively influenced the recruitment of new participants, as surgeries were no longer performed. Also, the virus has impacted the daily life, mental and physical health of many individuals, as well as their capacity to receive appropriate after-care such as physiotherapy. This may have influenced the results by people experiencing more pain and perhaps being in a more negative state of mind and having less activities to distract them from pain, possibly leading to more attention to their pain. Lastly, the COVID-19 virus made it inevitable that the PNE session of one participant had to be delivered by phone rather than in person. Despite the limitations of the current study, this study provides a detailed overview of the knowledge so far, as well as creating a new conceptual model involved in the pain experience of TKA patients.

The larger RCT, which the current study is part of, and other future studies can further validate the conceptual model which has been created in the current study. They can also include other factors which may be important for targeting pain after TKA to expand the conceptual model. In practice this model could be used to pre-operatively identify TKA-patients at risk of higher levels of post-operative pain. These patients could be provided with an effective intervention to (indirectly) alleviate pain after TKA. Despite the current study finding no effectiveness, PNE may be the right intervention to target acute pain after TKA, as it is for many other types of pain.

References

Affleck, G., Urrows, S., Tennen, H., Higgins, P., & Abeles, M. (1996). Sequential daily relations of sleep, pain intensity, and attention to pain among women with fibromyalgia. *Pain, 68*(2-3), 363-368. https://doi.org/10.1016/S0304-3959(96)03226-5

Andias, R., Neto, M., & Silva, A. G. (2018). The effects of pain neuroscience education and exercise on pain, muscle endurance, catastrophizing and anxiety in adolescents with chronic idiopathic neck pain: A school-based pilot, randomized and controlled study. *Physiotherapy Theory and Practice, 34*(9), 682-691. https://doi.org/10.1080/09593985.2018.1423590

Baker, P. N., Van der Meulen, J. H., Lewsey, J., & Gregg, P. J. (2007). The role of pain and function in determining patient satisfaction after total knee replacement: Data from the National Joint Registry for England and Wales. *The Journal of Bone and Joint Surgery, 89*(7), 893-900. https://doi.org/10.1302/0301-620X.89B7.19091

Brander, V. A., Stulberg, S. D., Adams, A. D., Harden, R. N., Bruehl, S., Stanos, S. P., & Houle, T. (2003). Predicting total knee replacement pain: A prospective, observational study. *Clinical Orthopaedics and Related Research, 416*, 27-36. https://doi.org/10.1097/01.blo.0000092983.12414.e9

Carr, A. J., Robertsson, O., Graves, S., Price, A. J., Arden, N. K., Judge, A., & Beard, D. J. (2012). Knee replacement. *The Lancet*, *379*(9823), 1331-1340. https://doi.org/10.1016/S0140-6736(11)60752-6

Chu, C. R., Millis, M. B., & Olson, S. A. (2014). Osteoarthritis: From palliation to prevention. *The Journal of Bone and Joint Surgery, 96* (15), 1-9. https://dx.doi.org/10.2106%2FJBJS.M.01209

Clarke, C. L., Ryan, C. G., & Martin, D. J. (2011). Pain neurophysiology education for the management of individuals with chronic low back pain: A systematic review and meta-analysis. *Manual therapy*, *16*(6), 544-549. https://doi.org/10.1016/j.math.2011.05.003

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale.

Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science, 1*(3), 98-101. https://doi.org/10.1111/1467-8721.ep10768783

Crombez, G., Eccleston, C., Van den Broeck, A., Goubert, L., & Van Houdenhove, B. (2004). Hypervigilance to pain in fibromyalgia: The mediating role of pain intensity and catastrophic thinking about pain. *The Clinical Journal of Pain, 20*(2), 98-102. http://hdl.handle.net/1854/LU-287518

Crombez, G., Viane, I., Eccleston, C., Devulder, J., & Goubert, L. (2013). Attention to pain and fear of pain in patients with chronic pain. *Journal of Behavioral Medicine, 36*(4), 371-378. https://doi.org/10.1007/s10865-012-9433-1

Deguchi, N., Hirakawa, Y., Izawa, S., Yokoyama, K., Muraki, K., Oshibuti, R., & Higaki, Y. (2019). Effects of pain neuroscience education in hospitalized patients with high tibial osteotomy: A quasi-experimental study using propensity score matching. *BMC Musculoskeletal Disorders, 20*(1), 516. https://doi.org/10.1186/s12891-019-2913-5

Dimova, V., Horn, C., Parthum, A., Kunz, M., Schöfer, D., Carbon, R., Griessinger, N., Sittl, R., & Lautenbacher, S. (2013). Does severe acute pain provoke lasting changes in attentional and emotional mechanisms of pain-related processing? A longitudinal study. *Pain, 154*(12), 2737-2744. https://doi.org/10.1016/j.pain.2013.08.005

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage.

