Inter-individual differences in early post-operative pain, cognitions, and emotions after total hip arthroplasty: A longitudinal cohort study

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Declaration of conflicting interest

All authors have no conflicts of interest to declare.

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Ethics approval

Ethical approval was obtained from the medical ethical committees of Hospital East-Limburg and Hasselt University (B3712021000002). All methods were conducted in accordance with the ethical standards of the declaration of Helsinki, and in accordance with relevant guidelines and regulations. All participants provided written informed consent before inclusion in the study.

Data availability statement

The data that support the findings of this study are not publicly available due to ethical restrictions, proprietary concerns, or other limitations. Questions on the data availability should be directed to the corresponding author, who may provide further information.

Author contributions

All authors contributed substantially to the conception and design of the study. AS acquired the data. AS, AT and BB contributed to the data analyses. All authors contributed substantially to the interpretation of the data. AS, JV and AT drafted the manuscript; JV, BB, TM, KB, KC, and AT revised and edited the manuscript critically.

All authors read and approved the final version of the manuscript to be published. All authors discussed the results and commented on the manuscript.

Abstract

Objective: To identify (1) pre- to early postoperative changes in pain and related cognitions and emotions, (2) early postoperative pain trajectories and their covariates, and (3) predictors of early postoperative cognitions and emotions.

Design: Longitudinal cohort study.

Setting: Secondary care setting at Hospital East-Limburg and the European Hip Center (Belgium).

Participants: 133 individuals with hip osteoarthritis undergoing total hip arthroplasty.

Intervention: Data were collected before total hip arthroplasty and during the first postoperative week.

Main Measures: Sociodemographic information, traumatic experiences, anxiety, depression, perceived injustice, fear-avoidance, self-efficacy, and pain-related variables were assessed. Statistical analyses included Friedman tests to evaluate pre- to postoperative changes in pain and related cognitions and emotions, Latent Class Growth Analysis and multinomial logistic regression to identify pain trajectories and their covariates, and Least Absolute Shrinkage and Selection Operator regression to identify predictors of early postoperative cognitions and emotions.

Results: Four early postoperative pain trajectories were identified. Two trajectories (36%, n=48) demonstrated no reduction in pain intensity one week after surgery. Higher levels of self-efficacy (odds ratio=0.83) and pre- to postoperative reductions in perceived injustice (odds ratio=0.86) were associated with lower odds of being

classified in the unremitting pain trajectory. Between 38% and 64% in the variance of early postoperative cognitions and emotions could be predicted. Preoperative perceived injustice showed a positive association with fear-avoidance (ß=1.96) and anxiety symptoms (ß=0.80).

Conclusions: Inter-individual differences exist in early postoperative pain after total hip arthroplasty but are poorly associated with cognitions or emotions. Preoperative perceived injustice may influence early postoperative cognitions and emotions.

Registration: ClinicalTrials.gov, NCT05265858 (https://classic.clinicaltrials.gov/ct2/show/NCT05265858)

Keywords: Osteoarthritis; total hip arthroplasty; cognitions; emotions; pain; trauma

Clinical messages

- Inform patients about the variability in early postoperative pain trajectories and the possibility of no immediate pain reduction after total hip arthroplasty.
- Consider evaluating preoperative levels of perceived injustice and traumatic experiences as these factors may influence postoperative cognitive and emotional outcomes.
- Closely monitor patients who do not experience a reduction in pain intensity within the first week postoperatively, as they may be at higher risk for prolonged pain.

Introduction

Hip osteoarthritis is a major cause of pain and disability worldwide, ultimately treated with total hip arthroplasty[1]. Despite advancements in surgical procedures, up to 23% of individuals experience long-term pain after total hip arthroplasty[2]. Although the literature remains inconclusive in individuals undergoing total joint arthroplasty[3, 4], acute postoperative pain is widely acknowledged as a risk factor for the development

of chronic postoperative pain[5]. Therefore, investigating early postoperative pain trajectories and their associated factors is essential for understanding the progression to chronic postoperative pain.

Nevertheless, despite their importance in the transition to chronic postoperative pain, evidence is limited regarding the origins and inter-individual differences in early postoperative pain and related cognitions and emotions. Individuals with unhelpful beliefs concerning their acute postoperative pain may be prone to adopt maladaptive coping strategies, ultimately leading to increased pain and disability[6]. Inconsistent findings have been reported on the association between early postoperative pain and psychological factors such as anxiety, depression, catastrophising, and optimism[7]. However, recent evidence has shown that high levels of pain catastrophising, unremitting after surgical procedures such as total hip arthroplasty, are associated with chronic postoperative pain[8].

