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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Body perception in women with and without pregnancy-related lumbopelvic pain and women with and without chronic low back pain

Margo Van Haelen
Kaat Verstraten

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. Lotte JANSSENS

COPROMOTOR :
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Research context

This exploratory longitudinal study can be situated in the domain of musculoskeletal research. It concentrates on the correlation between perceived body perception and dysfunction namely, (pregnancy-related) lumbopelvic pain (PLBP), without having a primary focus on treatment. The research is part of a broader project since a parallel investigation is being conducted to explore the connection between adaptations in postural control and PLBP. Both studies are supervised by promotor L.J. and co-promotor N.G.

In literature, there are several different variants applied to describe the word 'body perception'. The most frequently described variants are the terms body image, body awareness and body consciousness. Furthermore, it is important to consider that these terms are not always interpreted in the same way as well have different definitions. Some investigations situate the above-mentioned terms a lot more within psychological barriers (Chan et al., 2020; Roomruangwong, Kanchanatawan, Sirivichayakul, & Maes, 2017; Silveira, Ertel, Dole, & Chasan-Taber, 2015) while others interpret them within a more proprioceptive way of thinking (Beales, Lutz, Thompson, Wand, & O'Sullivan, 2016; Wand et al., 2017).

Therefore, it is important and interesting to start by defining how the word 'body perception' is applied in the context of this current research. Body perception is used to regulate the body's ability to perceive its own internal status (interoception) and neural maps that explain this status (Lotze & Moseley, 2007). The term interoception is often explained as the phenomenological perception of the internal state of the body (Ceunen, Vlaeyen, & Van Diest, 2016). This definition is closely related to the notion of body perception where an individual consciously feels that his body belongs to him and consists out of different structures that are connected in some way to each other. Moreover, body perception covers the dynamic concept between proprioceptive, tactile, and visual input that can be modified by personal beliefs, psychosocial factors, and memory (Lotze & Moseley, 2007).

In this research, a combination of two terms are embodied namely, low back pain (LBP) and pelvic girdle pain (PGP), which are collectively described as pregnancy-related lumbopelvic pain (PLBP). The above-mentioned term can refer to LBP, PGP or a combination of both in pregnant participants. LBP is typically identified by pain experienced between the 12^{th} rib and the gluteal fold (Gutke, Betten, Degerskär, Pousette, & Olsén, 2015; Wu et al., 2004). PGP is

characterized by pain experienced between the posterior iliac crest and the gluteal fold, especially near the sacroiliac joints (SIJ) (Gutke et al., 2015; Wu et al., 2004). Both LBP and PGP may radiate in the lower limbs. Specifically, both may radiate in the posterior thigh while only LBP can reach down to the foot. Pregnancy-related pelvic girdle pain typically starts during pregnancy or within the first three weeks postpartum (Mens, Vleeming, Stoeckart, Stam, & Snijders, 1996).

The initial objective of this investigation was to evaluate changes in body perception among pregnant women during the first and third trimester of pregnancy on the one hand, and at six weeks and six months post-partum on the other hand. However, because of the COVID-19 situation and lockdown, the research became more limited and consequently, the focus was restricted to trimester one and three without the inclusion of a postpartum period.

Because the research focuses on body perception in both pregnant individuals experiencing PLBP and non-pregnant participants with chronic LBP, mainly healthcare professionals might benefit from this investigation. In this way, they can identify how impairments in body perception might contribute to PLBP and chronic LBP. Similarly, they can also see where to step in and provide adequate treatment.

Since the investigation is part of a broader context, the research design and method have already been developed in advance by both the promotor and co-promotor. The recruitment of participants and the data acquisition was completed by the students in cooperation with the co-promotor. The test sessions took place in the REVAL Rehabilitation Research Center (UHasselt, Diepenbeek) and were performed by the co-promotor together with one of both students. The saving of the data for each participant was managed by the co-promotor while the data processing was conducted by the students themselves. The thesis was written and elaborated by both students with periodic feedback of the promotor and co-promotor.

1. Abstract

- **Background**: The correlation between body perception disturbances and chronic LBP in a non-pregnant population was indicated by multiple studies while this has not yet been sufficiently explored in a pregnant population experiencing PLBP.
- **Objectives**: To identify a possible difference in the experienced body perception at the lumbopelvic area **(1)** between pregnant women with and without PLBP in the third trimester of pregnancy, **(2)** between pregnant women with and without PLBP among the course of their pregnancy (trimester one versus trimester three), **(3)** between a painful and non-painful condition (pregnant and non-pregnant participants) as well as **(4)** between a pregnant and non-pregnant condition (regardless of experiencing either PLBP, LBP or being pain-free). Secondary, the research aims to explore the psychosocial factors that contribute to alterations in body perception in pregnant women.
- **Participants**: Nine pregnant participants were divided into two groups based on experiencing PLBP or not. In addition, 16 non-pregnant participants (demographically matched with the pregnant participants) were divided into two groups based on experiencing LBP or not.
- **Measurements**: The primary outcome measure was the experienced body perception at the lumbopelvic area which was measured by both the FreBAQ (pregnant individuals) and the Recognise Back App (pregnant and non-pregnant individuals). The secondary outcome measures compromised psychosocial factors including the TSK, FABQ, PCS, PCI, TPDS and the DASS-21. To assess differences in body perception between the groups, non-parametric tests and a Repeated Measures Mixed Effect Model were applied. Spearman's Correlation were used to evaluate the associations between body perception and psychosocial factors in pregnant women.
- **Results**: Greater disturbances in body perception were frequently more observed in pregnant individuals experiencing PLBP ($p=0.0484$) compared to healthy pregnant women. However, non-pregnant women (with or without LBP) experienced more alterations in body perception compared to pregnant women (with or without PLBP) ($p=0.0140$). Higher scores on the TSK, FABQ-PA, PCS, and PCI-passive were correlated with more disturbances in body perception.

- **Conclusion**: Alterations in body perception were significantly more observed in pregnant individuals with PLBP compared to healthy pregnant women. In addition, non-pregnant participants demonstrated more disturbances in body perception than pregnant women. Secondly, fear of movement, higher levels of fear-avoidance beliefs concerning physical activity, pain catastrophizing and applying a passive coping strategy were identified as being associated with an altered body perception in pregnant women.
- **Keywords**: Pregnancy, body perception, low back pain, pelvic girdle pain, lumbopelvic pain

2. Introduction

Lumbopelvic pain, which includes low back pain (LBP), pelvic girdle pain (PGP) or the combination of both, is a common feature during pregnancy with up to 85% of women reporting pain during their third trimester of pregnancy (Bastiaanssen, de Bie, Bastiaenen, Essed, & van den Brandt, 2005). While the majority of pregnant women recover soon after childbirth (Ostgaard, 1997), a significant number continues to experience complaints about an extended period of time (Albert, Godskesen, & Westergaard, 2001). It is established that the perceived pain and disability by women experiencing lumbopelvic pain are caused by various elements (Beales et al., 2016; Vleeming, Albert, Ostgaard, Sturesson, & Stuge, 2008). A variety of biological, psychological as well as lifestyle factors appear to influence the problem. Specific examples are hormonal factors (e.g. relaxin concentration and oral contraceptives), stress and job satisfaction, average body weight pre-pregnancy, … (Albert, Godskesen, Korsholm, & Westergaard, 2006; Bastiaanssen et al., 2005; Gutke, Ostgaard, & Oberg, 2008). Further research is necessary to address the impact of hormonal factors since there is limited consistency between studies.

In the majority of pregnant women who experience pregnancy-related lumbopelvic pain (PLBP), there is no evidence for specific underlying pathological abnormalities to be detected by diagnostic tests. Preliminary evidence indicates that a biopsychosocial perspective should be applied to identify the contributing factors to persistent pain in these pregnant women (Albert et al., 2006; Beales & O'Sullivan, 2011; O'Sullivan & Beales, 2007a; Vleeming et al., 2008). There is limited evidence for pelvic asymmetries, and especially the beliefs of the patient towards pelvic asymmetries and instability have been identified to provide a pathway towards kinesiophobia and fear avoidance (Beales & O'Sullivan, 2011; O'Sullivan & Beales, 2007a). In this psychological field, mainly depression and kinesiophobia have been identified as potential contributors to PLBP (Gutke, Josefsson, & Oberg, 2007; Gutke, Lundberg, Ostgaard, & Oberg, 2011).

Another factor recognised as a potential contributing factor to low back pain is an altered body perception (Wand et al., 2011; Wand et al., 2014). Alterations in body perception are thought to be connected to adaptations in motor control patterns in low back pain patients. A similar association may be relevant in (pregnant) women experiencing LBP, PGP or the combination

of both where motor control alterations have been associated with these impairments (Beales, O'Sullivan, & Briffa, 2009; Pool-Goudzwaard et al., 2005; O'Sullivan et al., 2002).

Additionally, patients with chronic LBP have a different perception of their back. This became clear when they had to make a drawing of the way their back feels to them (Nishigami et al., 2015). Furthermore, they have issues localising tactile inputs at the level of the back (Wand et al., 2013), exhibit diminished lumbar tactile acuity because of increased two-point discrimination thresholds (Catley et al., 2014) and demonstrate an inadequate back motor imagery performance (Bowering, Butler, Fulton, & Moseley, 2014; Bray & Moseley, 2011).

Currently, there is significantly more evidence of body perception disturbances in a non-pregnant population experiencing chronic LBP (Bowering et al., 2014; Bray & Moseley, 2011; Brumagne et al., 2000; Brumagne et al., 2008; Catley et al., 2014; Janssens et al., 2016; Nishigami et al., 2015). The connection between body perception and PLBP has not yet been sufficiently explored. Most studies completed in this research field mainly focused on psychological factors and especially pathologies, which can occur during pregnancy and the postpartum period. For example, a lot of studies investigated the correlation between altered body image and anorexia nervosa. To our knowledge, only three investigations have explored the connection between body perception and PLBP, namely the research of Wand et al. (2017), Beales et al. (2016) and Goossens et al. (2021). However, none of these investigations observed this connection prospectively among the course of pregnancy.

Both Wand et al. (2017) and Goossens et al. (2021) concluded that self-reported disruption of body perception, assessed by the Fremantle Back Awareness Questionnaire (FreBAQ), was significantly higher in pregnant women experiencing PLBP when compared to a healthy pregnant control group during the third trimester of pregnancy. The extent of body perception alteration was linked to pain intensity in both studies. Goossens et al. (2021) discovered that impairments in body perception correlated significantly with increased self-reported pain intensity and disability during trimester three. The connection between impaired body perception and pain intensity was also demonstrated to be significant six weeks postpartum (Goossens et al., 2021). Furthermore, Wand et al. (2017) observed a correlation between pain-related catastrophizing and altered body perception. These preliminary data suggest that alterations in body perception associated with PLBP might be mainly driven by negative

cognitive elements. Therefore, it is essential that future research focuses on the inclusion of a combination of multiple cognitive and affective factors.

In the research of Beales et al. (2016), who investigated the correlation between perceived body perception and persistent lumbopelvic pain in the postpartum period, the scores on the FreBAQ were found to be significantly higher in women experiencing moderate disability due to postpartum lumbopelvic pain when compared to a pain-free healthy control postpartum group. This suggests that body perception at the lumbopelvic area was more impaired in women experiencing postpartum lumbopelvic pain than when compared to a pain-free postpartum population. These observations are in line with the outcomes of the research of Goossens et al. (2021). However, the link between PLBP and experienced body perception has solely been investigated in the third trimester of pregnancy and postpartum period. Hence, it would be beneficial if future investigations focused on the course of pregnancy i.e. the evolution of the connection between PLBP and experienced body perception from trimester one to trimester three.

