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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The association of self-efficacy and fear-avoidance behaviour with central sensory function measured with thermal QST in patients with hip OA undergoing THA

Ante Houben
Ruth Sharp

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :

Prof. dr. Annick TIMMERMANS

BEGELEIDER :

De heer Abner SERGOORIS

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Acknowledgement

During the writing of this master's thesis we have received a lot of support and help. First, we would like to thank our promoter, Prof. Dr. Timmermans Annick, and our mentor, Drs. Sergooris Abner, for guiding and supporting us throughout the writing process. Their feedback has been of great value. Additionally, we would also like to acknowledge Prof. Dr. Kristoff Corten for the collaboration at 'Ziekenhuis Oost-Limburg' (ZOL). We are very grateful to him for referring patients who were eligible for our study and to the ZOL for giving us space to carry out the tests. Furthermore, we would like to acknowledge 'de Heuppraktijk' for providing us with time and space to recruit patients. We would also like to thank all patients for their time and willingness to participate in this study. Finally, we greatly appreciate the interest and time of our family, friends, and all others who read our master's thesis.

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Research context

Osteoarthritis (OA) is estimated to affect at least 240 million people worldwide and is one of the leading causes of pain and disability. (Hawker, 2019) OA is the most common type of arthritis which is defined by the presence of chronic inflammation, cartilage deterioration, and structural changes in the joint. (Fu, Zhou, Li, Jin, Liu, 2022) The disease is characterized by joint pain, stiffness, and swelling that may ultimately lead to reduced activity and participation. (Katz, Arant, & Loeser, 2011) The course of OA is heterogeneous, meaning that disease status may remain stable, while others may experience increasing pain, impairments, and/or structural damage within a relatively brief period of time. (Conaghan, Kloppenburg, Schett, Bijlsma & J.W.J., 2014) The hip joint is the third most affected location, and the incidence of hip OA has increased by 115.40% over the past 30 years. (Zhang & Jordan, 2010); Fu, Zhou, Li, Jin, Liu, 2022) When conservative treatment (e.g., exercise therapy or pharmacological treatment) is unable to reduce symptoms, total hip arthroplasty (THA) is a cost-effective treatment option. (Hochberg et al., 2012; Jones, Beaupre, Johnston, & Suarez-Almazor, 2007)

Pain is the most frequently reported symptom of hip OA (Lespasio, 2018) and typically follows a daily pattern of initial improvement in the morning and worsening of symptoms with daily activities. (Allen et al., 2009) In the late and chronic phase of the disease, pain perception may become more dependent on the central nervous system. (Lee, Nassikas & Clauw, 2011) Using quantitative sensory testing (QST), several studies established that central pain mechanisms may contribute to the development and chronification of pain in persons with hip OA. (Arendt-Nielsen & Yarnits, 2009; Arendt-Nielsen et al., 2010) In addition, there is increasing evidence that psychological factors may contribute to the pain experience in OA. (Somers, Keefe, Godiwala, & Hoyler, 2009) For example, increased fear-avoidance beliefs have been reported to lead to elevated levels of pain intensity in individuals with musculoskeletal pain. (George & Stryker, 2011) This is consistent with the findings of another study that lower fear-avoidance beliefs improve functioning in daily life and lead to less pain in patients with knee OA. (Fitzgerald, White & Piva, 2012) Besides, pain self-efficacy beliefs appeared to correlate with increased levels of pain intensity in individuals with hip OA. (Fu et al., 2020) These findings suggest that fear-avoidance beliefs and self-efficacy may contribute to alterations in pain intensity in OA, but further research is needed. (Fitzgerald et al., 2012; Fu et al., 2020) For the treatment, identifying prognostic indicators from the patient's history and examination is useful. (Chapple, Nicholson, Baxter & Abbott, 2011) This allows healthcare

professionals to more precisely predict the probability of disease progression and consequently refer patients to the most appropriate intervention. (Chapple et al., 2011)

This master's thesis is part of the ongoing Ph.D. "Clinical phenotypes in persons with hip osteoarthritis and prognostic factors of outcome following total hip arthroplasty". The objectives of this Ph.D. are (1) to identify specific clinical phenotypes, based on a set of biopsychosocial variables, in patients with hip OA before and after THA, and (2) to identify prognostic factors of outcome following THA, focusing on pain-related fear avoidance and perceived injustice. This research takes place at the Rehabilitation Research Center (REVAL), in collaboration with Prof. Dr. Corten from “Ziekenhuis Oost-Limburg” and “De Heuppraktijk”. The project code of this Ph.D. is R-11552. The writing and execution of the master’s thesis is supervised by Drs. Sergooris Abner, as mentor, and Prof. Dr. Timmermans Annick, as promoter. In agreement with the mentor, both students decided to perform a cross-sectional analysis of preoperative baseline data. Patients with hip OA, who were scheduled to undergo THA, were recruited from the “Ziekenhuis Oost-Limburg“ (ZOL) in Genk and “De Heuppraktijk” in Herselt and screened for inclusion criteria when they were willing to participate. Since May 2021, Drs. Sergooris Abner started collecting data by examining patients and in November 2021, both students joined Drs. Sergooris Abner for further data collection. The statistical analysis and the writing process of the master’s thesis were performed in collaboration between both students, as well as the writing of the abstract, introduction, method, statistical analysis, results, discussion, and conclusion.

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Table of Contents

1. Abstract

Background: Hip osteoarthritis (OA) is a chronic condition often associated with altered central pain processing. Psychological factors are thought to influence patients' pain experience, but the relationship with central pain processing is unclear.

Objectives: To identify the associations between self-efficacy, fear-avoidance behaviour, and central pain processing in patients with hip OA waiting for THA.

Participants: 53 patients with hip OA were recruited at "Ziekenhuis Oost-Limburg" in Genk and "de Heuppraktijk" in Herselt.

Measurements: Central somatosensory function (Temporal Summation and Conditioned Pain Modulation) was measured with quantitative sensory tests. Demographic information, pain-related variables (pain duration and intensity), fear-avoidance behaviour (FACS-D), self-efficacy (GSES), Hip Disability and Osteoarthritis Outcome Score (HOOS) were captured in all participants.

Results: Significant negative correlations were found between GSES and FACS-D ($r= -0.52, p<0.0001$), GSES and the pain-related cognitions and emotions dimension of FACS-D ($r=-0.58, p<0.001$), and GSES and the avoidance behaviour dimension of FACS-D ($r=-0.32, p<0.05$). No significant correlations were found with GSES and FACS-D for temporal summation and conditioned pain modulation. In multivariable regression analysis, both temporal summation and conditioned pain modulation showed no significant association with GSES, FACS-D, or the interaction between these variables. When adding and deleting variables to the model and performing stepwise pruned-forward regression until the highest AICc score was reached, gender and the number of pain locations in the past year were found to be significant contributors to the variance of temporal summation scores. For conditioned pain modulation, BMI and pain intensity did contribute nonsignificantly to the variance.

Conclusion: Fear-avoidance and self-efficacy are associated with each other, but not with temporal summation and conditioned pain modulation. Further research is needed on this topic and on the two dimensions of the FACS-D.