Regarding the origins of early postoperative cognitions and emotions, preoperative anxiety levels, optimism, and emotional representation of osteoarthritis have been identified as predictors of early postoperative anxiety[9]. However, other psychological factors, such as self-efficacy, have not yet been investigated, despite their influence on the threat appraisal of pain and the ability to cope with stressful life situations[10]. Additionally, the influence of childhood and adulthood traumatic experiences on early postoperative pain and related cognitions and emotions remains particularly underexplored. Trauma history has been associated with maladaptive coping strategies later in life, which could influence the experience and trajectory of postoperative pain, as well as the onset of chronic pain itself[11]. Furthermore, pain-related cognitions and emotions have been associated with insecure attachment styles, which might be the result of unresolved trauma[12]. Given the growing recognition

of the biopsychosocial model of pain, it is essential to understand how early psychological experiences, including trauma, influence postoperative outcomes in individuals undergoing total hip arthroplasty. This is particularly relevant to multidisciplinary rehabilitation teams, including orthopaedic surgeons, physiotherapists, occupational therapists, and psychologists. While psychologists may not be routinely involved in the postoperative care of individuals undergoing total hip arthroplasty, understanding the psychological influences on pain and recovery could inform tailored interventions for those who exhibit maladaptive coping strategies or have a history of psychological trauma.

To date, there is limited research examining the impact of trauma on the early postoperative pain trajectories and associated cognitions and emotions in individuals undergoing total hip arthroplasty. It is hypothesised that distinct early postoperative pain trajectories exist and are associated with early postoperative cognitions and emotions. Furthermore, a history of traumatic experiences is hypothesised to be associated with maladaptive early postoperative pain-related cognitions and emotions. This study aims (1) to investigate the pre- to early postoperative changes in pain and related cognitions and emotions after total hip arthroplasty, (2) to identify early postoperative pain trajectories and their potential covariates, and (3) to examine the association between preoperative biopsychosocial factors and early postoperative cognitions and emotions.

Methods

Study design

This study is based on pre- and early postoperative data from a larger longitudinal prospective cohort study (ClinicalTrials.gov Identifier: NCT05265858), all information

and the complete protocol have been published elsewhere[13]. Ethical approval was obtained from the medical ethical committees of Hospital East-Limburg and Hasselt University (B3712021000002).

Participants and recruitment

Participants were recruited from a secondary care setting at Hospital East-Limburg in Genk (Belgium) and the European Hip Center in Westerlo (Belgium). Recruitment started in May 2021 until September 2023. Individuals with a confirmed clinical or radiographic primary diagnosis of hip osteoarthritis, and on the waiting list for a total hip arthroplasty, were invited to participate in this study. Exclusion criteria were (1) rheumatic arthritis or other rheumatic diseases, (2) avascular necrosis or other pathological conditions explaining the symptoms, (3) neurological disorders significantly influencing the symptoms of hip osteoarthritis, (4) revision total hip arthroplasty, (5) a history of pathological fractures (e.g., osteoporosis, tumour…), and (6) other planned surgical procedures during the follow-up period (e.g., contralateral total hip arthroplasty, total knee arthroplasty …). All participants provided written informed consent before being included in the study.

Measurements

Measurements were performed approximately one week before surgery and on the first, third, fifth and seventh day after surgery (Figure 1).

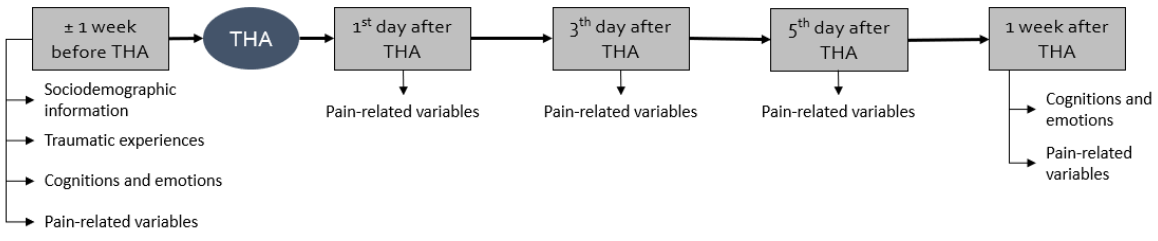

Figure 1. Study design. THA=total hip arthroplasty.