In summary, to our knowledge, body perception in pregnant women has never been monitored over a prolonged period of time and has never been linked to a combination of multiple psychosocial factors. Likewise, the additional comparison of experienced body perception in pregnant individuals (with and without PLBP) and non-pregnant individuals (with and without LBP) as well as the comparison between a painful and non-painful condition (regardless of being pregnant or not) has never been carried out before.

Therefore, the primary aim of this exploratory longitudinal study was to see whether there is a difference in the experienced body perception at the lumbopelvic area between women with and without PLBP at two different stages of pregnancy namely, in the first trimester of pregnancy and the third trimester. Secondary, a comparison was made between the two pregnant groups and an external dataset of non-pregnant women to explore whether there were differences in experienced body perception between a painful and non-painful condition as well as between pregnant and non-pregnant individuals. Differences between these four above-mentioned groups (alternating combined as 2x2) were analysed as the primary objective of this investigation.

Additionally, the secondary aim was to explore possible correlations between the experienced body perception at the lumbopelvic area in pregnant women on the one hand and psychosocial factors on the other hand including fear of movement and pain-related fear, fear-avoidance beliefs, catastrophising, coping strategies, as well as depression, anxiety and stress.

3. Methods

3.1. Research aims and hypotheses

A complete overview of the objectives with corresponding hypotheses of this investigation is given in Table 1.

The primary aim of the current study concerned the evaluation of the experienced body perception at the lumbopelvic area **(1)** between pregnant women with and without PLBP during the third trimester of pregnancy, as well as **(2)** the self-reported difference in body perception experienced between the first and third trimester of pregnancy. Additionally, an external dataset of non-pregnant women (with and without LBP) was implemented to enhance the statistical power. In this way, differences in body perception at the lumbopelvic area could be investigated **(3)** between a painful (either PLBP or LBP) and non-painful condition, regardless of being pregnant or not, and **(4)** between pregnant and non-pregnant women, regardless of experiencing PLBP or LBP.

Further objectives of this investigation focused on possible correlations between the experienced body perception at the lumbopelvic area and psychosocial factors among pregnant women. In this way, the relationship between alterations in body perception and psychosocial factors including fear of movement and pain-related fear, fear-avoidance beliefs, catastrophising, coping strategies, and psychological factors such as depression, anxiety and stress could be investigated. Moreover, the potential correlation between body perception and psychosocial factors also considered the difference at two time points, namely trimester one and three, as well as the presence or absence of PLBP in pregnant women.

The hypotheses of these objectives were as follows: we expected a decrease in experienced body perception at the lumbopelvic area in pregnant women with PLBP compared to pregnant women without this type of pain during the third trimester of pregnancy. Moreover, more disruptions in body perception at the lumbopelvic area were expected in trimester three of pregnancy compared to trimester one. In addition, it was hypothesized that women

experiencing either PLBP or LBP (regardless of being pregnant or not) as well as pregnant women (regardless of the presence or absence of pain) would have more disturbances in perceived body perception at the lumbopelvic region compared to pain-free women and non-pregnant women, respectively. Lastly, it was expected that more disturbances in psychosocial factors were associated with greater disruptions in experienced body perception at the lumbopelvic area in pregnant women. The researchers expected that the potential correlations between psychosocial factors and disturbances in body perception among pregnant women would be more present in the third trimester of pregnancy (compared to the first trimester) and more prevalent in pregnant women with PLBP (compared to the absence of PLBP).

Table 1

Aims and corresponding hypotheses

Outcome measures		Aims		Hypotheses	
		Participants with and without PLBP	Participants with or without pain (either PLBP or LBP)	Participants with and without PLBP	Participants with or without pain (either PLBP or LBP)
Primary outcome measures	Recognise Back App	- Difference in body perception between PW with and without PLBP in T3	- Difference in body perception between participants with PLBP or LBP and without PLBP or LBP - Difference in body perception between PW and non-PW	- Decreased body perception in PW with PLBP compared to PW without PLBP	- Decreased body perception in participants with PLBP or LBP compared to participants without PLBP or LBP - Decreased body perception in PW compared to non-PW
	FreBAQ	- Difference in body perception within (T1 versus T3) and between (with and without PLBP) PW	n/a	- Decreased body perception in PW with PLBP compared to PW without PLBP - Decreased body perception in T3 compared to T1	n/a
Secondary outcome measures (psychosocial factors including TSK, FABQ, PCS, PCI, TPDS and DASS-21)		- Effect of 1) time (T1 versus T3), 2) the presence of PLBP (yes or no), and 3) psychosocial factors on body perception - Interactions and correlations between psychosocial factors and time (T1 versus T3) or the presence of PLBP (yes or no)	n/a	- Disturbances in body perception more visible in T3 compared to T1 (separate effect of each model) - Disturbances in body perception more visible in PW with PLBP compared to PW without PLBP (separate effect of each model) - More disturbances in psychosocial factors associated with greater disruption in body perception	n/a

FreBAQ – Fremantle Back Awareness Questionnaire, TSK – Tampa Scale for Kinesiophobia, FABQ – Fear-Avoidance Beliefs Questionnaire, PCS – Pain Catastrophizing Scale, PCI – Pain Coping Inventory, TPDS – Tilburg Pregnancy Distress Scale, DASS-21 – Depression Anxiety Stress Scale, PW – Pregnant Women, Non-PW – Non-pregnant women, PLBP – pregnancy-related lumbopelvic pain, LBP – Low Back Pain, T1 – trimester one, T3 – trimester three, n/a – not applicable

3.2. Research design

In order to investigate the objectives of this research among pregnant individuals (with or without PLBP), an exploratory longitudinal research design was used. The study incorporated two comprehensive measurements, one in the first trimester of pregnancy (gestational week 9-14) and one in the third trimester of pregnancy (gestational week 32-36). Additionally, the investigation of the external dataset involved a cross-sectional design comparing body perception at the lumbopelvic area between non-pregnant women experiencing LBP on the one hand and a healthy (non-pregnant) control group on the other hand. In this way, all primary research aims of the current study could be analysed and explored.

3.3. Medical ethics

All the nine included pregnant participants voluntarily cooperated in the research and signed the informed consent. Approval for the research (with inclusion of the informed consent document) was obtained from the Medical Ethics Committee of the UHasselt (ZOL: B371201942396 and Clinicaltrials.gov: NCT04226716). In addition, the Ethics Committee Jessa Hospital validated the research of the external (non-pregnant) dataset (Jessa Hospital: B243201836858).

3.4. Sample size and recruitment

The initial goal of the research was to recruit 140 multiparous women who are pregnant of their (more than) second child. The majority of investigations within the topic ‘pregnancy’, do not distinguish between primiparous and multiparous women. Therefore, the focus of this study is on multiparous women exclusively.

The recruitment of the multiparous women occurred by advertisements within several clinical settings such as the consulting rooms of general practitioners, gynaecological departments in hospitals, private midwife practices and private physiotherapy practices. Due to the COVID-19 situation, the sample size of this research diminished to the inclusion of only nine participants.

Since this was a limited sample size, participants from a parallel ongoing research project were included. Within this project, body perception was evaluated among non-pregnant participants who experienced chronic LBP or not. By incorporating this parallel research project, the sample size has a further inclusion of 16 participants.

When a participant was found to be eligible, following the inclusion and exclusion criteria (3.5. Participants), she was invited for the first test session which took place at the REVAL Rehabilitation Research Center (UHasselt, Diepenbeek). This first test session took place during the first trimester of pregnancy between gestational week 9-14. The following test session were scheduled during the third trimester of pregnancy (between gestational week 32-36).

3.5. Participants

3.5.1. Inclusion criteria

Participants were included in this research when they met the following inclusion criteria: (1) aged between 18-40 years old, (2) singleton pregnancy, (3) pregnant of their (more than) second child, (4) willing to sign an informed consent form.

3.5.2. Exclusion criteria

In case the participant did not meet the inclusion criteria or fulfilled one of the exclusion criteria, the participant was excluded from the research. The following exclusion criteria were implemented to the participants: (1) pregnant for more than 14 weeks, (2) history of surgery or major trauma to the spine, pelvis and/or lower limbs, (3) experiencing specific balance or vestibular disorders, (4) spinal deformities, (5) rheumatic disease, (6) neurological abnormalities (e.g. peripheral neuropathy), (7) uncorrected visual problems, (8) hyperemesis gravidarum, (9) acute ankle problems, (10) pre-existing disorders that could interfere with the course of pregnancy (e.g. hypertension, kidney disease, coagulation disorders), (11) (a history of) psychiatric disorders (identified with the Structured Clinical Interview for DSM-5 (SCID-5), and (12) non-Dutch speaking.

3.5.3. Inclusion and exclusion criteria of the external dataset (experiencing LBP or not)

As described in the section 3.4. Sample size and recruitment, the current investigation was enhanced in its sample size by the inclusion of several participants from a parallel ongoing research project which investigated the possible correlation between experienced body perception and LBP. The inclusion and exclusion criteria of this investigation are listed below (Table 2) for background information.

Table 2

Inclusion and exclusion criteria of the external dataset

General inclusion criteria	General exclusion criteria	Specific inclusion criteria: group with LBP	Specific exclusion criteria: healthy group (no LBP)
- Age: 18-65 years old - Sufficient knowledge of Dutch (written and spoken)	- History of surgery in the spine - Specific LBP (with inclusion disco-radicular conflict) - Underlying serious condition (e.g. MS, Cerebrovascular Accident, CRPS) - During the past year: treatment for sensorimotor control at the level of the lumbar spine - Previous experience with the left-right discrimination tool	- Chronic non-specific LBP (> 3 months at least 3 days/week)	- Self-reported LBP in the past year

LBP – Low Back Pain, MS – multiple sclerosis, CRPS – Chronic Regional Pain Syndrome

3.5.4. Anthropometric data

During the first test session, the height (expressed in centimetres) of each participant was questioned together with the pre-pregnancy body weight (expressed in kilograms). Based on these two data, it was possible to calculate the Body Mass Index (BMI) (expressed in kilogram/meter^2) of each participant. In this first test session, the maternal age and education level were also noted. During the following test session, the current bodyweight of the participants at that moment was measured. In this way, the BMI was calculated during each test session. Concerning the non-pregnant participants of the external dataset, education level, age, BMI and gender were considered in this research. Specifically, these non-pregnant participants were demographically matched with the pregnant participants based on education level, age and gender.

3.5.5. Sociodemographic information and information about lifestyle

Regarding the sociodemographic and lifestyle information, the following elements of the pregnant participants were investigated during the first test session (trimester one of pregnancy): (1) number of pregnancies, child-births and miscarriages, (2) marital status, (3) monthly household income, and (4) history of pelvic low back pain (yes-no). Furthermore, during each test session (trimester one and trimester three) four additional topics were assessed namely, the job status of the participants, their involvement in physical activity, a

subjective assessment of sleep quality and lastly, the functional status of the participants. Each of these four topics will be described in this section.

The first topic consisted of determining the job status of the participants. The participants were asked to choose an option that applied to their employment status, i.e. working full-time, working part-time or on sick leave. In the case of sick leave, additional information was obtained concerning the cause. Specifically, participants were questioned whether the reason for sick leave was pregnancy-related or not.