Keywords: Clinical phenotype, Fear-avoidance, Hip osteoarthritis, Pain, Prognostic factors, Quantitative Sensory Testing, Self-efficacy, Total hip arthroplasty

2. Introduction

Osteoarthritis (OA) is considered the most common chronic joint disease and is estimated to affect more than 240 million people worldwide. (Hawker, 2019; Bijlsma, Berenbaum, & Lafeber, 2011) The disease typically develops insidiously and slowly over several years, with the main complaints being joint pain, stiffness, and swelling, leading to impairment of patients' activities and participation. (Martel-Pelletier et al., 2016; Katz, Arant, & Loeser, 2011) The hip joint is one of the most affected joints by this disease. (Bijlsma et al., 2011) For initial treatment of hip OA, patients may be given conservative treatment, such as exercise therapy or pharmacologic treatment. (Hochberg et al., 2012) When conservative treatment fails to reduce symptoms in end-stage hip OA, total hip arthroplasty (THA) is a cost-effective treatment option. (Jones, Beaupre, Johnston, & Suarez-Almazor, 2007) Undergoing a THA can improve physical functioning, bodily pain, and physical functioning, yet not everyone is satisfied with the outcome. (Shan, Shan, Graham, & Saxena, 2014) Approximately 11% of patients remain dissatisfied, with persistent pain (41%) and functional limitation (35%) given as the most common reasons. (Halawi et al., 2019) In addition, the quality of life in patients with hip OA after THA is overall lower compared to healthy individuals. (Mariconda, Galasso, Costa, Recano & Cerbasi, 2011)

The pain experienced by individuals with hip OA varies and is not exclusively attributable to disease progression or structural joint damage. (Finan et al., 2013) In general, the most common painful sites in hip OA are the buttocks, gluteal region, groin, and lumbar spine. (Willet et al., 2019; Khan, Mcloughlin, Giannakas, Hutchinson & Andres, 2004) Besides these sites, patients may report pain in other parts of the body, which can indicate some degree of widespread pain. (Willet et al., 2019) Regarding widespread pain, a previous study found that this type of pain was associated with higher preoperative pain intensity in individuals awaiting THA. (Wylde et al., 2016) Besides pain intensity, the quality of pain symptoms varies between aching (92.3%), sharp (63.5%), stiffness (13.5%), burning (11.6%), radiating (11.6%), and numbness (9.6%). (Hawker et al., 2008) There is increasing evidence that individual differences in pain intensity are due to alterations in the central processing of nociceptive signals. (Kuni, Wang, Rickert, Ewerbeck, & Schiltenwolf, 2014) These alterations are primarily accountable for the increased sensitivity of mechanoreceptors in regions beyond the affected area. (Koltzenburg, 2000) Individuals can describe neuropathic pain-like symptoms without an indication of actual nerve damage, suggesting that neuropathic pain might contribute to the pain experienced in OA. (Neogi, 2013) Additionally, some patients experience short-term, recurrent pain while others have more continuous pain. (Neogi, 2013).

For further research, quantification of peripheral and central sensory function may therefore be valuable. Quantitative sensory testing (QST) can be used as a tool to detect and discriminate changes in sensory and nociceptive pathways in individuals with hip OA, as they tend to have lower pain pressure thresholds (PPT) compared to healthy individuals. (Kuni et al., 2014) In addition, it has been shown individuals with knee OA exhibit less efficient conditioned pain modulation (CPM) in contrast to individuals without the disease. (Arendt-Nielsen et al., 2010) Lastly, another study demonstrated a correlation between preoperative temporal summation (TS) and pain intensity in rest after THA. (Izumi, Petersen, Laursen, Arendt-Nielsen & Graven-Nielsen, 2016)

A variety of factors can influence central pain processing, like the duration of pain. Patients with chronic pain may have problems with pain or sensory processing, possibly leading to higher sensitivity to sensory stimuli. (Phillips & Clauw, 2011b) Since OA has been shown to be one of the most common causes of chronic pain, it is possible that many patients with OA have higher sensitivity. (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Phillips et al., 2011b) There is also increasing evidence concerning psychological factors that may explain pain experience in persons with OA. (Somers, Keefe, Godiwala, & Hoyler, 2009) In hip and knee OA, López-Bravo et al. (2020) have shown that increased levels of fear of movement and catastrophizing are associated with increased levels of pain intensity. In addition, an association between feelings of anxiety and higher pain intensity was found in persons with hip OA, suggesting that feelings of anxiety may predict pain intensity. (Summers, Haley, Reveille & AlarcOan, 1988) Furthermore, there is evidence that pain catastrophizing and pain self-efficacy beliefs correlate with increased pain intensity in individuals with hip OA. (Fu et al., 2020) This is consistent with a study that found that self-efficacy and WOMAC subscale pain scores appear to be related. (López-Bravo et al., 2020)

As mentioned before, there is evidence that psychological factors may influence patients' experience of pain. (Somers et al., 2009; López-Bravo et al., 2020; Summers et al., 1988; Fu et al., 2020) However, there is still little literature that uses objective measures of pain and links psychological factors to central pain processing. Since self-efficacy and fear-avoidance behaviour are known to influence patients' pain experience, this study focused on the possible association of self-efficacy and fear-avoidance behaviour with central pain processing in patients with hip OA awaiting a THA. In addition, a possible correlation between self-efficacy and fear-avoidance behaviour in this patient group was investigated. Lastly, it was researched if there was a correlation between two dimensions of the Dutch version of the Fear-Avoidance Component Scale.

3. Methods

3.1. Research question

The main objective of this study was to determine the associations between self-efficacy, fear-avoidance behaviour, and central sensory function in patients with hip OA awaiting THA. The hypotheses were that higher levels of fear-avoidance behaviour and lower levels of self-efficacy are associated with impaired central sensory function, as expressed by lower ability to modulate pain sensations and increased temporal summation of pain. Another hypothesis was that individuals with lower self-efficacy display higher levels of fear-avoidance behaviour.

Besides the main objective, a correlation between two subscales of the Dutch version of the Fear-Avoidance Component Scale was investigated.

3.2. Participants

Persons with hip OA scheduled for Direct Anterior Approach (DAA) THA were recruited at 'Ziekenhuis Oost-Limburg' in Genk and 'de Heuppraktijk' in Herselt (May 2021 - March 2022). Persons with a confirmed primary clinical or radiological diagnosis of hip OA were eligible for participation in the study. Patients with rheumatoid arthritis, other rheumatic diseases, or pathologic conditions explaining symptoms (e.g., avascular necrosis) were excluded from the study. If the symptoms of hip OA were significantly affected by a neurological disease (e.g., Parkinson's Disease, cerebrovascular accident), patients were also excluded. Additional exclusion criteria were THA revision surgery, history of pathological fractures (e.g., osteoporosis, tumors), and other major surgical procedures during the follow-up period (e.g., heterolateral THA, total knee arthroplasty). All participants read and signed an informed consent form prior to participation.

3.3. Procedure

This study consisted of a cross-sectional analysis of baseline data from an ongoing longitudinal prospective cohort study entitled "Clinical phenotypes in persons with hip osteoarthritis and prognostic factors of outcome following total hip arthroplasty". (HIPPROCLIPS, ClinicalTrials.gov Identifier: NCT05265858) The aim of the ongoing study is to understand and predict outcomes after THA in individuals with hip OA. Potential participants were screened for inclusion and exclusion criteria by a researcher of the study. If inclusion criteria were met, information about the study was provided. Individuals willing to participate in the study were scheduled for the first measurement 1 or 2 weeks before surgery. Questionnaires, hip muscle strength tests, performance-based

measures, Quantitative Sensory Testing (QST), and a semi-structured psychiatric interview were administered in a standardised protocol. The completed questionnaires were a general questionnaire with questions about demographics (e.g., age, gender, body mass index (BMI)) and about hip pain (e.g., duration, intensity, medication), the Hip Disability and Osteoarthritis Outcome Score (HOOS), the Hospital Anxiety and Depression Scale (HADS), the Dutch Fear-Avoidance Component Scale (FACS-D), the Tampa Scale of Kinesiophobia (TSK), the Injustice Experience Questionnaire (IEQ), the Dutch General Self-Efficacy Scale (GSES), Perceived Stress Scale (PSS), the 36-Item Short-Form Health Survey (SF -36), the Groningen Orthopaedic Social Support Scale, the Patient-Specific Functional Scale (PSFS), pain intensity with the Numerical Pain Rating Scale (NPRS), the Global Perceived Effect (GPE), and the Numerical Rating Scale of Patient Satisfaction (NRS). During the first postoperative week, participants were required to complete a questionnaire on days 1, 3, 5, and 7. At 6 weeks, 3 months, and 12 months postoperatively, participants were asked to complete questionnaires, performance-based measures, Quantitative Sensory Testing, and muscle strength tests. The semi-structured psychiatric interview was conducted again 12 months after surgery. Participants did not receive financial compensation. The study protocol and recruitment procedures were approved by the Medical Ethical Committee of Ziekenhuis Oost-Limburg and of Hasselt University, with approval registration number B3712021000002.