The following sociodemographic information was gathered from each participant using a questionnaire: age (years), sex (female/male), height (m), body weight (kg), smoking status (yes/no), educational level (elementary school, secondary school, higher education, or other), marital status (single, living together, married, divorced, other), and employment status (working, sick leave, retired, student, unemployed). Body Mass Index (kg/m^2) was calculated using self-reported height and weight. Participants were asked to indicate whether they were diagnosed with one of the following comorbidities: heart disease, diabetes, psychiatric disorders, epilepsy, cancer, hypertension, major surgery, osteoporosis, joint prosthesis, or other comorbidities.

The Dutch version of the Childhood Trauma Questionnaire was used to assess participants' history of abuse or neglect in their childhood using 25 items across five dimensions: physical abuse; physical neglect; emotional abuse; emotional neglect; and sexual abuse [14]. Each item is scored on a five-point Likert scale, ranging from one "never true", to five "very often true". The total score ranges from 25 to 125, and subscale score ranges from five to 25. The following cut-off scores distinguishing between "none to low", "low to moderate", "moderate to severe", and "severe to extreme" exposure to childhood trauma were used: emotional abuse (≤8; 9-12; 13-15; ≥16), emotional neglect (≤9; 10-14; 15-17; ≥18), physical abuse (≤7; 8-9; 10-12; ≥13), physical neglect (≤7; 8-9; 10-12; ≥13), and sexual abuse (≤5; 6-7; 8-12; ≥13) [15].

The Traumatic Experiences Checklist was used to evaluate a wide range of potential traumatising experiences during childhood and adulthood[16]. The questionnaire covers traumatic experiences in six areas: emotional abuse; emotional neglect; sexual harassment; sexual abuse; physical abuse; and threat to life or bizarre punishment/intense pain. Furthermore, 11 items relating to family events are included, such as a divorce or loss of a significant other. For each of the 29 potentially traumatic

experiences, participants were required to indicate whether they had encountered the event in their lives (yes/no), their age at the time of the event, and the impact of the event on the individual, ranging from one “no impact” -to five “very severe impact”. The total number of traumatic experiences (ranging from zero to 29), the number of experiences during childhood (<18 years of age) and adulthood (>18 years of age) separately, and the average impact, ranging from one “no impact” to five “very severe impact”, were extracted as measures of trauma.

The Hospital Anxiety and Depression Scale was used to screen for symptoms of anxiety and depression. The Hospital Anxiety and Depression Scale is a 14-item questionnaire with subscales for anxiety and depression[17]. Each item is scored from zero ”not applicable” to three ”certainly applicable”. Higher scores indicate more symptoms of anxiety/depression. In accordance with the current literature, the optimal cut-off score of 8 points was used for each subscale[18].

The Dutch version of the Fear-Avoidance Components Scale was used to assess pain-related fear-avoidance[19]. The Fear-Avoidance Components Scale is a 20-item questionnaire with scores ranging from zero “completely disagree” to five “completely agree”. Higher scores indicate more fear-avoidance. Five severity levels have been proposed: subclinical (0–20), mild (21–40), moderate (41–60), severe (61–80), and extreme (81–100)[19].

Perceived injustice was measured with the Injustice Experience Questionnaire[20]. The Injustice Experience Questionnaire consists of 12 items, scored on a range from zero “not at all” to four “all the time”. The total score ranges between zero and 48 and higher total scores reflect higher levels of perceived injustice. Cut-off scores of 19 and 30 are reported for medium and high levels of perceived injustice, respectively.

The General Self-Efficacy Scale is used to measure self-efficacy [21]. It consists of ten statements (optimistic "self-beliefs") that ask about how people think and act in general. Items are scored on a four-point Likert scale, resulting in a total score between 10 and 40 points, with higher scores indicating more self-efficacy. The General Self-Efficacy Scale was only administered preoperatively.

Finally, participants were asked to indicate their pain duration (months), use of pain medication (none, seldom, most days and/or nights, all days and/or nights), and number of painful body regions (last week and last year). The average pain intensity over the last week and 'at this moment' was assessed by the Numeric Pain Rating Scale, an 11-point scale ranging from zero ("no pain") to ten ("worst possible pain") [22]. Evidence in individuals with chronic musculoskeletal pain has demonstrated that an NPRS score ≤ 5 correspond to mild, scores of 6-7 to moderate and scores ≥ 8 to severe pain[23].

Statistics

Statistics were performed in R (Version 3.6.3) using RStudio (2022.07.2). Missing values in the dataset were handled using the missForest algorithm[24]. The distribution of the imputed variables was examined through histograms to ensure that the imputed values were consistent with the overall data distribution. Descriptive statistics are presented as mean and standard deviation for normally distributed continuous variables, median and interquartile range for non-normally distributed continuous variables, and as absolute numbers and percentages for categorical variables.