Secondly, the pregnant women were questioned about whether or not they performed some type of physical activity (yes/less than recommended/no). Specifications concerning the three response options were defined as follows: the answer 'yes' deemed that the participants reached the recommendations of at least 150 minutes per week at moderate to vigorous aerobic intensity (Ferrari & Graf, 2017). The option 'less physically active than recommended' implied that the participants were less physically active than the required 150 minutes per week. And finally, the option 'no physical activity' was considered when no amount of sport was performed. When the latter option was applicable, additional information was requested about the reason for inactivity.

The third topic questioned the subjective quality of sleep with the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1988). The PSQI has a scoring range between zero and 21, with a higher score reflecting more disturbance in sleep quality. The current study also implemented the cut-off score of this questionnaire, namely a score higher than five indicating poor sleep quality (Buysse et al., 1988).

Lastly, the Dutch version of the Modified Low Back Pain Disability Questionnaire (MDQ) (Fritz & Irrgang, 2001) for the evaluation of disability due to lumbopelvic pain together with the Dutch version of the Quebec Back Pain Disability Scale (QBPDS) (Kopec et al., 1996) in an adjusted version (i.e. ‘Back pain and pelvic pain’ instead of ‘Back pain’ only) were used to assess the functional status of the pregnant participants. The MDQ assesses ten items and focuses on different elements of functioning: pain severity, lifting, sitting, standing, walking, sleeping, personal hygiene, social life, traveling, and employment/homemaking. Each item is scored from zero to five, where zero = no limitations, five = maximum limitations. The MDQ has a maximum score of 50 and is multiplied by two to obtain a percentage. A higher score

therefore indicates more limitations in functioning (Denteneer et al., 2018). The Dutch version of this questionnaire (MDQ) shows excellent test-retest reliability and good construct validity (Denteneer et al., 2018). Similar are the clinimetrics of the QBPDS which has high test-retest reliability and construct validity (Schoppink et al., 1996). The latter evaluates 20 items covering different aspects of functioning in daily life. Each item is scored from zero (not difficult) to five (not possible to perform), allowing a maximum score of 100 (Schoppink et al., 1996).

3.6. Outcome measures

3.6.1. Primary outcome measures

3.6.1.1. Body perception at the lumbar spine

Body perception at the lumbar spine was evaluated based on two different test items namely, the Recognise Back App and the Dutch version of the Fremantle Back Awareness Questionnaire (FreBAQ). The Recognise Back App objectively assesses both laterality recognition and motor imagery specifically at the level of the lumbar spine and was applied in both pregnant participants as well as non-pregnant participants. The FreBAQ is a subjective questionnaire that assesses self-reported body perception at the lumbopelvic region and was solely administered in pregnant women. A detailed description of both measurement tools is given below.

The Recognise Back App (Neuro-Orthopaedic Institute, Australia) is a measurement to evaluate laterality recognition which forms a factor that contributes to the integrity of the postural body schema (Wand et al., 2017). It is an application on a tablet device and is used for the assessment of lumbar left-right judgement accuracy and speed. The participants were positioned on a desk in a comfortable position with both hands placed on the desk. The tablet device was placed vertically and centred to the midline of the participant. Pictures of an individual that bent or rotated his/her trunk to either the left or right side were shown on the tablet device for maximally seven seconds. The participants were instructed to select the left or right button as fast and accurately as possible depending on how they thought the individual on the image was moving. The left-right judgement was performed using two components, namely vanilla as well as context. When the vanilla component was conducted, subjects were shown pictures with a neutral background, whereas in context, pictures were shown of individuals performing a specific activity from daily life. In order to make the

participants more familiar with the application, a practice trial was completed by displaying ten practice images. These data were not saved. Thereafter, the participants completed a set of 40 images. The accuracy (in %) and response time (in seconds) in both conditions (vanilla and context) from each participant were recorded. The interpretation of the scores implied that a lower percentage on accuracy and a slower response time to perform the task were associated with more disturbance in body perception.

Recently, Williams et al. (2019) investigated the reliability and validity of the Recognise Back App. They assessed these elements for images of the back, feet, hands, and neck. The essence of this study was to evaluate body perception at the level of the lumbar spine, which meant that only pictures of the back were presented to the participants. The Recognise Back App on a mobile tablet exhibits good concurrent validity for images of the back and has good to excellent test-retest reliability. However, these results were found in a healthy population. This means that further research is needed to draw conclusions about the validity and reliability in specific populations, such as persons with lumbopelvic complaints.

Due to the COVID-19 situation and lockdown, five out of nine participants were not allowed to be physically present at the first test session during their first trimester of pregnancy. Instead of a physical test moment, a substitute phone call was planned. Because the Recognise Back App is an application on a tablet device, this test could not be performed by these five participants during their first test session. Therefore, the data from the first trimester were not included in the statistical analysis nor the investigation. During the second test session, these data were collected from eight out of nine participants included in the research. One participant preferred not to be physically present in the Rehabilitation Research Center during both test sessions because of COVID-19.

The FreBAQ is at present the only self-report questionnaire evaluating back-specific body perception in patients experiencing LBP (Wand et al., 2014). The questionnaire comprises nine different items, to which the participant needs to respond with: never (0), rarely (1), occasionally (2), often (3) or always (4). The items examine neglect-like signs (item 1-3), diminished proprioceptive acuity (item 4-5) and altered back symmetry as well as disrupted sensation in form and size (item 6-9) (Janssens et al., 2017). The maximum score for this questionnaire is 36, with a higher score indicating more disturbance in body perception. In addition, there is consistent evidence of a significant correlation between the FreBAQ scores

and the clinical status of patients who exhibit a different clinical image of lumbopelvic pain (Beales et al., 2016; Wand et al., 2014; Wand et al., 2016, Wand et al., 2017).

The Dutch version of the FreBAQ exhibits adequate internal consistency, sufficient test-retest reliability, and adequate discriminant and construct validity in both individuals experiencing LBP as well as healthy controls (Janssens et al., 2017). Therefore, the Dutch version of the FreBAQ was implemented in this research and data of all nine participants were collected during each test session.

3.6.1.2. Pregnancy-related lumbopelvic pain (PLBP) or low back pain (LBP)

The presence of PLBP among the nine pregnant women was measured by self-reported complaints concerning their lower back and/or pelvis. This implied that participants answered 'yes' or 'no' when asked about the presence of complaints in these areas. Pain experienced between the 12th rib and gluteal fold was recognised as LBP (Gutke et al., 2015; Wu et al., 2014), while PGP was considered when participants experienced pain between the posterior iliac crest and the gluteal fold, specifically in the area of the SIJ (Gutke et al., 2015; Wu et al., 2014).

Regarding the 16 non-pregnant participants of the external dataset, individuals were included in the research when they met the below mentioned definition of chronic LBP. Chronic LBP was defined as non-specific LBP which had been in existence for more than three months and occurred on at least three days per week.

3.6.2. Secondary outcome measures

3.6.2.1. Psychosocial factors

During each test session, a combination of six questionnaires involving various psychosocial factors were collected. Each of these six questionnaires were in Dutch. The main topics that are surveyed within the questionnaires include both cognitive as well as affective maladaptive pain beliefs. These psychosocial factors account for the secondary outcome measures of this research. Therefore, this study explored secondary if there was a potential connection between altered body perception on the one hand and the psychosocial factors on the other hand. The specification of these psychosocial questionnaires is listed below and can be divided

into three major topics namely, kinesiophobia and the associated beliefs, coping mechanisms, and psychological factors.

3.6.2.2. Kinesiophobia and the associated beliefs

The Dutch version of the Tampa Scale for Kinesiophobia (TSK) (Miller, Kori, & Todd, 1991) was used to measure fear of movement and pain-related fear. The TSK is a 17-item self-reported questionnaire carried out using a four-point Likert scale (one = strongly disagree; four = strongly agree) with a total score ranging from 17 to 68. In 1995, Vlaeyen, Kole-Snijders, Boeren & Van Eek identified a cut-off score of 37, with scores exceeding this value suggesting an increased level of fear of movement or (re)injury. Goubert et al. (2000) investigated the psychometric characteristics of the Dutch version of the TSK. Results showed that this version has a good internal consistency and can be considered valid. Regarding the test-retest reliability, further research is needed due to the limited data available. Because of these findings, the Dutch version of the TSK can be an important tool in detecting fear of movement in patients with low back pain.

The Dutch version of the Fear-Avoidance Beliefs Questionnaire (FABQ) (Vendrig, Deutz, & Vink, 1998) assessed the associated fear-avoidance beliefs of the participants. This questionnaire (FABQ-total) is divided into two subscales, one that evaluates fear-avoidance beliefs about work-related activities (FABQ-W) and a second subscale observing fear-avoidance beliefs about physical activities (FABQ-PA). The FABQ-W (range: 0-42) contains seven items, whereas four items are scored on the FABQ-PA (range: 0-24). Each item is subsequently scored on a seven-point Likert scale with a variation from zero (strongly disagree) to six (strongly agree) with a higher score representing more fear-avoidance beliefs according to the different scales (FABQ-total, FABQ-W, and FABQ-PA) (Swinkels-Meewisse, Swinkels, Verbeek, Vlaeyen, & Oostdorp, 2003).

In the same line as the previous questionnaires, the Dutch version of the Pain Catastrophizing Scale (PCS) (Sullivan & Bishop, 1995) was applied to evaluate catastrophic thinking related to pain and the individuals' pain perception. The Dutch version of the PCS consists, like the English version, of 13 items. Each item is scored on a five-point scale, where zero means 'not at all applicable' and four means 'always applicable'. The total score is then calculated with a maximum score of 52, with a higher score implying more catastrophic thinking (Van Damme

et al., 2000). In 2000, Van Damme et al. also described the available literature regarding the reliability and validity of the Dutch version of the PCS. The studies showed good internal consistency in chronic low back pain patients, as well as evidence of concurrent validity in this population (Crombez, Vlaeyen, Heuts, & Lysens, 1999; Crombez et al., 2002).

3.6.2.3. Coping mechanisms

The Dutch Pain Coping Inventory (PCI) (Kraaimaat, Bakker, & Evers, 1997) was completed by the participants to analyse their coping strategies specifically related to pain. The PCI includes 33 items divided into six topics that capture both cognitive and behavioural pain coping strategies representing active and passive coping dimensions. Each item is scored on a four-point Likert scale (whereby 1 indicates 'almost never' and 4 'very often') in terms of frequency with which strategies are adopted in coping with pain (Kraaimaat, 1997). Specifically, after adding up the scores for each coping strategy (active or passive), percentages can be calculated which indicate the most frequently applied coping strategy of the participant.

3.6.2.4. Psychological factors

Two out of six questionnaires focused on psychological factors. Some specifically concentrated on one single item, while others questioned multiple facets. Depression, stress, and anxiety are the three most frequently addressed items in the below-mentioned questionnaires but each of them concentrated on a different construct.

First, the Dutch Tilburg Pregnancy Distress Scale (TPDS) (Pop et al., 2011) was implemented in the current study to evaluate pregnancy-specific stress. During the development of the tool by Pop et al. (2011), the researchers also examined the psychometric variables and concluded that the instrument is valid and user-friendly but further investigation towards the implementation into clinical practice is necessary. Pregnancy-specific stress was measured by responses to a four-point Likert scale with total scores (TPDS-total) ranging from zero to 48 and a higher score indicating greater levels of maternal distress. The TPDS-total consists of two items, namely one subscale for the assessment of negative affect (TPDS-NA) and one for the evaluation of partner involvement (TPDS-PI) in pregnant women. The total subscale score of TPDS-NA (11 items) varies between zero and 33 and between zero and 15 for the scores of TPDS-PI (5 items). Similar to TPDS-total, higher scores on TPDS-NA and TPDS-PI indicate higher

levels of negative affect and reduced partner involvement, respectively (Boekhorst, Beerthuizen, Van Son, Bergink, Pop, 2020; Pop et al., 2011).