3.4. Outcomes

The independent variables in this study were self-efficacy, measured with the Dutch General Self-Efficacy Scale, and Fear-avoidance behaviour, measured with the Fear-Avoidance Component Scale (Dutch version). The dependent variables, Conditioned Pain Modulation and Temporal Summation, were measures of central sensory function, measured with thermal Quantitative Sensory Testing (Medoc TSA-2).

3.5. Self-efficacy

The Dutch General Self-Efficacy Scale (GSES) (Schwarzer, & Jerusalem, 1995) was used to measure how a person generally handles stressors or difficult situations in life. The questionnaire contained ten statements (optimistic “self-beliefs”), and the participant had to indicate the extent to which he or she agreed or disagreed at that moment, on a four-point Likert scale. The total score ranged from 10 to 40, with a higher score representing more self-efficacy. The scale has demonstrated excellent internal consistency and adequate test-retest reliability in individuals with arthritis. (Barlow, Williams, & Wright, 1996)

3.6. Fear-avoidance behaviour

The Dutch version of the Fear-Avoidance Component Scale (FACS-D) (De Baets et al., 2020; Neblett, Mayer, Hartzell, Williams, & Gatchel, 2016) was used to measure how participants thought and felt about their painful medical condition and how it affected their activity level over the past week. The specific constructs measured by the FACS-D were cognitive (pain catastrophizing), affective (pain-related fear/anxiety), and behavioural (avoidance). The questionnaire consisted of 20 questions, with each question requiring a score on a six-point scale ranging from 'strongly disagree' to 'strongly agree'. The total score ranged from 0 to 100, with a higher score indicating more fear-avoidance behaviour. Five severity levels of fear-avoidance were suggested: subclinical (0 to 20), mild (21 to 40), moderate (41 to 60), severe (61 to 80), and extreme (81 to 100). (Neblett, 2016) The FACS-D was found to have high test-retest reliability and fairly high internal consistency. (Neblett, 2016)

The ongoing study by Timmermans and Sergooris (HIPPROCLIPS, ClinicalTrials.gov Identifier: NCT05265858) identified two dimensions of the FACS-D, namely a pain-related cognitions and emotions dimension and an avoidance behaviour dimension. The pain-related cognitions and emotions dimension included questions 2 to 4, 6 to 10, and 12 to 14, while the avoidance behaviour dimension included the remaining questions. Further research is needed to identify these dimensions. In this study, the correlations between these two and their correlation with GSES and QST-tests were examined.

3.7. Central sensory function

The subjective nature of pain makes it challenging to objectively measure a person’s pain experience. Therefore, a valid instrument is needed to assess the state of central pain processing, such as Quantitative Sensory Testing (QST). (Backonja et al., 2013) In QST, the somatosensory function can be measured quantitatively based on the person’s responses to various stimuli. (Rolke et al., 2006) It reliably tests the sensory modalities of both large and small nerve fibers, whereas traditional clinical electrophysiological methods using standard skin surface electrodes focus mainly on the large fibers. (Chong & Cros, 2004; Backonja & Lauria, 2010) However, the tests are not entirely objective, due to the fact that the patient needs to respond voluntarily. (Uddin & MacDermid, 2016) In this study, Medoc's 'Thermosensory Stimulator Advanced 2' (TSA-2) was used. To determine the participant’s central somatosensory function, two QST-tests were analysed in this study, namely Temporal Summation of pain with a tonic heat stimulus and Conditioned Pain

Modulation. During all tests, the participants were not able to watch the computer screen and a maximum temperature of 45° was used.

To determine the temperature for the QST-tests, the patient's temperature corresponding to a VAS of 60 was obtained as follows. A thermode was placed on the contralateral forearm just proximal to the wrist on the volar side. During the test, the thermode heated up slowly and then remained at a constant temperature for a few seconds, at which the participant rated the perceived pain intensity on a scale from 0, i.e., no pain at all, to 100, i.e., the worst pain imaginable. The thermode then decreased and returned to baseline temperature (32°C). This procedure was repeated several times with a higher or lower temperature, depending on the perceived pain intensity, until a pain intensity of VAS of 60 points was reached.

Temporal Summation (TS) with a tonic heat stimulus was used to investigate nociceptive stimulus processing. (Jutzeler et al., 2019) A thermode was placed on the contralateral forearm just proximal to the wrist on the volar side and the temperature of the thermode was set to the temperature corresponding to a VAS of 60 points. During the measurement, the thermode heated up to the temperature, and the participant had to rate the perceived pain intensity on a scale from 0, i.e., no pain at all, to 100, i.e., the worst pain imaginable. The participant then had to maintain pain intensity at the same level for 2 minutes by raising, lowering, or maintaining temperature using a response device. TS scores were calculated as the sum of the temperature differences between the last temperature before the participant clicked to lower the temperature, and the last temperature before the next temperature increase or the endpoint of the measurement.

Conditioned Pain Modulation (CPM) was used to test the ability of the central nervous system to modulate pain sensation. Two thermodes were used for the CPM protocol. The main thermode was located on the participant's contralateral forearm, just proximal to the wrist on the volar side. The secondary thermode was located on the ipsilateral forearm, just proximal to the wrist on the volar side. During the measurement, the main thermode first warmed up to the temperature corresponding to the patient's VAS score of 60. Once the temperature was reached, the participant had to rate the perceived pain intensity using a Numerical Pain Rating Scale (NPRS) that ranged from 0, i.e., no pain at all, to 100, i.e., the worst pain imaginable. Then, the main thermode returned to baseline temperature (32°C), and the secondary thermode warmed to the temperature corresponding to the patient's VAS score of 60. The participant again had to rate the perceived pain intensity on the NPRS. The secondary thermode maintained this temperature for 25 seconds, and in the meantime the main thermode warmed up again. The participant needed to rate the perceived

pain intensity of the main thermode. CPM-scores were calculated as the difference in pain intensity between the first and second stimulus of the main thermode.