For the first aim of the study, to investigate the pre- to early postoperative changes in pain and related cognitions and emotions in individuals undergoing total hip arthroplasty, Friedman tests were performed with pain intensity and related cognitions

and emotions as dependent variables and timepoint (before and one week after total hip arthroplasty) as independent variable. Subsequently, post-hoc pairwise Wilcoxon tests were performed with Bonferroni correction for multiple comparisons.

The second aim, the identification of latent trajectory classes of early postoperative pain after total hip arthroplasty and their potential covariates, was analysed using a three-step approach. First, Latent Class Growth Analysis was performed to evaluate the existence of latent early postoperative pain trajectories. A model including parameters representing the initial preoperative pain intensity (intercept), the potential effect of total hip arthroplasty on pain intensity (step), and the rate of change in pain intensity after total hip arthroplasty (slope) was tested. Models were specified for a range of one to five latent classes. To determine the optimal number of classes that best captured the underlying patterns in the data, the Bayesian Information Criterion was assessed as a model fit index, with lower values indicating a better fit to the data. Additionally, Lo-Mendell-Rubin ad-hoc likelihood ratio tests were performed[25], and entropy and minimum posterior classification probability had to be greater than 0.90 to ensure classification quality. Classes with fewer than five participants were not considered. Wald tests were performed to test whether parameters (intercept, step and slope) were significantly different between classes. Secondly, subjects were allocated to these latent classes by considering their posterior class membership probabilities. In the third step, the relationship between the assigned class membership and potential covariates (age, gender, traumatic experiences, self-efficacy, and cognitions and emotions) was explored through a multinomial logistic regression analysis, using class membership as the dependent variable.

Finally, to evaluate the association between preoperative factors, including self-efficacy and traumatic experiences, and early postoperative cognitions and emotions,

Least Absolute Shrinkage and Selection Operator regression was used. Fitted models were constructed for each dependent variable (Fear-Avoidance Components Scale, Injustice Experience Questionnaire, anxiety and depression subscale of the Hospital Anxiety and Depression Scale). The training dataset, consisting of 81 participants randomly selected, was used for model development, and models were subsequently assessed on a test dataset comprising the remaining 42 participants. This distribution ensures adequate support for both model development and performance validation. Model performance was evaluated by analysing R-squared and Root Mean Square Error of Approximation.

Based on prior studies that conducted similar analyses[4, 9], an estimated sample size of 140 participants was considered to be appropriate for addressing the research questions. Additionally, in accordance with the widely accepted rule of thumb recommending a minimum of 10 participants per independent variable, a minimum sample size of 120 participants was determined for the LASSO regression analysis, which included 12 independent variables.

Results

One hundred forty-three participants were included, of which ten participants did not respond to the questionnaires. As such, 133 participants were included in this exploratory analysis. Descriptive statistics for baseline participant characteristics are reported in Table 1.

Table 1. Baseline participant characteristics

Characteristic	**Value** [a], N=133
Age, years	67.0 [59.0, 72.0]
Gender, female	65, 48.8%
BMI, kg/m^3	26.8 [24.3, 30.1]
Marital status	
Single	19, 14.3%

Living together	15, 11.3%
Married	91, 68.4%
Divorced	6, 4.5%
Other	2, 1.5%
Employment status	
Employed	24, 18.0%
Sick leave	14, 10.5%
Retired	90, 67.7%
Student	0, 0.0%
Unemployed	5, 3.8%
Educational level	
Elementary school	17, 12.8%
Secondary school	53, 39.8%
Higher education	58, 43.6%
Other	5, 3.8%
Comorbidities (>1)	70, 52.6%
Pain medication	
None	41, 30.8%
Seldom	38, 28.6%
Most days and/or nights	20, 15.0%
All days and/or nights	34, 25.6%

Legend. [a] Median [Q1, Q3]; n, %; BMI=Body Mass Index.

Pre- to early postoperative changes in pain and related cognitions and emotions

Significant reductions in pain intensity and scores on related cognitions and emotions were observed, except for perceived injustice (Table 2). Pain intensity decreased in the first postoperative week with a median difference in pre- to postoperative current and average Numeric Pain Rating Score of two points. Pain-related fear-avoidance decreased in the first postoperative week as well, represented by a median decrease on the Fear-Avoidance Components Scale of six points. Finally, symptoms of both anxiety and depression decreased in the early postoperative phase. Preoperative scores on the anxiety subscale of the Hospital Anxiety and Depression Scale were below the clinical threshold, but the median decrease was one point after total hip arthroplasty. Preoperative levels of depression slightly exceeded the clinical threshold,

and demonstrated a notable median reduction of six points after total hip arthroplasty, falling below the clinical threshold postoperatively.