The Dutch version of the 21-item Depression Anxiety Stress Scale (DASS-21) (Lovibond & Lovibond, 1995) is a shortened version of the DASS-42 and investigates three subscales, namely depression, anxiety, and stress in general. The DASS-21 consists of 21 items, including seven items for each subscale. Each subscale is scored on a four-point Likert scale where zero means 'not at all or never applicable' and three signifies 'very definitely applicable'. The scores on each subscale are subsequently added up to obtain a total score, with a higher score representing more depression, anxiety, or stress (De Beurs, Van Dyck, Marquenie, Lange, & Blonk, 2001). Regarding the clinimetrics, both the internal consistency and test-retest reliability were found to be adequate (De Beurs et al., 2001).

3.7. Data analysis

In general, for outcome measures analysed by using the Repeated Measures Mixed Effect Model (Laird & Ware, 1982), the optimal scores on the Akaike Information Criterion (AIC) (Akaike, 1974) and Bayesian Information Criterion (BIC) (Schwarz, 1978) were used to decide whether or not to include certain interactions in the analyses. The model with the lowest scores on the AIC and BIC were considered as the strongest model and therefore used to interpret the findings in section 4. Results. Additionally, no normality tests were conducted in the Repeated Measures Mixed Effect Model due to the small sample size in the current study. The remaining statistical tests (one-sample t-test, Signed-rank test, Wilcoxon Rank-Sum test, and two-sample exact test) were determined based on normality and homoscedasticity of the data. To perform all statistical analyses, JMP PRO 15.2 (SAS Institute Japan, Tokyo, Japan) was used. Statistical significance was set at $P \leq 0.05$ for interpreting all statistical results.

3.7.1. Data analysis anthropometric data

Differences in anthropometric data between the participants with and without PLBP on the one hand and the participants with and without LBP on the other hand were compared. This data concerned the age for which the differences in both groups were assessed using two non-parametrical tests, namely the Wilcoxon Rank-sum test (Wilcoxon, 1945) and 2-sample exact test (Student, 1908). These two non-parametrical tests were determined using the Shapiro-

Wilk test (Shapiro & Wilk, 1965) for normality and Brown-Forsythe test for homoscedasticity (Brown & Forsythe, 1974).

3.7.2 Data analysis sociodemographic information and information about lifestyle

To assess the changes in sociodemographic information and information about lifestyle between the first and third trimester of pregnancy, the Signed-rank test (Wilcoxon, 1945) and one-sample t-test (Student, 1908) were used. To determine these two statistical tests, normality was checked and achieved among the three questionnaires namely, the PSQI, MDQ and QBPDS.

3.7.2. Data analysis primary outcome measures

A distinction can be made between statistics used to evaluate body perception with the Recognise Back App on the one hand and the FreBAQ on the other hand. Both are discussed below.

The statistics of the Recognise Back App were performed firstly to evaluate the alterations in body perception at the lumbopelvic area between pregnant women with and without PLBP in the third trimester of pregnancy. Therefore, two non-parametric tests, namely the Wilcoxon Rank-Sum test and the two-sample exact test were performed. These two non-parametric tests were determined by conducting the Shapiro-Wilk test for normality and the Brown-Forsythe test for homoscedasticity. Secondly, data from the Recognise Back App were applied to analyse the changes in body perception by involving the external dataset. Due to the results of normality and homoscedasticity, statistical analyses of both objectives were performed using the Wilcoxon Rank-Sum test. The results with corresponding p-values are discussed in section 4.3. Normality tests of the data were interpreted by using the Shapiro-Wilk test, while homoscedasticity was again assessed using the Brown-Forsythe test.

The data obtained from the FreBAQ were implemented in order to evaluate the differences in body perception between the first and third trimester of pregnancy (within-group factor) and between pregnant women experiencing PLBP or not (between-group factor). To conduct and interpret these statistical analyses, a Repeated Measures Mixed Effect Model was used. The model did not contain the interaction between the two factors due to the reduced power, based on the AIC and BIC scores, by adding this interaction. Instead, they were evaluated separately within the model to analyse the effect on the FreBAQ.

3.7.3. Data analysis secondary outcome measures

The secondary outcome measures were administered in the present study and in both trimester one and three of pregnancy. Therefore, the data recorded by the FreBAQ were used to evaluate the changes in body perception at the lumbopelvic area between both trimesters of pregnancy.

Regarding the secondary outcome measures, a Repeated Measures Mixed Model was conducted to determine (1) the effects of time (trimester one versus trimester three), (2) the presence of PLBP (yes or no), (3) the psychosocial factors as well as (4) interactions between the effect of time or the presence of PLBP and psychosocial factors on body perception at the lumbopelvic area. To determine the complete statistical model of each secondary outcome measure, the most appropriate AIC and BIC codes were implemented to either include or exclude certain interactions within the model. In addition, Spearman's Correlation was performed to establish possible associations between the experienced body perception at the lumbopelvic area and the psychosocial factors among the pregnant participants. The non-parametric Spearman rank correlation coefficient was used due to the non-normally distributed data of the FreBAQ.

4. Results

4.1. Results anthropometric data

In this section, anthropometric data from both the current (pregnant women with or without PLBP) and parallel research (non-pregnant women with or without chronic LBP) will be discussed. Regarding the level of education, only one out of nine pregnant women is low educated. Consequently, one participant from the external dataset was matched at this level of education. Furthermore, the average age of the pregnant women with or without PLBP was 30 years and demographic linking by age resulted as well in a mean age of 30 years in the non-pregnant group with or without chronic LBP. Statistical analyses showed no significant differences between these two groups in terms of age ($p = 0.5480$) (Table 3).

In addition, the pregnant women had an average height of 168cm (range: 158-179 cm) and weighed 67.3 kg before pregnancy (range: 53-93 kg). BMI data shows a transfer from an average of 24.6 kg/m^2 in the first trimester of pregnancy to 28 kg/m^2 in the third trimester. The averages and standard deviations of these data are considered in detail in Table 3.

Table 3

Means and ± standard deviations (and associated range) of anthropometric data

Anthropometric data	Participants with and without PLBP (n=9)	Participants with and without LBP (n=16)	Differences between both groups (with and without PLBP – with and without LBP)
Height (cm)	168 ± 7.1 (Range: 158-179)	Data not available	n/a
Pre-pregnancy bodyweight (kg)	67.3 ± 11.8 (Range: 53-93)	Data not available	n/a
BMI T1 (kg/m^2)	24.6 ± 4.3 (Range: 21-32.8)	n/a	n/a
BMI (T3) (kg/m^2)	28 ± 4.6 (Range: 23.6-37.6)	21.8 ± 2.8 (Range: 18.6-28.4)	n/a
Age (yrs)	30 ± 1.6 (Range: 28.7-33.5)	30 ± 1.8 (Range: 27-33)	p = 0.5480

Cm – centimetres, kg – kilograms, BMI – Body Mass Index, kg/m^2 – kilogram/meter^2, T1 – trimester one, T3 – trimester three, yrs – years, PLBP – pregnancy-related lumbopelvic pain, LBP – low back pain, n/a – not applicable

4.2. Results sociodemographic information and information about lifestyle

Eight out of nine women had already given birth once, meaning they were expecting their second child when they participated in this study. The remaining participant had already experienced three pregnancies with two deliveries and one miscarriage. Furthermore, all pregnant women were living with their partners at the time of the measurement. In terms of monthly income, six households had an income between 3000 and 4999 euros, while the other households earned over 5000 euros per month. Lastly, the results about the history of PLBP showed that already seven participants had experienced this type of pain during a previous pregnancy.

A complete overview of the results concerning the employment status, physical activity, sleep quality, and disability due to lumbopelvic pain in the first and third trimester of pregnancy is given in Table 4. Each item is discussed briefly and separately below.

In trimester one of pregnancy, seven out of nine pregnant women worked full-time, while the remaining two were in part-time employment. These two pregnant women went on sick leave in trimester three of pregnancy because of different reasons. One experienced early contractions and went on prenatal leave, while the other pregnant women suffered from PLBP, dizziness, and low physical capacity.

Secondly, results concerning physical activity in the first trimester of pregnancy showed that three participants achieved the recommendations of being physically active for 150 minutes per week. In contrast, three out of nine pregnant women were less physically active than required and another three women answered 'no' when asked if they performed any type of physical activity. The reasons for their physical inactivity were mainly time issues and nausea as well as the fact that exercising was no longer possible due to the COVID-19 situation. In the third trimester of pregnancy, four women did not perform any physical activity with time constraints, low physical capacity, early contractions, varicose veins, and high levels of pregnancy-related lumbopelvic pain as the main reasons for their physical inactivity.

Thirdly, the PSQI details were as follows: in the first trimester of pregnancy, five women scored above the cut-off score of five, which implied that these women were suffering from poor sleep quality. Furthermore, the scores on the PSQI in the first trimester varied between three and ten on a total score of 21. In the third trimester of pregnancy, the number of participants increased to six women experiencing poor sleep quality. However, no significant differences between the first and third trimester of pregnancy were found in terms of sleep quality (t-test: $p = 0.1789$, Signed Rank-test: $p = 0.2188$).

Fourthly, the MDQ scores in the first trimester of pregnancy varied between zero and ten percent, suggesting that the participants did not experience many problems in functioning during this trimester. During the third trimester of pregnancy, small changes in percentages were observed with scores ranging between zero and 32 percent. The difference in disability due to lumbopelvic pain between trimester one and trimester three of pregnancy could also be statistically determined (t-test: $p = 0.0241$, Signed-rank test: $p = 0.0313$). These results imply that significantly more disability due to lumbopelvic pain is experienced in the third trimester of pregnancy compared to the first.

Finally, regarding the data of the QBPDS, the scores measured during the first test session ranged between zero and 18 on a maximum score of 100. During this first test session, two pregnant women had complaints of PLBP and scored eight and 18 on this questionnaire, while the scores of the remaining seven pregnant women without pain complaints ranged between zero and 11. In contrast, more women experienced difficulties in functioning in the third trimester of pregnancy according to their results on the QBPDS. The results in this trimester of pregnancy ranged between three and 59, which is substantially higher than the scores in

the first trimester. This difference between the two trimesters of pregnancy was also statistically identified with p-values of 0.0041 (t-test) and 0.0078 (Signed-rank test).