3.8. Statistics

Statistical analysis was performed using 'JMP Pro (16.2)'. (SAS, 2022) Participant characteristics were described by analysing data from the general questionnaires. First, a power analysis was performed with a power level of 0.80 and a significance level of 0.05 to determine if the minimum sample size required for this study was met. (Lachenbruch et al., 1989) To examine the correlations between central pain processing (CPM and TS), self-efficacy, and fear-avoidance behaviour, the Spearman correlation test was performed. This test describes a monotonic association between two variables, in which the data may not be normally distributed, and is powerful to outliers. (Schober, Boer, & Schwarte, 2018) Correlation coefficients of 0.00-0.10 were considered negligible, 0.10-0.39 weak correlations, 0.40-0.69 moderate correlations, 0.70-0.89 strong correlations, and 0.90-1.00 very strong correlations. (Schober et al.,2018) Multivariable linear regression was then performed twice, once with CPM as the dependent variable and once with TS as the dependent variable. The independent variables included in the analysis were self-efficacy and fear-avoidance behaviour. Age, gender, BMI, pain duration (in months), pain intensity at the moment, pain intensity averaged over the past week, number of pain locations in the past week, number of pain locations in the past year, Activity Limitations-Daily Living (HOOS-ADL) and Sport and Recreation Function (HOOS-SP) dimensions of the Hip disability and Osteoarthritis Outcome Score, FACS-D, and GSES were later added in the analysis. Using pruned forward selection, a model fit was determined with corrected Akaike's information criterion (AICc). This approach examines confounders with a mixture of forward and backward selection steps, adding and removing confounders from the model. (Estimation Method Options, 2021) The Akaike Information Criterion (AICc) was used to assess the likelihood of the model. (Lindsey & Sheather, 2010) AICc is recommended when the small sample size is small and the number of predictors is high relative to the sample size. (Lindsey et al., 2010) Afterwards, Cook's Distance was performed to find influential outliers in a set of predictor variables.

4. Results

4.1. Participants

A total of 53 individuals with hip osteoarthritis were included in this cross-sectional analysis of baseline data from a longitudinal cohort study. The mean duration of pain was 24.2 months. Participants reported a mean number of pain locations of 2.2 in the past week and 2.8 in the past year. The mean pain intensity was 5.1 out of 10 at the moment and 5.6 out of 10 in the past week. For patient-reported outcomes, participant functionality had a mean of 42.3 on the HOOS-ADL and a mean of 23.8 on the HOOS-SP. The overall mean score on the Fear-Avoidance Component Scale (FACS-D) was 40.4 with 17.5 on the pain-related cognitions and emotions dimension and 22.9 on the avoidance behaviour dimension. When considering the severity levels of the FACS-D, six participants were classified as subclinical, 20 as mild, 21 as moderate, five as severe, and only one as extreme. For the Self-Efficacy Scale (GSES), a mean score of 31 was obtained, corresponding to relatively high self-efficacy. For the QST measure TS, a mean score of 0.59 was obtained, with 28 of the 53 individuals showing a temporal summation effect. Of these 28 individuals, 11 were female and thus 17 were male. Looking at the differences between the sexes, the mean score for females was 0.36 and the mean score for males was 0.81 for TS. For individuals without temporal summation, 15 were female and 10 were male. For CPM, the mean score was 9.32, with 38 of 53 individuals having conditioned pain modulation. Regarding gender, 18 females and 20 males had CPM. The mean score of CPM by gender was 10.35 in women and 8.33 in men. Of those who had no CPM effect, 8 were female and 7 were male. Further details are shown in Table 1.

4.2. Results of the correlation analysis

As for the correlations between FACS-D and GSES, FACS-D showed a significant and moderately negative association with GSES ($r = -0.52$, $p<0.0001$). The pain-related cognitions and emotions dimension of FACS-D showed comparable outcomes with GSES, meaning a significant and moderate negative correlation ($r = -0.58$, $p<0.0001$). In addition, the avoidance behaviour dimension of FACS-D and GSES were significantly weakly and negatively associated ($r = -0.32$, $p<0.05$).

Regarding the correlations between FACS-D and GSES with TS, the following results were found. TS showed a weak and negative, but nonsignificant association with GSES ($r=-0.15$, $p=0.28$), FACS-D ($r=-0.02$, $p=0.89$), and the avoidance behaviour dimension of FACS-D ($r=-0.18$, $p=0.20$). A negligible positive correlation was found between TS and the pain-related cognitions and emotions dimension of FACS-D ($r=0.09$, $p=0.52$).

No significant correlations were found for CPM with FACS-D and GSES. Negative, weak correlations were found with FACS-D (r=-0.16, p=0.24), the pain-related cognitions and emotions dimension of the FACS-D (r=-0.17, p=0.22), and the avoidance behaviour dimension of the FACS-D (r=-0.15, p=0.27). A negligible correlation was found between CPM and GSES (r=0.03, p=0.84).

A detailed correlation matrix can be found in Table 2.

4.3. Results of the multivariable regression analysis of TS

Multivariable linear regression analysis was performed to determine whether fear-avoidance behaviour (FACS-D), self-efficacy (GSES), or the interaction of these factors significantly predicted TS scores. When testing the whole model, none of the variables proved significant (p=0.59). Only 4% of the variation in TS scores was explained by the variables FACS-D, GSES, and the interaction of these two factors (R^2 Adj=-0.04). No significant associations were found between TS and FACS-D (Std Beta=-0.16, p=0.48), TS and GSES (Std Beta=-0.27, p=0.23) or between TS and the interaction of FACS-D and GSES (Std Beta=-0.15, p=0.47). Details can be found in Table 3.

4.4. Results of the multivariable regression analysis of CPM

To test whether fear-avoidance behaviour (FACS-D) and self-efficacy (GSES) predicted CPM scores, a second multivariable linear regression analysis was performed. The whole model test revealed that none of the variables were significant (p=0.27). The variables FACS-D, GSES, and the interaction of these two factors explained about 2% of the variation in CPM scores (R^2 Adj=0.02). No significant association were found between CPM and FACS-D (Std Beta=-0.26, p=0.12), CPM and GSES (Std Beta=-0.13, p=0.44) or between CPM and the interaction of FACS-D and GSES (Std Beta=-0.22, p=0.13).

4.5. Results of the stepwise regression

The following variables were added to the regression models to perform stepwise pruned forward regression: Age, gender, BMI, pain duration (in months), pain intensity at the moment, pain intensity averaged over the past week, number of pain locations in the past week, number of pain locations in the past year, the Activity Limitations-Daily Living (HOOS-ADL) and the Sport and Recreation Function (HOOS-SP) dimensions of the Hip disability and Osteoarthritis Outcome Score, FACS-D, and GSES.

When adding these variables to the regression model, gender (p=0.01) and the number of pain locations in the past year (p=0.04) were found to be significant contributors to the variance of the TS scores. The model explained a total of 18% of the variance in TS, with an AICc value of 129.66.

For CPM, no significant contributors to the variance in scores were identified. When considering the model with the highest AICc value, BMI (p=0.27) and pain intensity (p=0.11) at the moment were included. This model explained a total of 8% of the variance in CPM, with an AICc value of 152.93.

Details of the stepwise regression can be found in Table 5 and Table 6.

4.6. Results of the Cook's Distance

Using Cook's Distance, it was found that there were no outliers in the multivariable linear regression analyses (TS: 0.3; CPM: 0.4).

5. Discussion

The course of OA is heterogeneous, so it is not optimal to apply the same treatment to all patients. (Conaghan et al., 2014) Previous research has shown that patient's psychological factors may influence the pain experienced in OA. (Somers et al., 2009) For example, increasing levels of fear of movement, pain catastrophizing, pain self-efficacy beliefs and self-efficacy were found to be associated with pain severity. (López-Bravo et al., 2020; Somers et al., 2009; Fu et al., 2020) The differences in pain intensity may be due to alterations in the central processing of nociceptive signals. (Kuni et al., 2014) Therefore, it can be valuable to identify specific psychological factors to determine who may be more at risk for altered central processing in hip OA so that treatments can be optimized and individualized. Since self-efficacy and fear-avoidance behaviour are known to influence patients' pain experience, this study focused on a possible association with central pain processing. (López-Bravo et al., 2020; Summers et al., 1988; Fu et al., 2020) In addition, a possible correlation between self-efficacy and fear-avoidance behaviour was investigated, as a negative correlation was expected. Lastly, a number of factors that might contribute to the variance in central processing scores were examined.