Table 2. Pre- to early postoperative reductions in pain and related cognitions and emotions

Variables	Preoperative [a]	One-week postoperative [a]	Difference [a]	p-value [b]
FACS-D (0-100)	38.0 [29.0, 50.0]	32.0 [22.0, 41.0]	-6.0 [-16.0, 2.0]	<0.001
IEQ (0-48)	5.0 [2.0, 11.0]	4.0 [1.0, 8.3]	-1.0 [-4.3, 1.0]	0.054
HADS-A (0-21)	3.6 [2.0, 6.0]	2.0 [1.0, 4.0]	-1.0 [-3.0, 0.0]	<0.001
HADS-D (0-21)	8.0 [6.9, 10.0]	2.0 [1.0, 4.0]	-6.0 [-7.0, -4.0]	<0.001
NPRS (0-10)				
At this moment	5.0 [4.0, 7.0]	3.0 [1.0, 5.0]	-2.0 [-4.0, 0.0]	<0.001
Average last week	6.0 [4.0, 7.0]	3.0 [2.0, 5.0]	-2.0 [-3.6, -0.5]	<0.001

[a] Median [Q1, Q3], [b] Post-hoc pairwise Wilcoxon tests with Bonferroni correction for multiple comparisons. NPRS=Numeric Pain Rating Scale, HADS-A=Anxiety subscale of the Hospital Anxiety and Depression Scale, HADS-D=Depression subscale of the Hospital Anxiety and Depression Scale, FACS-D=Dutch version of the Fear-Avoidance Components Scale; IEQ=Injustice Experience Questionnaire.

Trajectories of early postoperative pain after total hip arthroplasty

Model fit indices indicated that a four-class model best fit the observed data (Figure 2, Supplementary File 2).

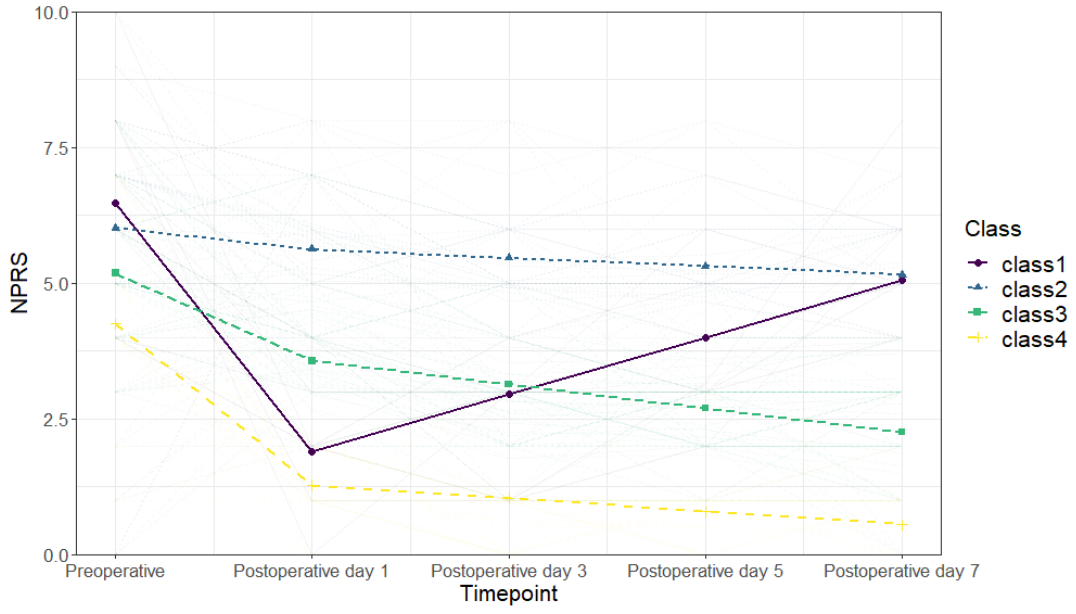

Figure 2. Four latent trajectory classes of early postoperative pain.

Class 1 (7%, n=9) was characterised by high initial pain intensity, followed by a sharp decrease in pain intensity one day after surgery, and a gradual increase in pain

intensity thereafter. Class 2 (29%, n=39) was characterised by a stable pain intensity without significant reductions in the first postoperative week. Class 3 represented the largest group of participants (44%, n=58) and was characterised by a significant initial decrease in pain intensity one day after surgery, followed by a further and steady decrease in pain intensity. Finally, class 4 (20%, n=27) was characterised by a strong initial decrease in pain intensity followed by a relatively stable yet slightly decreasing pain intensity.