Granot, M., & Ferber, S. G. (2005). The roles of pain catastrophizing and anxiety in the prediction of postoperative pain intensity: A prospective study. *The Clinical Journal of Pain, 21*(5), 439-445. https://doi.org/10.1097/01.ajp.0000135236.12705.2d

Harrison, L., Wilson, S., Heron, J., Stannard, C., & Munafò, M. R. (2016). Exploring the associations shared by mood, pain-related attention and pain outcomes related to sleep disturbance in a chronic pain sample. *Psychology & Health, 31*(5), 565-577. https://doi.org/10.1080/08870446.2015.1124106

Horn-Hofmann, C., Scheel, J., Dimova, V., Parthum, A., Carbon, R., Griessinger, N., Sittl, R., & Lautenbacher, S. (2018). Prediction of persistent post-operative pain: Pain-specific psychological variables compared with acute post-operative pain and general psychological variables. *European Journal of Pain, 22*(1), 191-202. https://doi.org/10.1002/ejp.1115

IBM Corporation (2017). *IBM SPSS Statistics for Windows, Version 25.0*. IBM Corporation.

Katz, J., & Seltzer, Z. E. (2009). Transition from acute to chronic postsurgical pain: Risk factors and protective factors. *Expert Review of Neurotherapeutics, 9*(5), 723-744. https://doi.org/10.1586/ern.09.20

Lautenbacher, S., Huber, C., Kunz, M., Parthum, A., Weber, P. G., Griessinger, N., & Sittl, R.

(2009). Hypervigilance as predictor of postoperative acute pain: Its predictive potency compared with experimental pain sensitivity, cortisol reactivity, and affective state. *The Clinical Journal of Pain*, *25*(2), 92-100. https://doi.org/10.1097/AJP.0b013e3181850dce

Lautenbacher, S., Huber, C., Schöfer, D., Kunz, M., Parthum, A., Weber, P. G., Roman, C., Griessinger, N., & Sittl, R. (2010). Attentional and emotional mechanisms related to pain as predictors of chronic postoperative pain: A comparison with other psychological and physiological predictors. *Pain, 151*(3), 722-731. https://doi.org/10.1016/j.pain.2010.08.041

Lawrence, R. C., Felson, D. T., Helmick, C. G., Arnold, L. M., Choi, H., Deyo, R. A., Gabriel, S., Hirsch, R., Hochberg, M. C., Hunder, G. G., Jordan, J. M., Katz, J. N., Kremers, H. M., & Wolfe, F. (2008). Estimates of the prevalence of arthritis and other rheumatic conditions in the United States: Part II. *Arthritis & Rheumatism, 58*(1), 26-35. https://doi.org/10.1002/art.23176

Lingard, E. A., Katz, J. N., Wright, E. A., & Sledge, C. B. (2004). Predicting the outcome of total knee arthroplasty. *The Journal of Bone and Joint Surgery, 86*(10), 2179-2186.

Lluch, E., Duenas, L., Falla, D., Baert, I., Meeus, M., Sanchez-Frutos, J., & Nijs, J. (2018). Preoperative pain neuroscience education combined with knee joint mobilization for knee osteoarthritis. *The Clinical Journal of Pain*, *34*(1), 44-52. https://doi.org/10.1097/AJP.0000000000000511

Louw, A., Diener, I., Butler, D. S., & Puentedura, E. J. (2011). The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. *Archives of Physical Medicine and Rehabilitation, 92*(12), 2041-2056. 10.1016/j.apmr.2011.07.198. https://doi.org/10.1097/BRS.0000000000000444

Louw, A., Diener, I., Landers, M. R., & Puentedura, E. J. (2014). Preoperative pain neuroscience education for lumbar radiculopathy: A multicenter randomized controlled trial with 1-year follow-up. *Spine*, *39*(18), 1449-1457. https://doi.org/10.1097/BRS.0000000000000444