The results of the present study on the correlation between self-efficacy and fear-avoidance behaviour, namely a negative significant correlation, are consistent with results of studies on other chronic diseases. (De Moraes, de Góes, Damiani & Mattos, 2014; Denison, Åsenlöf & Lindberg's, 2004) These studies examined self-efficacy using the Chronic Pain Self-efficacy Scale (CPSS) and the Self-Efficacy Scale (SES), while fear-avoidance was examined using the Tampa Scale for Kinesiophobia. Due to differences in measurements and thus results, caution should be used when comparing studies. A possible explanation for the correlation between self-efficacy and fear-avoidance behavior is that individuals who are more limited in activities of daily living have lower self-efficacy scores. (De Moraes et al., 2014; Marks, Allegrante & Lorig, 2005) This can cause them to become more anxious because they have less confidence in their own abilities, which puts them in a vicious cycle of more anxiety and lower self-efficacy, which in turn increases anxiety avoidance scores. (De Moraes et al., 2014; Marks et al., 2005)

To our knowledge, no other study has examined the relationship between self-efficacy and TS with thermal QST measures. A study using mechanical TS found a significantly weak and negative association between self-efficacy, measured with the Pain Self-efficacy Beliefs questionnaire, and mechanical TS at the remote site in adult patients with chronic musculoskeletal pain. (Mani, Adhia,

Leong, Vanneste, & De Ridder, 2019) In the present study, thermal TS was measured using a thermode to stimulate a tonic heat pulse to assess central pain processing, so caution should be taken when comparing the results. In the present study, self-efficacy and TS were found to be uncorrelated. However, it was expected that a correlation would be found. In the study of Law and Sluka (2016), a correlation was found between less physical activity and a higher TS effect, suggesting that physical activity modifies central pain processing. Since self-efficacy influences physical activity, it was hypothesised that there would be a correlation between these two variables.

In the present study, no significant correlation and no significant association were found between fear-avoidance behaviour and TS. These results contrast with those of Robinson (2010), who found a significant positive weak correlation between the Fear of Pain Questionnaire (FAQ) and TS in patients with chronic low back pain. The discrepancies between the results of the present study and the study by Robinson (2010) may be due to the fact that the QST protocols were different, leading to heterogeneity and consequently restricting comparisons of studies. (Suokas et al., 2012) In contrast, Lenoir et al. (2021) found a weak, nonsignificant correlation between TS and the short version of the Pain Anxiety Symptoms Scale, which assesses fear avoidance and other fear responses to pain. In the present study, a negative correlation was expected between fear-avoidance behaviour, as patients with greater fear tend to have a lower pain threshold. (Rhudy & Meagher, 2000) Therefore, our hypothesis was that fear-avoidance behaviour might also influence central pain processing.

Considering the potential variables that could significantly contribute to the variance of TS scores, the present study identified gender and the number of pain locations in the past year. Regarding gender, more males (62.96%) than females (42.31%) had TS, with males having a higher mean score. Considering that females are at higher risk of developing central sensitization, it was expected that more females would have TS with higher scores, which is inconsistent with present study results. (Smith et al., 2018) Comparing the contribution of gender with other studies, the results are contradicting. (Jutzeler et al., 2019; Fillingrim, Maixner, Kincaid, & Silva, 1998; Robinson, Wise, Gagnon, Fillingrim, and Price, 2004; Sarlani, Grace, Reynolds, & Greenspan, 2004) In terms of the number of pain locations in the past year, to our knowledge, no other study has examined the association with TS. Nevertheless, this variable was included in the analysis, because widespread pain is associated with central sensitization, and thus may alter central pain processing. (Ji, Nackley, Huh, Terrando, and Maixner, 2018) Considering the other variables included in the regression analysis, in the study of Farrel and Gibson (2007) age was found to have a significant effect on the

variance of TS scores, with lower stimulation frequencies required for TS to occur in older individuals. This was not found in the present study. In addition, individuals with higher BMI were expected to have greater TS in OA, but this was in contrast to the results of the present study. (Gløersen et al., 2022) Furthermore, pain intensity was considered as a potential contributor to the variance of the TS scores because pain intensity correlates with temporal summation after THA. (Izumi et al., 2016) Other variables included in the analysis were pain duration and pain locations, as higher Central Sensitization Inventory scores were found to be correlated with these two variables. (Van Wilgen et al., 2017; Tanaka et al., 2021) Finally, the HOOS-ADL and HOOS-SP subscales were included in the analysis, as less physical activity level is associated with higher TS scores. (Law et al., 2016) However, all of these variables were found not to contribute significantly to the variance in TS scores in the present study.

Regarding the correlation between self-efficacy and CPM, only one study has examined this correlation using the GSES to measure self-efficacy and found a weak nonsignificant negative correlation. (Ng, 2019) This result is slightly comparable to the present study. However, it should be noted that the protocols used to measure CPM and the study populations were different, which could lead to the differences in results. (Imai, Petersen, Mørch, & Arendt Nielsen, 2016; Enax-Krumova et al., 2020) Considering the results of previous studies, it was expected to find an association between self-efficacy and CPM in the present study, as the study by Law et al. (2016) showed that less physical activity was associated with lower CPM scores.

The relationship between CPM and fear-avoidance behaviour has, to our knowledge, not been investigated. Looking at comparable outcomes to fear-avoidance behaviour, Geva and Defrin (2013) found a significant negative association between CPM and fear of pain in healthy triathletes, with less CPM associated with greater anxiety. These results are in contrast to the results of the present study, where no significant association was found between CPM and fear-avoidance behaviour. However, because fear of pain is not the same as fear-avoidance behaviour and the study protocols are completely different, the results may not be fully comparable. Nevertheless, it was expected that a negative correlation between fear-avoidance behaviour and CPM would be found in the present study. As mentioned earlier, patients with greater fear and thus possibly more fear-avoidance behaviour have lower pain thresholds. (Rhudy et al., 2000) Therefore, it was assumed that an association would be found due to the fact that fear-avoidance behaviour might influence central pain processing.

In the present study, no factors were found to contribute significantly to the variance in CPM scores. However, CPM appears to be age-dependent, being significantly better in younger individuals than in older individuals. (Hermans et al., 2015). Evidence on the effects of gender is conflicting. (Martel, Wasan, & Edwards, 2013; Hermans et al., 2015) Additionally, the study by Ibancos-Losada, Osuna-Pérez, Castellote-Caballero, and Díaz-Fernández (2020) investigated a possible association between CPM and sociodemographic variables (i.e., age, gender, and BMI) and found no significant correlation. This is consistent with the results of the present study. Besides, it was believed that longer pain duration and more pain locations would be associated with higher CPM scores. This was found in the study by Tanaka et al. (2021), in which these variables were associated with higher Central Sensitisation Inventory scores. For pain intensity, it was hypothesised that higher pain intensity would lead to lower CPM scores, as the study by Steen Pettersen et al. (2019) found these results in patients with hand osteoarthritis. As mentioned earlier, Law et al. (2016) concluded that lower levels of physical activity were associated with higher levels of CPM. Therefore, the HOOS-ADL and HOOS-SP subscales were included in the analysis.