The four-class model parameters are presented in Table 3. Wald tests revealed that initial preoperative pain intensity (intercept) was different between class 1 and class 4, and between class 2 and class 4. The immediate effect of total hip arthroplasty on pain intensity (step) was different between all classes, except between class 1 and class 4. Finally, the rate of change in pain intensity after total hip arthroplasty (slope) was different between class 1 and all other classes, and between class 2 and class 3.

Table 3. Final LCGA model with parameters

Class	Intercept	Step	Slope	n (%)
1	6.48***	-4.57***	1.05***	9 (7%)
2	6.02***	-0.39	-0.16	39 (29%)
3	5.18***	-1.61***	-0.44***	58 (44%)
4	4.25***	-2.97***	-0.24*	27 (20%)

*Legend. Significance levels: <0.001***, <0.01**, <0.5**

Covariates of early postoperative pain trajectories

The results of the multinomial logistic regression analysis, presented in Supplementary File 3, showed that for each additional year in age, the odds of being categorised in class 3 (relative to class 4) increased by an odds ratio of 1.06 (95% confidence interval [1.00, 1.13]). Furthermore, the odds of belonging to class 2 (relative to class 4) decreased by an odds ratio of 0.86 (95% confidence interval [0.75, 0.99]) for every

point improvement in pre-to postoperative perceived injustice, and decreased by an odds ratio of 0.83 (95% confidence interval [0.72, 0.95]) for every point increase in preoperative self-efficacy.

Preoperative factors associated with early postoperative cognitions and emotions

Based on the preoperative variables selected by the Least Absolute Shrinkage and Selection Operator regression models, 42%, 64%, 47% and 38% of the variance in one-week postoperative scores of the Fear-Avoidance Components Scale, Injustice Experience Questionnaire, and anxiety and depression subscales of the Hospital Anxiety and Depression Scale could be predicted, respectively (Table 4). However, only the models for the postoperative anxiety and depression subscales of the Hospital Anxiety and Depression Scale scores performed well in the test set, explaining 52% and 37% of the variance, respectively.

For each standard deviation increase in preoperative scores on the Fear-Avoidance Components Scale, Injustice Experience Questionnaire, and anxiety and depression subscales of the Hospital Anxiety and Depression Scale, postoperative scores of these respective questionnaires increased by 6.48, 4.42, 1.14 and 1.05 points. Furthermore, for each standard deviation increase in preoperative scores on the Injustice Experience Questionnaire, postoperative scores on the Fear-Avoidance Components Scale and depression subscale of the Hospital Anxiety and Depression Scale increased with 1.96 and 0.80 points, respectively.

Regarding the role of traumatic experiences, no significant associations were found with early postoperative cognitions and emotions. Nevertheless, the number of traumatic experiences during both childhood and adulthood, as measured by the

Traumatic Experiences Checklist, were included in the Least Absolute Shrinkage and Selection Operator regression model and showed positive associations with the early postoperative cognitions and emotions. In contrast, the Childhood Trauma Questionnaire demonstrated negative associations with early postoperative cognitions and emotions, with coefficients ranging from -0.15 to -1.73.

Finally, general self-efficacy, as measured by the General Self-Efficacy Scale, was included as an independent variable in the Least Absolute Shrinkage and Selection Operator regression models for postoperative scores on the Injustice Experience Questionnaire and the depression subscale of the Hospital Anxiety and Depression scale, and was found to be negatively associated with these dependent variables.

Table 4. LASSO regression analyses

Independent variables	**Dependent variables** [a]			
	FACS-D	***IEQ***	***HADS-A***	***HADS-D***
(Intercept)	33.42	7.00	3.28	3.26
Age		-0.30 (0.27)	-0.20 (0.11)	
Gender		0.91 (0.77)	0.51 (0.33)	
BMI			0.16 (0.29)	0.04 (0.19)
Preoperative NPRS		0.21 (0.76)		
Preoperative HADS-A		0.50 (0.82)	**1.14 (0.34) ****	
Preoperative HADS-D	0.33 (0.71)		0.58 (0.36)	**1.05 (0.21) ****
Preoperative FACS-D	**6.48 (0.66) *****	0.29 (0.81)		0.10 (0.22)
Preoperative IEQ	**1.96 (0.56) ***	**4.42 (0.90) *****	0.35 (0.37)	**0.80 (0.21) ****
TEC childhood		0.85 (0.85)	0.56 (0.37)	
TEC adulthood		1.21 (0.89)	0.59 (0.36)	0.38 (0.24)
CTQ	-1.73 (0.60)	-1.19 (0.75)	-0.46 (0.37)	-0.15 (0.18)
GSES		-0.24 (0.91)		-0.26 (0.20)
R^2	**0.42**	**0.64**	**0.47**	**0.38**