Table 4

Results sociodemographic information and information about lifestyle

Sociodemographic information and information about lifestyle		**Number of participants in T1**	**Number of participants in T3**	**P-values (differences between T1 and T3)**	
Employment status	Full-time	7	6	n/a	
	Part-time	2	1	n/a	
	Sick leave	0	2	n/a	
Physical activity: achieving the recommendations of 150min/week	Yes	3	2	n/a	
	Less than recommended	3	3	n/a	
	No	3	4	n/a	
		Questionnaire score in T1 Means ± Standard deviations (Range)	**Questionnaire score in T3 Means ± Standard deviations (Range)**	**T-test**	**Signed-rank test**
PSQI (0-21)		6 ± 2.4 (Range: 3-10)	7.2 ± 2.6 (Range: 5-13)	p = 0.1789	p = 0.2188
MDQ (0-50)		2.4 ± 3.3 (Range: 0-10)	13.1 ± 12.7 (Range: 0-32)	**p = 0.0241**	**p = 0.0313**
QBPDS (0-100)		7.6 ± 5.1 (Range: 0-18)	31 ± 21.5 (Range: 3-59)	**p = 0.0041**	**p = 0.0078**

Significant results are indicated in bold with $p \leq 0.05$. T1– trimester one, T3 – trimester three, PSQI – Pittsburgh Sleep Quality Index, MDQ – Modified Low Back Pain Disability Questionnaire, QBPDS – Quebec Back Pain Disability Scale, n/a – not applicable

4.3. Results primary outcome measures

Due to the normal distribution and equal variances of the data from the Recognise Back App in the third trimester of pregnancy, the Wilcoxon Rank-Sum test and two-sample exact test could be conducted. After performing these two non-parametric tests, the results showed there were no significant differences in body perception between pregnant women with and without PLBP in the third trimester of pregnancy ($p > 0.05$). The specification of these results with corresponding p-values can be found in Table 5 and Figure 1 and 2.

Additional results, measured with the Recognise Back App, were observed according to the two analyses using the external dataset (3.1. Research aims and hypotheses). Regarding the assumptions, one non-normal distribution was observed in each of the two different analyses, namely vanilla mean speed in the non-painful condition within the first analysis (verified with Shapiro-Wilk test: $p = 0.0255$) and non-pregnant condition within the second analysis (verified with Shapiro-Wilk test: $p = 0.0060$). However, equal variances (verified with Brown-Forsythe test: **painful condition:** vanilla mean speed: $p = 0.5271$, vanilla mean accuracy: $p = 0.4391$, context mean speed: $p = 0.9714$, context mean accuracy: $p = 0.8556$; **pregnant condition:** vanilla mean speed: $p = 0.4991$, vanilla mean accuracy: $p = 0.2752$, context mean speed: $p = 0.4067$, context mean accuracy: $p = 0.1856$) were found which resulted in the use of the Wilcoxon-signed Rank test to interpret the results. These findings are explained below for each analysis.

The first analysis focused on identifying changes in body perception between a painful and non-painful condition. Results from the Recognise Back App showed no significant differences between a painful and non-painful condition among the different factors of body perception, i.e. vanilla mean speed ($p = 0.3790$), vanilla mean accuracy ($p = 0.2219$), context mean speed ($p = 0.3465$), and context mean accuracy ($p = 0.3042$). Specifically, this implied there is no significant difference in body perception at the lumbopelvic area between women (pregnant or not) experiencing pain complaints (either PLBP or LBP) and women (either pregnant or not) without pain complaints (either PLBP or LBP). An overview of these findings with corresponding p-values is provided in Table 5 and Figure 1 and 2.

Secondly, the aim was to evaluate the difference in body perception between pregnant and non-pregnant women without considering the presence or absence of a painful condition

(PLBP or LBP). The main finding showed a significant difference between these groups for context mean accuracy ($p = 0.0140$) indicating that non-pregnant women have more disturbances in body perception at the lumbopelvic area than pregnant women. The other results of the Recognise Back App (i.e. vanilla mean speed, vanilla mean accuracy, and context mean speed) were not significantly different between these groups and are detailed in Table 5 and Figure 1 and 2.

By applying the Repeated Measures analysis to compare the first and third trimesters of pregnancy, it was found that body perception, measured with the FreBAQ, was significantly associated with the presence of PLBP ($p = 0.0484$). Specifically, this implicated, according to the hypothesis of this analysis, that pregnant women who experience PLBP have significantly more disruption in body perception at the lumbopelvic area. However, no significant differences were established between the first and third trimester of pregnancy ($p = 0.1698$), suggesting that body perception does not significantly differ between these two trimesters of pregnancy (Table 5 and Figure 3). In this analysis, the interaction of the within-group factor (trimester one versus trimester three) and between-group factor (PLBP yes or no) was not included due to the reducing effect of the model when adding this interaction (based on the AIC and BIC scores). By removing the interaction out of the model, the AIC and BIC scores were respectively 105.80567 and 105.25752, while its inclusion gave higher AIC and BIC scores namely 110.62878 and 108.33465 resulting in a diminished effect of the model.

Table 5

*Results primary outcome measures**: means ± standard deviations (p-values)***

Measurement tool for body perception		Results of participants with or without PLBP	Results of participants with or without pain (either PLBP or LBP)	
			painful versus non-painful condition	pregnant versus non-pregnant condition
Recognise Back App	Vanilla mean speed	With PLBP: 1.3 ± 0.2, without PLBP: 1.4 ± 0.3 (p = 0.4429)	Painful: 1.4 ± 0.3, non-painful: 1.4 ± 0.4 (p = 0.3790)	Pregnant: 1.4 ± 0.3, non-pregnant: 1.4 ± 0.4 (p = 0.3533)
	Vanilla mean accuracy	With PLBP: 97.5 ± 2.0, without PLBP: 97.5 ± 3.5 (p = 0.5000)	Painful: 96.9 ± 3.3, non-painful: 95.7 ± 3.8 (p = 0.2219)	Pregnant: 97.5 ± 2.7, non-pregnant: 95.5 ± 3.9 (p = 0.1156)
	Context mean speed	With PLBP: 2.3 ± 0.4, without PLBP: 2.6 ± 0.3 (p = 0.0857)	Painful: 2.6 ± 0.5, non-painful: 2.6 ± 0.6 (p = 0.3465)	Pregnant: 2.4 ± 0.4, non-pregnant: 2.7 ± 0.6, p = 0.1099
	Context mean accuracy	With PLBP: 82.5 ± 7.9, without PLBP: 80.6 ± 8.0 (p = 0.3714)	Painful: 75 ± 13.5, non-painful: 71.2 ± 15 (p = 0.3042)	Pregnant: 81.6 ± 7.4, non-pregnant: 68.1 ± 14.9 **p = 0.0140**
FreBAQ	Effect of time (T1 versus T3)	T1: 2.9 ± 2.4, T3: 7 ± 5.8 (p = 0.1698)	n/a	
	Effect of PLBP (yes or no)	With PLBP: 7.9 ± 5.5, without PLBP: 3.1 ± 3.0 **(p = 0.0484)**		

Significant results are indicated in bold with p ≤ 0.05**.** FreaBAQ – Fremantle Back Awareness Scale, PLBP – pregnancy-related lumbopelvic pain, T1 – trimester one, T3 – trimester three, n/a – not applicable

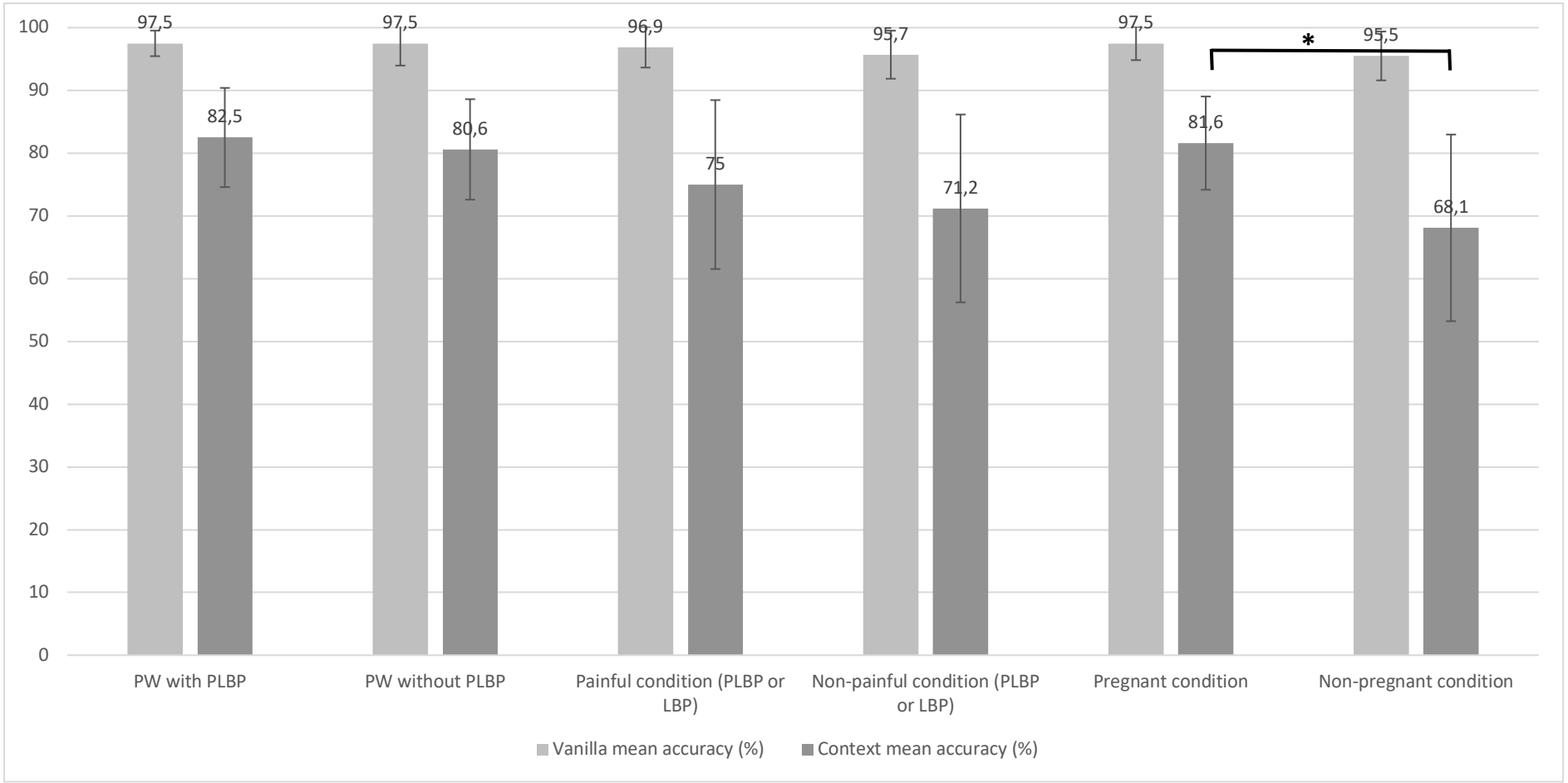

Figure 1: *Means and standard deviations of vanilla and context mean accuracy (expressed in percentages), measured with the Recognise Back App (* = significant result) (primary outcome measures)*