Study strengths and limitations

A cross-sectional study is an appropriate study design to determine the prevalence and associations of outcomes. (Wang & Cheng, 2020) However, unlike prospective cohort studies, it is not possible to determine the temporal relation between dependent and independent variables. (Setia, 2016; Grimes & Schulz, 2002) This type of study design also carries the risk of bias, including selection bias, which is a risk in this study. Selection bias may be due to the fact that only a sample of individuals with OA who were already eligible for THA was selected. In addition, participants were recruited only at “Ziekenhuis Oost-Limburg” and “De Heuppraktijk”. Furthermore, no control group or reference values were used to verify whether these values should be considered normal. It is recommended that future researchers include a control group or reference values, to make these comparisons possible. Further, it is recommended to recruit participants from more medical institutions to better generalise the results. Another added value for future studies would be the inclusion of preoperative and postoperative measurements as in the ongoing study of which the present study is part of. (HIPPROCLIPS, ClinicalTrials.gov Identifier: NCT05265858)

TS can examine the processing of nociceptive stimuli in more detail. (Jutzeler et al., 2019) There are various ways to measure TS, and in this study it was done with a tonic heat stimulus and a participant-controlled temperature. There is limited evidence on the test-retest reliability of testing with a tonic heat stimulus. (Naert, Kehlet, & Kupers, 2008) However, the use of a participant-

controlled temperature has been shown to reliably examine TS of pain. (Jutzeler et al., 2019) An advantage of the method used in this study to assess TS is that the use of an individually adjusted stimulus temperature, namely the temperature corresponding to a VAS 60 on 100, is less susceptible to floor and ceiling effects during measurement. (Granot, Granovsky, Sprecher, Nir, & Yarnitsky, 2006)

In CPM, the ability of the central nervous system to inhibit pain is assessed. (Damien, Colloca, Bellei-Rodriguez, & Marchand, 2018) This response occurs in healthy individuals, but it may be reduced in chronic pain patients. (Damien et al., 2018) Because there are a variety of studies on CPM testing paradigms, analyses, and reports, assessing the reliability of CPM is challenging. (Kennedy, Kemp, Ridout, Yarnitsky, & Rice, 2016) Besides, current data on the repeatability of CPM responses are inconsistent. This is likely due to the different CPM protocols used in different laboratories and clinics, depending on the physical and mental state of the subjects, whether they are healthy volunteers or pain patients, and the time intervals between measurement sessions. (Granovsky, Miller-Barmak, Goldstein, Sprecher, & Yarnitsky, 2016) Recommendations for QST include refinement and acquisition of standardised protocols. (Georgopoulos et al., 2019)

6. Conclusion

In summary, the present study demonstrated a significant negative correlation between GSES and FACS-D, but no significant correlations between the GSES and FACS-D with CPM and TS. In the regression analysis, no associations were found between FACS-D, GSES, or the combination of these two variables with TS and CPM. When adding more variables to the regression model, gender and number of pain locations in the past year were found to be significant contributors to the variance of TS. For CPM, BMI and pain intensity at the moment were found to be contributors to the variance, but this was not significant.

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Appendix

Table 1

Participants' characteristics and outcomes

Variable	Mean (SD; range)
Gender (n)	
Women (%)	26 (49.1%)
Men (%)	27 (50.9%)
Age (years)	65.2 (9.8; 34-81)
BMI	27.5 (5.2; 18.4-44.4)
Number of pain locations other than hip	
Last week (0-9)	2.2 (1.2; 1-7)
Last year (0-9)	2.8 (1.3; 1-7)
Pain duration (months)	24.2 (34; 1-180)
Pain intensity	
At the moment (0-10)	5.1 (2.4; 0-9)
Last week (0-10)	5.6 (1.9; 1-9)
Functionality	
HOOS-ADL (0-68)	42.3 (17.6; 7.4-80.9)
HOOS-SP (0-16)	23.8 (19.5; 0-81.3)
Fear-avoidance behaviour	
FACS-D (0-100)	40.4 (16.8; 10-83)
Dimension pain-related cognitions and emotions (0-55)	17.5 (10.2; 0-48)
Dimension avoidance behaviour (0-45)	22.9 (8.8; 5-41)
Self-efficacy	
GSES (10-40)	31 (5.2; 20-39)
Temporal Summation	
Number of patients with TS (women)	28 (11)
Number of patients without TS (women)	25 (15)
TS in all patients	0.59 (0.85; 0-3.74)
TS in women	0.36 (0.55; 0-1.85)
TS in men	0.81 (1.02; 0-3.74)

Table 1 (continued)

Participants' characteristics and outcomes

Variable	Mean (SD; range)
Conditioned Pain Modulation	
Number of patients with CPM (women)	38 (18)
Number of patients without CPM (women)	15 (8)
CPM in all patients	9.32 (13.09; -30-60)
CPM in women	10.35 (15.23; -10-60)
CPM in men	8.33 (10.83; -30-30)

Note. BMI: Body Mass Index; HOOS-ADL: Hip disability and Osteoarthritis Outcome Score - Activity Limitations-Daily Living; HOOS-SP: Hip disability and Osteoarthritis Outcome Score - Sport and Recreation Function; FACS-D: Fear-Avoidance Component Scale; GSES: Dutch General Self-Efficacy Scale; TS: Temporal Summation; CPM: Conditioned Pain Modulation.

Table 2

Correlation of Self-Efficacy, Fear-Avoidance, CPM, and TS (Spearman's Rho)

	FACS-D	FACS-D – dimension pain-related cognitions and emotions	FACS-D – dimension avoidance behaviours	GSES
GSES	-0.52**	-0.58**	-0.32*	/
TS	-0.02	0.09	-0.18	-0.15
CPM	-0.16	-0.17	-0.15	0.03

Note. FACS-D: Dutch-Fear-Avoidance Component Scale; GSES: Dutch General Self-Efficacy Scale; CPM: Conditioned Pain Modulation; TS: Temporal Summation.
*p<.05
**p<.0001

Table 3

Multivariable linear regression of TS with FACS-D and GSES

Analysis of Variance		**Summary of Fit**	
F Ratio	**P-value**	**R^2**	**R^2 adj**
0.65	0.59	0.08	-0.04
Parameter Estimates			
Variables	**Std Beta**	**P-value**	**VIF**
FACS-D	-0.16	0.48	1.25
GSES	-0.27	0.23	1.21
FACS-D*GSES	-0.15	0.47	1.04

Note. R^2: Rsquare; R^2 adj: Rsquare Adjusted; Std Beta: Standardized Beta Coefficient; VIF: variance inflation factor; FACS-D: Dutch-Fear-Avoidance Component Scale; GSES: Dutch General Self-Efficacy Scale.

Table 4

Multivariable linear regression of CPM with FACS-D and GSES

Analysis of Variance		**Summary of Fit**	
F Ratio	**P-value**	**R^2**	**R^2 adj**
1.34	0.27	0.08	0.02
Parameter Estimates			
Variables	**Std Beta**	**P-value**	**VIF**
FACS-D	-0.26	0.12	1.50
GSES	-0.13	0.44	1.45
FACS-D*GSES	-0.22	0.13	1.05

Note. R^2: Rsquare; R^2 adj: Rsquare Adjusted; Std Beta: Standardized Beta Coefficient; VIF: variance inflation factor; FACS-D: Dutch-Fear-Avoidance Component Scale; GSES: Dutch General Self-Efficacy Scale.

Table 5

Multivariable linear regression of TS with stepwise regression

Model Summary		
AICc	**R^2**	**R^2 Adj**
129.66	0.22	0.18
Parameter Estimates		
Variables	**P-value**	**VIF**
Age	0.10	2.09
Gender	0.01	1.04
Number of pain locations – last year	0.04	0.70

Note. AICc: corrected Akaike Information Criterion; R^2: Rsquare; R^2 Adj: Rsquare Adjusted; VIF: variance inflation factor.