Legend. [a] Coefficient (Standard Error), BMI=Body Mass Index, NPRS=Numeric Pain Rating Scale, HADS-A=Anxiety subscale of the Hospital Anxiety and Depression Scale, HADS-D=Depression subscale of the Hospital Anxiety and Depression Scale, FACS-D=Dutch version of the Fear-Avoidance Components Scale; IEQ=Injustice

*Experience Questionnaire; GSES=General Self-Efficacy Scale; TEC=Traumatic Experiences Checklist; CTQ=Childhood Trauma Questionnaire. Significance levels: <0.001***, <0.01**, <0.5**

Discussion

Overall, reductions were found in all measures of pain and related cognitions and emotions, except for perceived injustice. While reductions in pain intensity were clinically significant, changes in pain-related fear-avoidance were below the smallest detectable change, and preoperative anxiety levels were low[19]. Depressive symptoms exceeded clinical thresholds preoperatively and strongly decreased postoperatively. These findings suggest that total hip arthroplasty may have a positive impact on psychological functioning. However, levels of perceived injustice were similar to those in other chronic pain populations[19], but did not improve early after total hip arthroplasty.

Four distinct trajectories of early postoperative pain were identified, with a notable proportion of individuals falling into the two pain trajectories without reductions in pain intensity early after total hip arthroplasty (36%, n=48). These results confirm previous research, indicating large inter-individual differences in early postoperative pain after total hip arthroplasty[4]. Future research should investigate whether individuals within the pain trajectories without early reductions in pain intensity are at a higher risk of developing chronic pain after total hip arthroplasty, since this association has not been confirmed in research on total hip arthroplasty[26]. Studies investigating the association between early-postoperative movement-evoked pain and the development of chronic postoperative pain only showed an association with pain intensity at six weeks, but not at six months after total hip arthroplasty[4, 27]. However, these studies did not consider initial pain intensity and early postoperative change in pain intensity, but looked at maximal movement-evoked pain intensity over the first two postoperative days[27], and pain trajectory membership over the first five postoperative days[4].

General self-efficacy and pre-to postoperative reductions in perceived injustice were the only factors associated with an early postoperative pain trajectory. These results suggest that early postoperative pain trajectories may be influenced by other factors. However, it is crucial to recognise that while cognitions and emotions may not be associated with early postoperative pain trajectories, they may still play a significant role in the transition from acute to chronic postoperative pain. Fear-avoidance and perceived injustice have already been associated with the transition from acute to chronic pain[28], and with negative pain outcomes in individuals undergoing total knee arthroplasty[29, 30]. Therefore, further research should explore whether individuals with early postoperative maladaptive cognitions and emotions have an increased risk of developing long-term pain and disability after total hip arthroplasty.

The findings surprisingly revealed conflicting patterns for the association between self-reported measures of traumatic experiences and early postoperative cognitions and emotions. The Traumatic Experiences Checklist showed positive associations, suggesting that a higher number of traumatic experiences during childhood and adulthood may exacerbate early postoperative feelings of perceived injustice, anxiety and depression. This aligns with existing literature linking traumatic experiences across the lifespan to symptoms of anxiety and depression[31]. In contrast, the Childhood Trauma Questionnaire showed negative associations with early postoperative cognitions and emotions. These results contradict existing research, suggesting that childhood trauma increases the risk of developing depression in response to stressful events, via neuroendocrine and behavioural adaptations[32, 33]. However, mean scores on its subscales were well below those reported in a recent meta-analysis, indicating a low prevalence of childhood trauma in the study population[34]. Moreover, the weak to moderate correlation between both trauma questionnaires (Supplementary File 1)

suggests they may not measure these constructs in the same way. Finally, the Traumatic Experiences Checklist also includes items on other adverse life events such as threat to life, intense pain, and family events like divorce, potentially capturing a greater overall burden of trauma. This might exceed an individual's reserve capacity to adapt and cope effectively with new stressors, thus leading to the heightened cognitive and emotional symptoms after total hip arthroplasty[35].