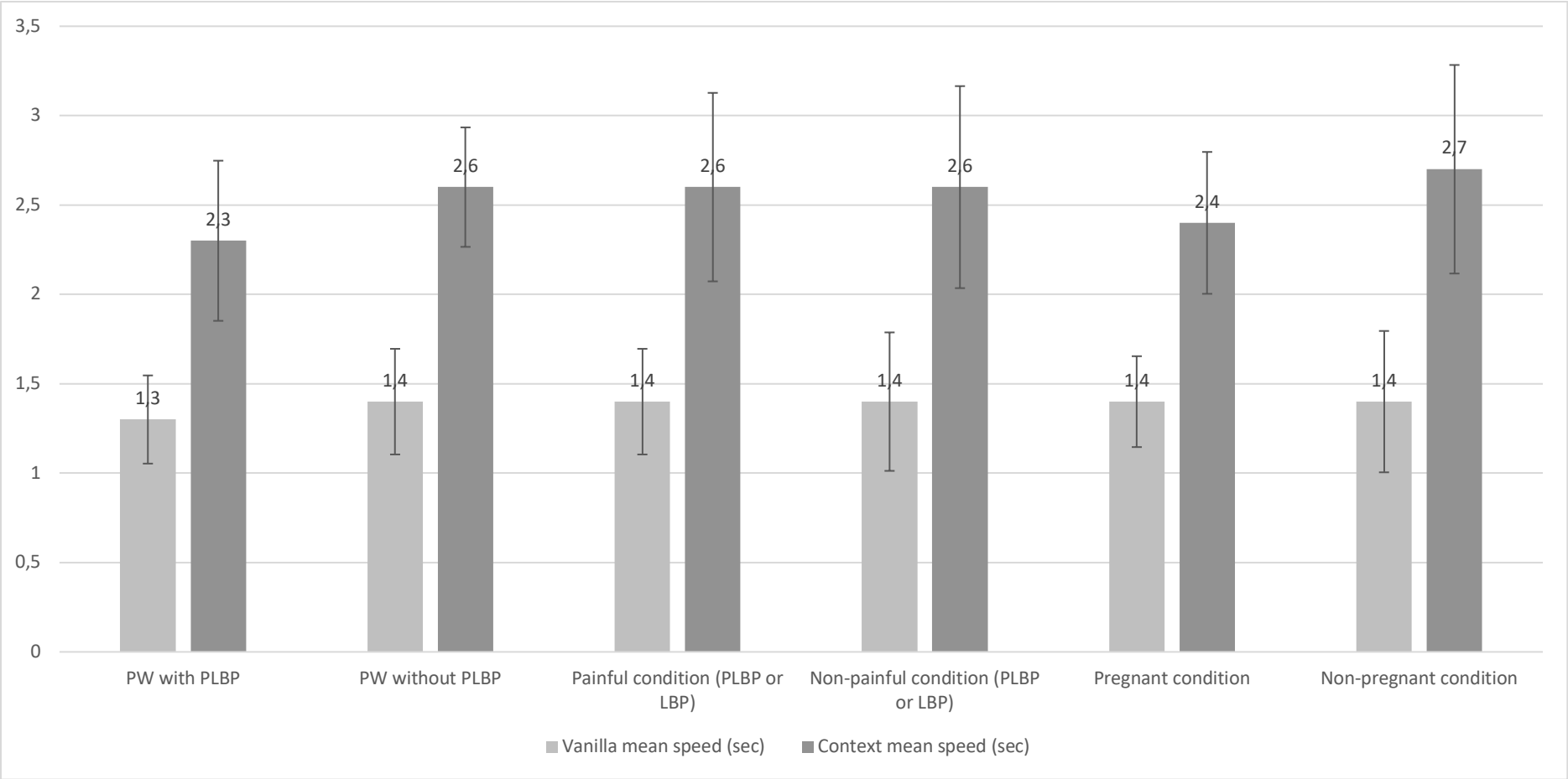

Figure 2: *Means and standard deviations of vanilla and context mean speed (expressed in seconds) measured with the Recognise Back App (primary outcome measures)*

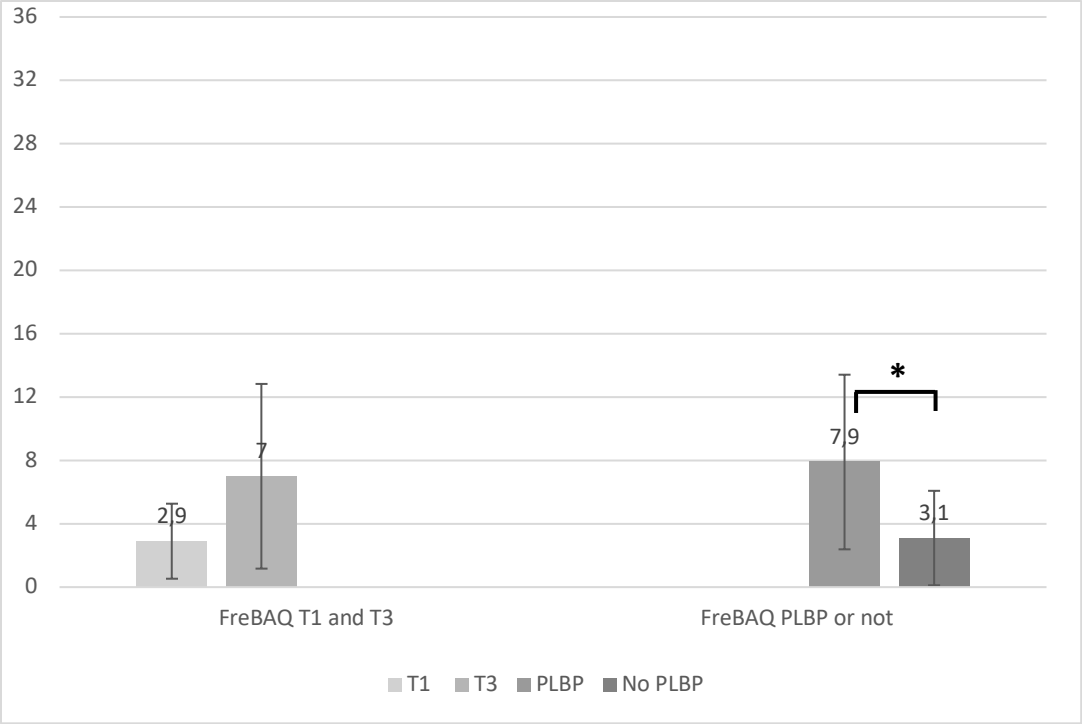

Figure 3: *Means and standard deviations of the scores on the Fremantle Back Awareness Scale (* = significant result) (primary outcome measures)*

4.4. Results secondary outcome measures

In this section, results of the psychosocial factors, which were divided into kinesiophobia and associated beliefs, coping mechanisms, and psychological factors, are individually reported. This makes it feasible to evaluate the association between psychosocial factors and body perception at the lumbopelvic area (measured with the FreBAQ). Depending on the AIC and BIC scores from the Repeated Measures Mixed Effect Models, interactions between psychosocial factors and time (trimester one versus trimester three) or presence of PLBP (yes or no) were included and described. All findings with associated p-values of the secondary outcome measures are detailed in Table 6.

4.4.1. Results kinesiophobia and the associated beliefs

The results of the TSK, which assesses fear of movement and pain-related fear, will be discussed first. These findings are interpreted according to the most appropriate model, which in this case included the interaction between the trimesters of pregnancy and the scores on the TSK. The scores on this questionnaire in the first trimester varied between 26 and 39, with three pregnant women scoring above the cut-off value of 37. In the last trimester, the number

of pregnant women scoring above the cut-off value increased to four. The statistical analysis showed a significant interaction (p = 0.0081) between fear of movement and the different trimesters of pregnancy on changes in body perception at the lumbopelvic area. This makes it possible to accept the hypothesis of this research, which indicates there is a significant correlation between experiencing more fear of movement in the third trimester of pregnancy and disruptions in body perception at the lumbopelvic region (spearman: p = 0.0286, r = 0,7204). Furthermore, a substantial significant effect (p = 0.0127) of the presence of PLBP on disturbances in body perception was discovered regarding this model. In this way, it is established that pregnant women with PLBP experience more disturbances in body perception at the lumbopelvic area. This result could not be extended to the influence of the different trimesters of pregnancy on body perception, where no significant result was found (p = 0.1086).

Secondly, the association between fear-avoidance beliefs (measured with the FABQ) and body perception could not be found with regard to the FABQ-total (spearman: p = 0.4632, r = 0.1847) and FABQ-W (spearman: p = 0.5966, r = 0.1338). In addition, there were no significant effects of time (trimester one versus trimester three), the presence of PLBP (yes or no) or the presence of fear-avoidance beliefs (FABQ-total and FABQ-W) on body perception at the lumbopelvic area. The interactions of these factors were not incorporated into the statistical analyses due to the reducing effect of the model by including them (based on AIC and BIC scores). However, when analysing fear-avoidance beliefs concerning physical activity (FABQ-PA), the interaction between the presence of PLBP (yes or no) and FABQ-PA was included due to the strength of this model. The results of this analysis showed there seems to be an indication of the effect of fear-avoidance beliefs concerning physical activity on disruptions in body perception, although this finding was not significantly established (p = 0.0507). In contrast, a significant interaction between the presence of PLBP and FABQ-PA was discovered (p = 0.0144). Therefore, the disturbances in body perception at the lumbopelvic area in pregnant women could be explained by the presence of PLBP in combination with higher levels of fear-avoidance beliefs concerning physical activity (spearman: p = 0.0026, r = 0.9274).

Regarding the results on the PCS in the first trimester of pregnancy, the scores ranged between zero and 35 whereas these findings changed to scores varying between four and 33 in the last trimester. By performing the Repeated Measures analysis, a significant (p = 0.0432)

effect of the PCS scores on alterations in body perception at the lumbopelvic area in pregnant women was found. This finding could also be supported by a significant correlation (spearman: p = 0,0032, r = 0.6552) between higher levels of pain catastrophising and more disruptions in body perception at the lumbopelvic area in a pregnant population. In contrast, no significant results could be determined regarding the effect of the different trimesters of pregnancy (p = 0.1692) and the presence of PLBP (p = 0.0570) on body perception at the lumbopelvic area within this model. Also in this Repeated Measures analysis, interactions were not considered because of the poor AIC and BIC scores by including them.

4.4.2. Results coping mechanisms

Considering the details on the PCI, eight out of nine pregnant women applied an active coping strategy in the first trimester of pregnancy, while the number of participants using an active coping strategy in the third trimester decreased to six. The remaining three women therefore used a passive strategy to cope with their pain in this last trimester of pregnancy. The analyses of the active coping strategy did not include any interacting factors, whereas the analysis of the passive strategy explored one interaction, namely the effect of the different trimesters of pregnancy and passive coping style on changes in body perception. No significant results were found regarding the effect of an active coping strategy on changes in body perception (p = 0.4939). Regarding this model a substantial effect (p = 0.0475) of PLBP on disruptions in body perception was identified, implying that pregnant women with PLBP experience more disturbances in body perception at the lumbopelvic area. Concerning the results of using a passive coping strategy, a significant (p = 0.0237) interaction between both trimesters of pregnancy and a passive coping strategy on disruptions in body perception at the lumbopelvic area was observed. Larger disturbances in body perception in the last trimester of pregnancy were therefore determined by the use of a passive coping strategy in this trimester of pregnancy (spearman: p = 0.0453, r = 0.6766). In addition, no significant effects of time (p = 0.0850) nor the presence of PLBP (p = 0.0765) on disturbances in body perception were established in the analysis of this model.

4.4.3. Results psychological factors

The results of the TPDS-NA varied in the first trimester of pregnancy between one and 14 on the maximum score of 33. These results remained relatively similar in the third trimester with

a scoring range between two and 13. Regarding the statistical analyses, no significant results ($p = 0.2063$) were found when evaluating the effect of TPDS-NA on changes in body perception. However, the separate effect of the presence of PLBP on alterations in body perception was found to be statistically significant ($p = 0.0345$). These results could be extended to the analyses of the TPDS-total where first no significant effects ($p = 0.0950$) of this questionnaire on changes in body perception were found. Secondly, a significant effect of the presence of PLBP on disruptions in body perception was identified in this model ($p = 0.0136$). Regarding the results of the TPDS-PI, a significant interaction ($p = 0.0365$) was found between the presence of PLBP (yes or no) and partner involvement (TPDS-PI) on alterations in body perception. However, no significant correlation between lower levels of partner involvement in combination with the presence of PLBP and disturbances in body perception at the lumbopelvic area was observed (spearman: $p = 0.5540$, $r = -0.2728$). In addition, the different trimesters of pregnancy had a significant influence ($p = 0.0405$) on alterations in body perception. This result makes it possible to conclude that, regarding this model, significantly more disturbances in body perception occurred in the third trimester of pregnancy compared to the first trimester.