Table 6

Multivariable linear regression of CPM with stepwise regression

Model Summary		
AICc	**R^2**	**R^2 Adj**
152.93	0.11	0.08
Parameter Estimates		
Variables	**P-value**	**VIF**
BMI	0.27	2.07
Pain intensity – At the moment	0.11	0.99

Note. AIC: corrected Akaike Information Criterion; R^2: Rsquare; R^2 Adj: Rsquare Adjusted; VIF: variance inflation factor.

Verklaring op Eer

Ondergetekende, student aan de Universiteit Hasselt (UHasselt), faculteit Revalidatiewetenschappen aanvaardt de volgende voorwaarden en bepalingen van deze verklaring:

1. Ik ben ingeschreven als student aan de UHasselt in de opleiding Revalidatiewetenschappen en kinesitherapie waarbij ik de kans krijg om in het kader van mijn opleiding mee te werken aan onderzoek van de faculteit Revalidatiewetenschappen aan de UHasselt. Dit onderzoek wordt beleid door Timmermans Annick en kadert binnen Wetenschappelijke stage deel 1. Ik zal in het kader van dit onderzoek creaties, schetsen, ontwerpen, prototypes en/of onderzoeksresultaten tot stand brengen in het domein van Musculoskeletale revalidatie (hierna: "De Onderzoeksresultaten").

2. Bij de creatie van De Onderzoeksresultaten doe ik beroep op de achtergrondkennis, vertrouwelijke informatie[1], universitaire middelen en faciliteiten van UHasselt (hierna: de "Expertise").

3. Ik zal de Expertise, met inbegrip van vertrouwelijke informatie, uitsluitend aanwenden voor het uitvoeren van hogergenoemd onderzoek binnen UHasselt. Ik zal hierbij steeds de toepasselijke regelgeving, in het bijzonder de Algemene Verordening Gegevensbescherming (EU 2016-679), in acht nemen.

4. Ik zal de Expertise (i) voor geen enkele andere doelstelling gebruiken, en (ii) niet zonder voorafgaande schriftelijke toestemming van UHasselt op directe of indirecte wijze publiek maken.

5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

6. In zoverre De Onderzoeksresultaten auteursrechtelijk beschermd zijn, omvat bovenstaande overdracht onder meer de volgende exploitatiewijzen, en dit steeds voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding:

   - het recht om De Onderzoeksresultaten vast te (laten) leggen door alle technieken en op alle dragers;
   - het recht om De Onderzoeksresultaten geheel of gedeeltelijk te (laten) reproduceren, openbaar te (laten) maken, uit te (laten) geven, te (laten) exploiteren en te (laten) verspreiden in eender welke vorm, in een onbeperkt aantal exemplaren;

[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

- het recht om De Onderzoeksresultaten te (laten) verspreiden en mee te (laten) delen aan het publiek door alle technieken met inbegrip van de kabel, de satelliet, het internet en alle vormen van computernetwerken;
- het recht De Onderzoeksresultaten geheel of gedeeltelijk te (laten) bewerken of te (laten) vertalen en het (laten) reproduceren van die bewerkingen of vertalingen;
- het recht De Onderzoeksresultaten te (laten) bewerken of (laten) wijzigen, onder meer door het reproduceren van bepaalde elementen door alle technieken en/of door het wijzigen van bepaalde parameters (zoals de kleuren en de afmetingen).

De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

Ik behoud daarbij steeds het recht op naamvermelding als (mede)auteur van de betreffende Onderzoeksresultaten.

7. Ik zal alle onderzoeksdata, ideeën en uitvoeringen neerschrijven in een "laboratory notebook" en deze gegevens niet vrijgeven, tenzij met uitdrukkelijke toestemming van mijn UHasseltbegeleider Timmermans Annick.

8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

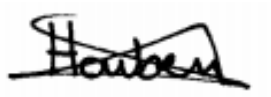
Naam: Houben Ante

Adres: Vlaamse-Gaaistraat 6, 3920 Lommel

Geboortedatum en –plaats: 08/10/1998, te Lommel

Datum: 09/11/2020

Handtekening:



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5. Aangezien ik in het kader van mijn onderzoek beroep doe op de Expertise van de UHasselt, draag ik hierbij alle bestaande en toekomstige intellectuele eigendomsrechten op De Onderzoeksresultaten over aan de UHasselt. Deze overdracht omvat alle vormen van intellectuele eigendomsrechten, zoals onder meer – zonder daartoe beperkt te zijn – het auteursrecht, octrooirecht, merkenrecht, modellenrecht en knowhow. De overdracht geschiedt in de meest volledige omvang, voor de gehele wereld en voor de gehele beschermingsduur van de betrokken rechten.

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[1] Vertrouwelijke informatie betekent alle informatie en data door de UHasselt meegedeeld aan de student voor de uitvoering van deze overeenkomst, inclusief alle persoonsgegevens in de zin van de Algemene Verordening Gegevensbescherming (EU 2016/679), met uitzondering van de informatie die (a) reeds algemeen bekend is; (b) reeds in het bezit was van de student voor de mededeling ervan door de UHasselt; (c) de student verkregen heeft van een derde zonder enige geheimhoudingsplicht; (d) de student onafhankelijk heeft ontwikkeld zonder gebruik te maken van de vertrouwelijke informatie van de UHasselt; (e) wettelijk of als gevolg van een rechterlijke beslissing moet worden bekendgemaakt, op voorwaarde dat de student de UHasselt hiervan schriftelijk en zo snel mogelijk op de hoogte brengt.

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De overdracht van rechten voor deze exploitatiewijzen heeft ook betrekking op toekomstige onderzoeksresultaten tot stand gekomen tijdens het onderzoek aan UHasselt, eveneens voor de hele beschermingsduur, voor de gehele wereld en zonder vergoeding.

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8. Na de eindevaluatie van mijn onderzoek aan de UHasselt zal ik alle verkregen vertrouwelijke informatie, materialen, en kopieën daarvan, die nog in mijn bezit zouden zijn, aan UHasselt terugbezorgen.

Gelezen voor akkoord en goedgekeurd,

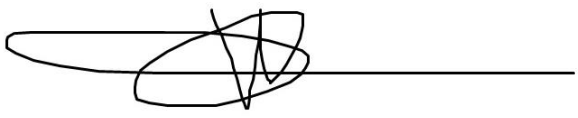
Naam: Ruth Sharp

Adres: Boekbindersweg 35 3920 Lommel

Geboortedatum en –plaats : 06/02/1998 te Lommel

Datum: 9/11/2020

Handtekening:



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UHASSELT
KNOWLEDGE IN ACTION

INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
23/08/2021	Uitleg over verloop MP2	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
22/09/2021	Bespreking mogelijke onderzoeksvraag	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
29/10/2021	Bespreking protocol	Promotor: 

		Copromotor/Begeleider:  Student(e):  Student(e): 
26/11/2021	Bespreking protocol + verder verloop metingen	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
08/02/22	Bespreking inleiding	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 

07/03/2022	Bespreking inleiding en methode + meet momenten	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
15/03/22	Data bespreking	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
08/04/22	Bespreking data-analyse + finaliseren inleiding/methode	Promotor:  Copromotor/Begeleider:  Student(e): 

		Student(e): 
26/04/22	Bespreking data-analyse	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
11/05/22	Vragen in verband met de statistiek	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Ante Houben **Datum:** 03-06-2022

Titel Masterproef: The association of self-efficacy and fear-avoidance behaviour with central sensory function measured with thermal QST in patients with hip OA undergoing THA.