Louw, A., Diener, I., & Puentedura, E. J. (2015). The short term effects of preoperative neuroscience education for lumbar radiculopathy: A case series. *International Journal of Spine Surgery, 9*. https://doi.org/10.14444/2011

Louw, A., Puentedura, E. J., Reed, J., Zimney, K., Grimm, D., & Landers, M. R. (2019b). A controlled clinical trial of preoperative pain neuroscience education for patients about to undergo total knee arthroplasty. *Clinical Rehabilitation*, *33*(11), 1722-1731. https://doi.org/10.1177/0269215519857782

Louw, A., Zimney, K., & Puentedura, E. (2016b). Retention of pain neuroscience knowledge: A multi-centre trial. *New Zealand Journal of Physiotherapy*, *44*(2), 91-96. https://doi.org/10.15619/NZJP/44.2.04

Louw, A., Zimney, K., Puentedura, E. J., & Diener, I. (2016a). The efficacy of pain neuroscience education on musculoskeletal pain: a systematic review of the literature. *Physiotherapy Theory and Practice*, *32*(5), 332-355. https://doi.org/10.1080/09593985.2016.1194646

Louw, A., Zimney, K., Reed, J., Landers, M., & Puentedura, E. J. (2019a). Immediate preoperative outcomes of pain neuroscience education for patients undergoing total knee arthroplasty: A case series. *Physiotherapy Theory and Practice*, *35*(6), 543-553. https://doi.org/10.1080/09593985.2018.1455120

Luna, I. E., Kehlet, H., Petersen, M. A., & Aasvang, E. K. (2017). Clinical, nociceptive and psychological profiling to predict acute pain after total knee arthroplasty. *Acta Anaesthesiologica Scandinavica*, *61*(6), 676-687. https://doi.org/10.1111/aas.12899

Lunn, T. H., Gaarn-Larsen, L., & Kehlet, H. (2013). Prediction of postoperative pain by preoperative pain response to heat stimulation in total knee arthroplasty. *PAIN*, *154*(9), 1878-1885. https://doi.org/10.1016/j.pain.2013.06.008

Malfliet, A., Kregel, J., Coppieters, I., De Pauw, R., Meeus, M., Roussel, N., Cagnie, B., Danneels, L., & Nijs, J. (2018a). Effect of pain neuroscience education combined with cognition-targeted motor control training on chronic spinal pain: A randomized clinical trial. *JAMA Neurology*, 75(7), 808-817. https://doi.org/10.1001/jamaneurol.2018.0492

Malfliet, A., Kregel, J., Meeus, M., Roussel, N., Danneels, L., Cagnie, B., Dolphens, M., & Nijs, J. (2018a). Blended-learning pain neuroscience education for people with chronic spinal pain: Randomized controlled multicenter trial. *Physical Therapy*, *98*(5), 357-368. https://doi.org/10.1093/ptj/pzx092

Martinez, V., Fletcher, D., Bouhassira, D., Sessler, D. I., & Chauvin, M. (2007). The evolution of primary hyperalgesia in orthopedic surgery: Quantitative sensory testing and clinical evaluation before and after total knee arthroplasty. *Anesthesia and analgesia*, *105*(3), 815. https://doi.org/10.1213/01.ane.0000278091.29062.63

Moseley, G. L., & Butler, D. S. (2015). Fifteen years of explaining pain: the past, present, and future. *The Journal of Pain*, *16*(9), 807-813. https://doi.org/10.1016/j.jpain.2015.05.005

Oliveria, S. A., Felson, D. T., Reed, J. I., Cirillo, P. A., & Walker, A. M. (1995). Incidence of symptomatic hand, hip, and knee osteoarthritis among patients in a health maintenance organization. *Arthritis & Rheumatism: Official Journal of the American College of Rheumatology*, *38*(8), 1134-1141. https://doi.org/10.1002/art.1780380817

Riddle, D. L., Wade, J. B., Jiranek, W. A., & Kong, X. (2010). Preoperative pain catastrophizing predicts pain outcome after knee arthroplasty. *Clinical Orthopaedics and Related Research, 468*(3), 798-806. https://doi.org/10.1007/s11999-009-0963-y

Roelofs, J., Peters, M. L., McCracken, L., & Vlaeyen, J. W. (2003). The pain vigilance and awareness questionnaire (PVAQ): Further psychometric evaluation in fibromyalgia and other chronic pain syndromes. *Pain*, *101*(3), 299-306. https://doi.org/10.1016/S0304-3959(02)00338-X