Clinicians should inform individuals on the heterogeneity in early postoperative pain trajectories and the fact that a substantial proportion of individuals might have no reduction in pain intensity one week after total hip arthroplasty. From a clinical perspective, it is also interesting that preoperative perceived injustice was found to be associated with early postoperative maladaptive cognitions and emotions. However, it is important to note that while interventions such as pain education, cognitive behavioural therapy, motivational interviewing, and acceptance and commitment therapy show promise in addressing psychological factors related to pain, the literature remains limited in demonstrating their effectiveness to reduce perceived injustice specifically[36]. Additionally, it has not yet been demonstrated that modifying perceived injustice leads to long-term improvements in pain and disability.

The findings of this study should be interpreted with consideration of several limitations. First, the relatively small sample size may have reduced the statistical power of the results. Among the 133 participants, four distinct pain trajectories were identified, with only nine participants in the first trajectory. This might have influenced the outcomes of the multinomial regression model and the Least Absolute Shrinkage and Selection Operator regression models. Consequently, future studies should aim to validate these findings in an independent cohort. Secondly, no information was collected concerning the anaesthesia protocols that were used. Anaesthesia protocols might likely influence

442 the acute postoperative pain trajectory; however, studies have reported considerable
443 variability in acute pain trajectories after total hip arthroplasty, even in individuals
444 undergoing the same analgesic procedures[37]. The standard-of-care in the hospital
445 consisted of spinal anaesthesia with a nerve block, and a standardized post-operative
446 medication protocol was provided to all participants. However, individual variations in
447 medication use were not monitored, limiting our ability to assess its impact on early
448 postoperative pain.

449 In conclusion, this exploratory analysis identified four early postoperative pain
450 trajectories, with a substantial proportion of individuals without early postoperative
451 reductions in pain intensity. Conflicting patterns were found for the association
452 between measures of traumatic experiences and early postoperative cognitions and
453 emotions. Due to the small sample size and exploratory nature of this study, findings
454 should be interpreted with caution and validated in larger, independent cohorts.

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456 None

457 **Declaration of conflicting interest**

458 All authors have no conflicts of interest to declare.

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462 **Ethics approval**

463 Ethical approval was obtained from the medical ethical committees of Hospital East-
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accordance with the ethical standards of the declaration of Helsinki, and in accordance with relevant guidelines and regulations. All participants provided written informed consent before inclusion in the study.

Data availability statement

The data that support the findings of this study are not publicly available due to ethical restrictions, proprietary concerns, or other limitations. Questions on the data availability should be directed to the corresponding author, who may provide further information.

Author contributions

All authors contributed substantially to the conception and design of the study. Abner Sergooris acquired the data. Abner Sergooris, Annick Timmermans and Bruno Bonnechère contributed to the data analyses. All authors contributed substantially to the interpretation of the data. Abner Sergooris, Jonas Verbrugghe and Annick Timmermans drafted the manuscript; Jonas Verbrugghe, Bruno Bonnechère, Thomas Matheve, Katleen Bogaerts, Kristoff Corten, and Annick Timmermans revised and edited the manuscript critically. All authors read and approved the final version of the manuscript to be published. All authors discussed the results and commented on the manuscript.

Legends for illustrations and tables

Figure 1. Study design. THA=total hip arthroplasty

Figure 2. Four latent trajectory classes of early postoperative pain.

Table 1. Baseline participant characteristics

Legend. [a] Median [Q1, Q3]; n, %; BMI=Body Mass

Index.

Table 2. Pre- to early postoperative reductions in pain and related cognitions and emotions

[a] Median [Q1, Q3], [b] post-hoc pairwise Wilcoxon tests with Bonferroni correction for multiple comparisons. NPRS=Numeric Pain Rating Scale, HADS-A=Anxiety subscale of the Hospital Anxiety and Depression Scale, HADS-D=Depression subscale of the Hospital Anxiety and Depression Scale, FACS-D=Dutch version of the Fear-Avoidance Components Scale; IEQ=Injustice Experience Questionnaire.

Table 3. Final latent class growth analysis model with parameters

*Legend. Significance levels: <0.001***, <0.01**, <0.5**

Table 4. Least Absolute Shrinkage and Selection Operator regression analyses

*Legend. [a] Coefficient (Standard Error), BMI=Body Mass Index, NPRS=Numeric Pain Rating Scale, HADS-A=Anxiety subscale of the Hospital Anxiety and Depression Scale, HADS-D=Depression subscale of the Hospital Anxiety and Depression Scale, FACS-D=Dutch version of the Fear-Avoidance Components Scale; IEQ=Injustice Experience Questionnaire; GSES=General Self-Efficacy Scale; TEC=Traumatic Experiences Checklist; CTQ=Childhood Trauma Questionnaire. Significance levels: <0.001***, <0.01**, <0.5**

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