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	NVT	1	2	3	4	5
Opstelling onderzoeksvraag	O	O	O	☑	O	O
Methodologische uitwerking	O	O	O	☑	O	O
Data acquisitie	O	O	O	☑	O	O
Data management	O	O	O	☑	O	O
Dataverwerking/Statistiek	O	O	O	☑	O	O
Rapportage	O	O	O	O	☑	O

2) Niet-bindend advies: Student(e) krijgt toelating/~~geen toelating~~ (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/~~niet~~ (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag ~~wel~~/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)
02/06/22	03-06-2022	03-06-2022

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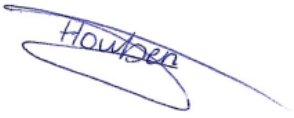
KNOWLEDGE IN ACTION

INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
23/08/2021	Uitleg over verloop MP2	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
22/09/2021	Bespreking mogelijke onderzoeksvraag	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
29/10/2021	Bespreking protocol	Promotor: 

		Copromotor/Begeleider:  Student(e):  Student(e): 
26/11/2021	Bespreking protocol + verder verloop metingen	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
08/02/22	Bespreking inleiding	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 

07/03/2022	Bespreking inleiding en methode + meet momenten	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
15/03/22	Data bespreking	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
08/04/22	Bespreking data-analyse + finaliseren inleiding/methode	Promotor:  Copromotor/Begeleider:  Student(e): 

		Student(e): 
26/04/22	Bespreking data-analyse	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 
11/05/22	Vragen in verband met de statistiek	Promotor:  Copromotor/Begeleider:  Student(e):  Student(e): 

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Ruth Sharp **Datum:** 03-06-2022

Titel Masterproef: The association of self-efficacy and fear-avoidance behaviour with central sensory function measured with thermal QST in patients with hip OA undergoing THA.

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
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   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	**NVT**	**1**	**2**	**3**	**4**	**5**
Opstelling onderzoeksvraag	O	O	O	☑	O	O
Methodologische uitwerking	O	O	O	☑	O	O
Data acquisitie	O	O	O	☑	O	O
Data management	O	O	O	☑	O	O
Dataverwerking/Statistiek	O	O	O	☑	O	O
Rapportage	O	O	O	O	☑	O

2) <u>Niet-bindend advies:</u> Student(e) krijgt toelating/~~geen toelating~~ (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/~~niet~~ (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag ~~wel~~/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)
02/06/22	03-06-2022	03-06-2022

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Ante Houben <ante.houben@student.uhasselt.be>

Inschrijvingsformulier MP2

Annick TIMMERMANS <annick.timmermans@uhasselt.be> 30 mei 2022 om 15:50
Aan: Ruth Sharp <ruth.sharp@student.uhasselt.be>
Cc: Abner SERGOORIS <abner.sergooris@uhasselt.be>, Ante Houben <ante.houben@student.uhasselt.be>

Beste Ruth en Ante

Zowel Abner als ikzelf hebben jullie masterproef doorgenomen en wij geven jullie graag toestemming om deze in te dienen en mondeling te verdedigen.

Vr groeten

Annick Timmermans en Abner Sergooris

Annick Timmermans
Hoogleraar/Professor Musculoskeletal Rehabilitation
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Universiteit Hasselt - Campus Diepenbeek
Agoralaan Gebouw A - B-3590 Diepenbeek

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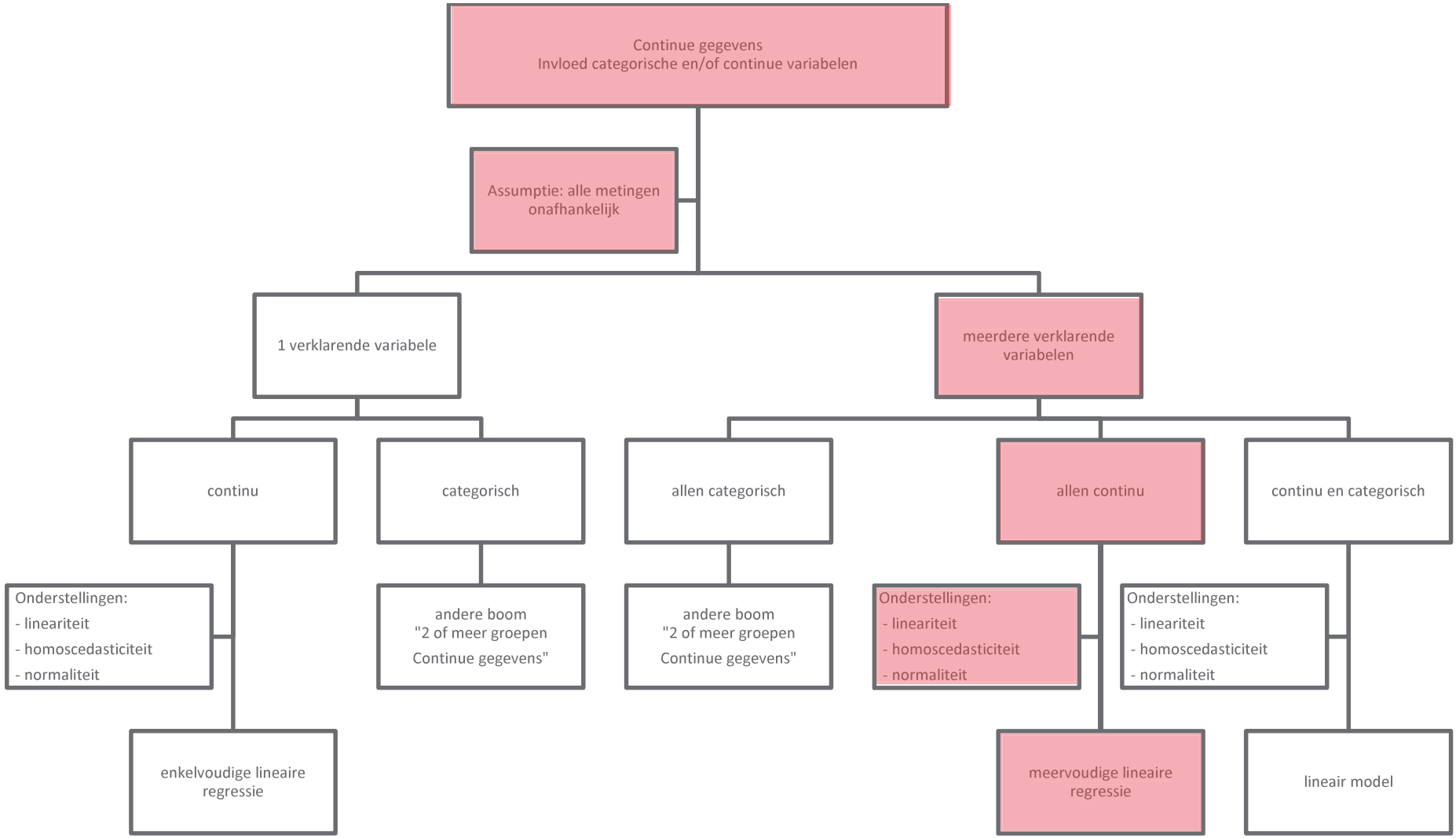
Op za 28 mei 2022 om 16:39 schreef Ruth Sharp <ruth.sharp@student.uhasselt.be>:
[Tekst uit oorspronkelijke bericht is verborgen]


Continue gegevens
Invloed categorische en/of continue variabelen
Assumptie: alle metingen onafhankelijk
1 verklarende variabele
meerdere verklarende variabelen
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categorisch
allen categorisch
allen continu
continu en categorisch
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
andere boom
"2 of meer groepen
Continue gegevens"
andere boom
"2 of meer groepen
Continue gegevens"
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
Onderstellingen:
- lineariteit
- homoscedasticiteit
- normaliteit
enkelvoudige lineaire regressie
meervoudige lineaire regressie
lineair model