Roorda, L. D., Jones, C. A., Waltz, M., Lankhorst, G. J., Bouter, L. M., Van Der Eijken, J. W., Willems, W. J., Heyligers, I. C., Vaaklander, D. C., Kelly, K. D., & Suarez-Almazor, M. E. (2004). Satisfactory cross cultural equivalence of the Dutch WOMAC in patients with hip osteoarthritis waiting for arthroplasty. *Annals of the rheumatic diseases*, *63*(1), 36-42. https://doi.org/10.1136/ard.2002.001784

Scheel, J., Sittl, R., Griessinger, N., Strupf, M., Parthum, A., Dimova, V., Horn-Hofmann, C., Thiel, F., Beckmann, M. W., & Lautenbacher, S. (2017). Psychological predictors of acute postoperative pain after hysterectomy for benign causes. *The Clinical Journal of Pain, 33*(7), 595-603. https://doi.org/10.1097/AJP.0000000000000442

Schiphof, D., Boers, M., & Bierma-Zeinstra, S. M. (2008). Differences in descriptions of Kellgren and Lawrence grades of knee osteoarthritis. *Annals of the rheumatic diseases, 67*(7), 1034-1036. http://dx.doi.org/10.1136/ard.2007.079020

Singh, J. A., Gabriel, S., & Lewallen, D. (2008). The impact of gender, age, and preoperative pain severity on pain after TKA. *Clinical orthopaedics and related research, 466*(11), 2717-2723. https://doi.org/10.1007/s11999-008-0399-9

Sullivan, M., Tanzer, M., Stanish, W., Fallaha, M., Keefe, F. J., Simmonds, M., & Dunbar, M. (2009). Psychological determinants of problematic outcomes following total knee arthroplasty. *Pain, 143*(2), 123-129. https://doi.org/10.1016/j.pain.2009.02.011

Treede, R. D., Rief, W., Barke, A., Aziz, Q., Bennett, M. I., Benoliel, R., Cohen, M., Evers, S., Finnerup, N. B., First, M. B., Giamberardino, M. A., Kaasa, S., Kosek, E., Lavand'homme, P., Nicholas, M., Perrot, S., Scholz, J., Schug, S., Smith, B. H., …, Wang, S. (2015). A classification of chronic pain for ICD-11. *Pain, 156*(6), 1003. https://doi.org/10.1097/j.pain.0000000000000160

Van Oosterwijck, J., Meeus, M., Paul, L., De Schryver, M., Pascal, A., Lambrecht, L., & Nijs, J. (2013). Pain physiology education improves health status and endogenous pain inhibition in fibromyalgia: A double-blind randomized controlled trial. *The Clinical Journal of Pain, 29*(10), 873-882. https://doi.org/10.1097/AJP.0b013e31827c7a7d

Watson, J. A., Ryan, C. G., Cooper, L., Ellington, D., Whittle, R., Lavender, M., Dixon, J., Atkinson, G., Cooper, K., & Martin, D. J. (2019). Pain neuroscience education for adults with chronic musculoskeletal pain: A mixed-methods systematic review and meta-analysis. *The Journal of Pain, 20*(10), 1140e1-1140e22. https://doi.org/10.1016/j.jpain.2019.02.011

Wilson, R. A., Watt-Watson, J., Hodnett, E., & Tranmer, J. (2016). A randomized controlled trial of an individualized preoperative education intervention for symptom management after total knee arthroplasty. *Orthopaedic Nursing, 35*(1), 20-29. https://doi.org/10.1097/NOR.0000000000000210

Wood, L., & Hendrick, P. A. (2019). A systematic review and meta-analysis of pain neuroscience education for chronic low back pain: Short-and long-term outcomes of pain and disability. *European Journal of Pain, 23*(2), 234-249. https://doi.org/10.1002/ejp.1314

Wu, C. W., Morrell, M. R., Heinze, E., Concoff, A. L., Wollaston, S. J., Arnold, E. L., Singh, R., Charles, C., Skovrun, M. L., Fitzgerald, J. D., Moreland, L. W., & Kalunian, K. C. (2005). Validation of American College of Rheumatology classification criteria for knee osteoarthritis using arthroscopically defined cartilage damage scores. *Seminars in arthritis and rheumatism*, 35(3), 197-201. https://doi.org/10.1016/j.semarthrit.2005.06.002