The second item of the psychological questionnaires consisted of the assessment of depression, anxiety, and stress using the Dutch version of the DASS-21. Results from the DASS-depression ($p = 0.4113$) and DASS-stress ($p = 0.4690$) subscales showed no significant influence on changes in body perception at the lumbopelvic area. However, a significant effect ($p = 0.0499$) of anxiety levels measured with the DASS-anxiety subscale on disruptions in body perception at the lumbopelvic area was discovered. Although, no significant correlation between higher anxiety levels and alterations in body perception was found (spearman: $p = 0.3683$, $r = 0.2255$). In addition, the presence of PLBP, regarding to the Repeated Measures analysis of the DASS-anxiety, had a considerable effect ($p= 0.0086$) on body perception. This finding implied that pregnant women with PLBP experience more disturbances in body perception at the lumbopelvic area.

It is notable that the scores on the subscale DASS-stress tended to be the highest in both trimester one (Range: 0-9) and trimester three (Range: 1-11) whereas the anxiety subscale varied mostly between both trimesters of pregnancy (Range trimester one: 0-3; range

trimester three: 0-8). Finally, the scores on the DASS-depression varied between zero and four in the first trimester of pregnancy and between zero and eight in the third trimester.

Table 6

Results secondary outcome measures: means ± standard deviations (p-values)

Effects on body perception (FreBAQ)	Results of the psychosocial factors in pregnant women with and without PLBP												
	TSK	FABQ			PCS	PCI		TPDS			DASS-21		
		FABQ-total	FABQ-W	FABQ-PA		PCI-active	PCI-passive	TPDS-total	TPDS-NA	TPDS-PI	DASS-depression	DASS-stress	DASS-anxiety
Effect of time (T1 versus T3)	T1: 34.2 ± 4.9, T3: 34.6 ± 7.0 (p=0.1086)	T1: 21.4 ± 10.9, T3: 24 ± 15.2 (p=0.1786)	T1: 7.8 ± 6.3, T3: 8.6 ± 7.2 (p=0.1759	T1: 8.7 ± 4.3, T3: 10.7 ± 5.6 (p=0.4966)	T1: 11.9 ± 10.9, T3: 16.1 ± 10 (p=0.1692)	T1: 58.1 ± 10.9, T3: 56.1 ± 8.2 (p=0.1785)	T1: 47.6 ± 9.5, T3: 48.9 ± 8.3 (p=0.0850)	T1: 13.9 ± 6.2; T3: 14 ± 5.8 (p=0.2144)	T1: 8.5 ± 3.8, T3: 8.8 ± 3.0 (p=0.1791)	T1: 5.3 ± 3.1, T3: 5.2 ± 4.4 **(p=0.0405)**	T1: 0.8 ± 1.4, T3: 1.7 ± 2.6 (p=0.1964)	T1: 3.6 ± 2.8, T3: 7.1 ± 3.0 (p=0.3885)	T1: 0.9 ± 1.1, T3: 2.7 ± 2.7 (p=0.7158)
Effect of PLBP (yes or no)	Yes: 34.4 ± 7.8, No: 34.5 ± 4.8 **(p=0.0127)**	Yes: 31.1 ± 11.4, no: 17.4 ± 11.2 (p=0.0768)	Yes: 12.1 ± 5.8, no: 5.7 ± 5.7 (p=0.0783)	Yes: 11.9 ± 4.6, no: 8.3 ± 4.9 (p=0.0746)	Yes: 17.7 ± 7.2, no: 11.6 ± 11.7 (p=0.0570)	Yes: 55.1 ± 4.5, no: 58.4 ± 11.6 **(p=0.0475)**	Yes: 50.7 ± 9.4, no: 46.6 ± 8.2 (p= 0.0765)	Yes: 13.7 ± 5.7, no: 14.1 ± 6.1 **(p=0.0136)**	Yes: 8.9 ± 2.3, no: 8.5 ± 4.0 **(p=0.0345)**	Yes: 4.9 ± 4.7, no: 5.5 ± 3.2 (p=0.0877)	Yes: 2.6 ± 2.9, no: 0.5 ± 0.7 (p=0.1656)	Yes: 5.4 ± 3.7, no: 5.3 ± 3.3 (p=0.0572)	Yes: 2.4 ± 2.9, no: 1.4 ± 1.7 **(p=0.0086)**
The effect of a psychosocial factor	34.4 ± 5.9 (p=0.8386)	22.7 ± 12.9 (p=0.9354)	8.2 ± 6.5 (p=0.9006)	9.6 ± 4.9 (p=0.0507)	14 ± 10.4 **(p=0.0432)**	57.1 ± 9.4 (p=0.4939)	48.2 ± 8.6 (p=0.3853)	13.9 ± 5.8 (p=0.0950)	8.6 ± 3.3 (p=0.2063)	5.3 ± 3.7 (p=0.7121)	1.3 ± 2.1 (p=0.4113)	5.3 ± 3.3 (p=0.4690)	1.7 ± 2.2 **(p=0.0499)**
Interaction: time*psychosocial factor	**p = 0.0081**	n/a	n/a	n/a	n/a	n/a	**p = 0.0237**	n/a	n/a	n/a	n/a	n/a	n/a
Interaction: PLBP*psychosocial factor	n/a	n/a	n/a	**p = 0.0144**	n/a	n/a	n/a	n/a	n/a	**p = 0.0365**	n/a	n/a	n/a

Significant results are indicated in bold with p ≤ 0.05. FreBAQ – Fremantle Back Awareness Questionnaire, TSK – Tampa Scale for Kinesiophobia, FABQ – Fear-Avoidance Beliefs Questionnaire, FABQ-W – Fear-Avoidance Beliefs Questionnaire about work-related activities, FABQ-PA – Fear-Avoidance Beliefs Questionnaire about physical activity, PCS – Pain Catastrophizing Scale, PCI – Pain Coping Inventory, TPDS – Tilburg Pregnancy Distress Scale, TPDS-NA – Tilburg Pregnancy Distress Scale Negative Affect, TPDS-PI – Tilburg Pregnancy Distress Scale Partner Involvement, DASS-21 – Depression Anxiety Stress Scale, T1 – trimester one, T3 – trimester three, PLBP – pregnancy-related lumbopelvic pain, n/a – not applicable

5. Discussion

This exploratory longitudinal study documented **(1)** the disturbances in body perception experienced at the lumbopelvic area between pregnant women with and without PLBP during the third trimester of pregnancy as well as **(2)** the self-reported difference in body perception experienced between the first and third trimester of pregnancy, **(3)** whether a painful or non-painful condition as well as a pregnant or non-pregnant condition has an impact on impairments in body perception at the lumbopelvic area, and **(4)** the possible influences of psychosocial factors on alterations in experienced body perception at the lumbopelvic area.

The first finding demonstrated that greater levels of disturbances in body perception at the lumbopelvic area were significantly more frequent in pregnant women experiencing PLBP compared to women without this type of pain. Secondly, the level of disturbances was not different between trimester three and trimester one. In addition, non-pregnant women had more alterations in body perception than pregnant women, regardless whether they experienced PLBP or chronic LBP. Thirdly, increased alterations in body perception were significantly correlated with experiencing higher levels of fear of movement (TSK) and applying a more passive coping strategy (PCI-passive) during the third trimester of pregnancy. Furthermore, modifications in experienced body perception at the lumbopelvic area were significantly associated with elevated levels of fear-avoidance beliefs concerning physical activity (FABQ-PA) in combination with experiencing PLBP. Finally, increased levels of pain catastrophizing (PCS) were significantly correlated with more self-reported disturbances in experienced body perception without the influence of the different trimesters of pregnancy nor the presence of PLBP.

Several attempts have been previously made to investigate the disturbances in experienced body perception at the lumbopelvic area during pregnancy (Wand et al., 2017; Goossens et al., 2021) and in the postpartum period (Beales et al., 2016; Goossens et al., 2021) as well as its interaction to the presence of (postpartum) PLBP. Among these three previous studies there is no consistency in time of observation in the literature to draw valid conclusions that can be repeatedly demonstrated. This heterogeneity in time periods (during pregnancy and in the postpartum period) causes difficulties in establishing direct connections among the investigations since the evidence concerning this research topic is limited.

The results of Wand et al. (2017) and Goossens et al. (2021) were consistent with the findings of the current study emphasising the negative impact of PLBP on body perception among pregnant individuals. This observation was previously and repeatedly discovered in non-pregnant individuals who experienced chronic LBP (Bowering et al., 2014; Bray & Moseley, 2011; Brumagne et al., 2000; Brumagne et al., 2008; Catley et al., 2014; Janssens et al., 2016; Nishigami et al., 2015). In these latter investigations, different variants of physical examinations involving motor control patterns, motor imagery as well as lumbosacral proprioceptive and tactile tests were applied for the (indirect) assessment of body perception. The self-reported FreBAQ was less incorporated among the studies involving non-pregnant participants, whereas the specific investigations within pregnant individuals were frequently conducted by solely applying the FreBAQ without the implementation of physical tests (Beales et al., 2016; Goossens et al., 2021; Wand et al., 2017).

In summary, the results of the above-mentioned investigations revealed consensus regarding the effect of experiencing PLBP or chronic LBP on disturbances in body perception at the lumbopelvic area (Beales et al., 2016; Bowering et al., 2014; Bray & Moseley, 2011; Brumagne et al., 2000; Brumagne et al., 2008; Catley et al., 2014; Goossens et al., 2021; Janssens et al., 2016; Nishigami et al., 2015; Wand et al., 2017). In addition, the findings of the current study demonstrated the adverse impact of PLBP on body perception. Therefore, in our opinion, the integration of a focus on body perception within the treatment protocol of both LBP patients as well as pregnant individuals who experience PLBP is essential. Moreover, the treatment and management of pregnancy-related complaints such as LBP, PGP or a combination of both (PLBP) as well as the involvement of disturbances in body perception are of paramount importance as these conditions cause increased complications during delivery (Brown & Johnston, 2013). Consequently, different treatment methods for PLBP have been suggested and described in the existing literature, namely exercise therapy (Stafne et al., 2012), manual therapy (Licciardone et al., 2010), acupuncture (Kvorning et al., 2004) and the application of pelvic belts (Kordi et al., 2013). Recently, Gutke et al. (2015) systematically reviewed the effects of these treatment options and discovered qualitative and positive results when implementing acupuncture and pelvic belts in the treatment of pregnant women experiencing PLBP.

Furthermore, results from the current investigation acknowledged no significant differences in body perception when comparing a painful and non-painful condition regardless of being pregnant or not. In contrast, previous studies found an association between alterations in body perception at the lumbopelvic area and LBP in a non-pregnant population (Wand et al., 2011; Wand et al., 2014). Moreover, Osborn & Smith (2006) described how patients with chronic LBP reported that their back had become a part of their body that no longer belonged to them. A possible explanation for these contradictory findings is the low number of subjects experiencing LBP or PLBP (ten out of 26) within this investigation. Further research with more subjects and consequently a higher statistical power should be carried out to draw valid conclusions.

Contrary to the hypotheses, the current research discovered a significant difference in experienced body perception at the lumbopelvic region between a pregnant and non-pregnant population, regardless of experiencing any pain complaints (either PLBP or LBP), in which the non-pregnant individuals exhibit more disturbances in experienced body perception than pregnant individuals. This phenomenon can possibly be explained by the considerable chronic character of LBP (compared to PLBP) and its effect on body perception at the lumbopelvic area. Chronic LBP in this non-pregnant population may have been present for several months or even years, making enforced alterations in body perception more likely. Therefore, further research is recommended to identify a difference in body perception between pregnant and non-pregnant women and to set clear cut-off boundaries to either include or exclude pain symptoms within the study.

Other influences that should be considered as contributing factors to alterations in body perception at the lumbopelvic area are numerous cognitive and affective factors (Beales et al., 2016; Goossens et al., 2021; Wand et al., 2017). The current investigation could identify a significant influence of the following factors on experienced body perception in pregnant individuals: more fear of movement (TSK) and having a passive coping strategy (PCI) during the third trimester of pregnancy, higher levels of fear-avoidance beliefs concerning physical activity (FABQ-PA) in combination with experiencing PLBP and more catastrophizing thoughts about pain complaints (PCS). The connection between alterations in body perception and experiencing more fear of movement was not aligned with the conclusions of the research of Wand et al. (2017) who did not discover an association between both factors during the third

trimester of pregnancy. In contrary, Beales et al. (2016) observed elevated levels of kinesiophobia measured with the TSK in postpartum individuals who experience moderate disability due to PLBP.

Another finding from the current study, which is similar to the results of the investigation by Wand et al. (2017), concerned the alterations in body perception at the lumbopelvic region that correlated significantly with increased pain catastrophizing (PCS). Likewise, Wand et al. (2017) identified a significant influence of pain catastrophizing cognitions on body perception in a pregnant population. Contradictory results were found in the investigation by Beales et al. (2016) who found no consistent differences in body perception at the lumbopelvic area related to pain catastrophizing. The latter study described an explanation for these conflicting findings, namely the limited power of these statistical analyses with regard to this psychosocial factor (Beales et al., 2016). Another possible explanation for the inconsistency within the investigation of Beales et al. (2016) is the fact that the researchers observed these findings within the postpartum period while the current investigation focused on trimester one and three of pregnancy.

Moreover, solely Beales et al. (2016) investigated coping strategies among postpartum women but could not detect a significance between alterations in coping strategies and postpartum individuals who experience increased levels of disability. Although, our research observed a connection between impairments in body perception and adopting a passive coping strategy in the third trimester of pregnancy without making the association with disability.

Previous research in a non-pregnant population experiencing chronic LBP has established a correlation between disturbances in body perception on the one hand and psychological distress (DASS-21), fear avoidance beliefs about physical activity (FABQ-PA), and pain catastrophizing cognitions (PCS) on the other hand among this population (Nishigami et al., 2017; Wand et al., 2016). Regarding the current findings, an additional connection between increased levels of fear avoidance beliefs about physical activity (FABQ-PA) in combination with the presence of PLBP on alterations in body perception at the lumbopelvic area was established among the pregnant individuals. In our opinion, higher scores on the FABQ-PA could be linked to the increased fear of movement (TSK) and their mutual effects on alterations in body perception. This connection could be explained by the considerable

overlap between the constructs of the two questionnaires, since they both contain questions about pain-related fear (Crombez et al., 1999).

The major limitation of the investigation was the inclusion of a small sample size due to the COVID-19 situation. The findings are susceptible to varying interpretations due to the lack of power of the study, and should therefore be interpreted with caution. Another limitation, as a consequence of the decreased number of participants included in the research, is the fact that normality could not be tested in the Repeated Measures Mixed Effect Models. This is because the detection of normally distributed data would have been purely coincidental and moreover dispensable since a small sample size would influence normality tests to an increased extent and this consequently reduces the strength of this type of test.

As mentioned in the research context, the COVID-19 situation prevented us from achieving the initial aim of this study, namely the additional assessment of body perception at the lumbopelvic area at both six weeks and six months postpartum. Body perception at the lumbopelvic area has never been monitored over an extended period of time in pregnant individuals and the further inclusion of a postpartum period would definitely be an added value within future research. This follow up period is needed to provide solid conclusions about disturbances in body perception and their progression in pregnant women with and without PLBP. Hence, it was an additive benefit to involve an additional dataset in the current investigation in order to evaluate multiple effects and differences among the different groups (alternating combined as 2x2) since this comparison was never carried out before. Likewise, the comparison between two different stages of pregnancy namely, the first and third trimester of pregnancy, is unique to this research topic.

In this research, body perception at the lumbopelvic region was examined by applying two different trials (FreBAQ and Recognise Back App). Other investigations incorporated physical examinations that reflect a dimension of body perception e.g. lumbar motor control with the inclusion of dissociation tasks and repositioning sense, lumbar motor imagery, alterations in lumbosacral proprioceptive acuity and responses to lumbosacral proprioceptive stimuli patterns (Bowering et al., 2014; Bray & Moseley, 2011; Brumagne et al., 2000; Brumagne et al., 2008; Catley et al., 2014; Janssens et al., 2016; Wand et al., 2011; Wand et al., 2014). Some of these physical examinations were investigated in a non-pregnant population experiencing chronic LBP where results demonstrated there tended to be a connection between

experienced impairments in body perception and adaptations in motor control patterns (Bowering et al., 2014; Bray & Moseley, 2011; Brumagne et al., 2000; Brumagne et al., 2008; Catley et al., 2014; Janssens et al., 2016; Wand et al., 2011; Wand et al., 2014). However, to our knowledge, these physical tests are less specific to solely measure body perception at the lumbopelvic area. Therefore, further research can be conducted to determine the degree of validity between the physical tests on the one hand and FreBAQ and/or Recognise Back App on the other hand. In addition, an important benefit for future research is to investigate the correlation between the trials in terms of validity among pregnant individuals with or without PLBP. Certainly, since there is evidence that there is an association between motor control alterations and disturbances in body perception among women who experience PLBP (Beales et al., 2009).

Finally, the research aimed at identifying and exploring numerous cognitive and affective factors within the psychosocial borders of an individual that could have a potential impact on the experienced body perception. In this way, the research highlights the importance of a biopsychosocial approach concerning body perception and its relevance in both the assessment and treatment of pregnant women with or without PLBP. Although, not all aspects could be taken into account. Instead, we aimed at targeting some different aspects within psychosocial factors than the ones described before in literature. Therefore, the potential correlation between body perception and sleep quality (measured with the PSQI) on the one hand and disability as a consequence of pain (measured with the MDQ and QBPDS) on the other hand were not involved in this research. Instead, these data were merely descriptive implemented in order to complete the details about the participants. The latter mentioned variables (MDQ and QBPDS) were included in both the research of Beales et al. (2016) and Goossens et al. (2021). Beales et al. (2016) discovered significant disturbances in both body perception and sleep adequacy in postpartum women who experience PLBP but was unable to establish direct interactions between these factors. Goossens et al. (2021) could identify a correlation between increased self-reported pain intensity and disability during trimester three on impairments in body perception whereas the connection between impaired body perception and pain intensity continued during the six weeks postpartum period. It would be beneficial if future investigations would focus more on different aspects of pain, and the

possible simultaneously occurring disability, in combination with varying aspects of psychosocial factors and their communal influence on body perception.

6. Conclusion

Primary findings demonstrated that greater levels of disturbance in body perception at the lumbopelvic area were significantly more frequent in pregnant women experiencing PLBP compared to women without these pain complaints. In addition, non-pregnant women had significantly greater disturbances in body perception at the lumbopelvic area than pregnant women.

Concerning the secondary outcome measures, alterations in body perception in pregnant participants were significantly correlated with more fear of movement and having a passive coping strategy during the third trimester of pregnancy, higher levels of fear-avoidance beliefs concerning physical activity in combination with experiencing PLBP and more catastrophizing thoughts about pain complaints. These findings imply the importance of a biopsychosocial approach concerning body perception and its relevance in assessing and treating pregnant women with and without PLBP.

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8. Appendix

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INVENTARISATIEFORMULIER WETENSCHAPPELIJKE STAGE DEEL 2

DATUM	INHOUD OVERLEG	HANDTEKENINGEN
20.11.2020	Mail: Start MP2	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
01.12.2020	Mail: Vragen omtrent start MP2	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
02.12.2020	Test moment participant: Bespreking start MP2 + implementatie dataset Dr. Thomas Matheve	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
22.12.2020	Mail: Feedback situering, introductie en methoden	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
08.01.2021	Mail: Dataset ontvangen van beide studies	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
15.03.2021	2 mails: Vragen omtrent psychosociale vragenlijsten + bijbehorende psychometrische karakteristieken	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
17.03.2021	Test moment participant: Bespreking vragen omtrent statistiek	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten

18.03.2021	5 mails: Vragen en feedback optionele statistiek	Copromotor/Begeleider: Dr. Nina Goossens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
12.04.2021	Mail: directe begeleiding MP2 door Prof. Dr. Lotte Janssens (Co-promotor: zwangerschapsverlof)	Promotor: Prof. Dr. Lotte Janssens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
03.05.2021	Mail: Feedback: Acknowledgement, abstract, outcome measures, data analyse, resultaten, tabellen alsook de integratie van de dataset van Dr. Thomas Matheve	Promotor: Prof. Dr. Lotte Janssens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
21.05.2021	Mail: Finale feedback	Promotor: Prof. Dr. Lotte Janssens Student(e): Margo Van Haelen Student(e): Kaat Verstraten
25.05.2021	Mail: Informatie goedkeuring ethische commissie en studie design parallel onderzoek Dr. Thomas Matheve	Promotor: Prof. Dr. Lotte Janssens Student(e): Margo Van Haelen Student(e): Kaat Verstraten

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

Naam Student(e): ……Datum:……..

Titel Masterproef:……

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	O
Methodologische uitwerking	O	O	O	O	O	O
Data acquisitie	O	O	O	O	O	O
Datamanagement	O	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	O	O	O
Rapportage	O	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)

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Inschrijvingsformulier verdediging masterproef academiejaar 2020-2021,
Registration form jury Master's thesis academic year 2020-2021,

GEGEVENS STUDENT - *INFORMATION STUDENT*

Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1540133 Verstraten Kaat**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

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PART A - MANDATORY - TO BE FILLED OUT BY THE STUDENT

Titel van Masterproef/*Title of Master's thesis:* BODY PERCEPTION IN WOMEN WITH AND WITHOUT PREGNANCY-RELATED LUMBOPELVIC PAIN AND WOMEN WITH AND WITHOUT CHRONIC LOW BACK PAIN

☒ behouden - *keep*

☐ wijzigen - *change to*:

/:

O behouden - *keep*

O wijzigen - *change to*:

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s)*: MARGO VAN HAELEN

X behouden - *keep*

O wijzigen - *change to:*

LUIK B - VERPLICHT - IN TE VULLEN DOOR DE PROMOTOR(EN)
PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

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De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

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PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

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LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

24.05.2021

Datum en handtekening promotor(en)
Date and signature supervisor(s)

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Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1644374 Van Haelen Margo**
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PART B - MANDATORY - TO BE FILLED OUT BY THE SUPERVISOR(S)

Wijziging gegevens masterproef in luik A/*Change information Master's thesis in part A:*

O goedgekeurd - *approved*

O goedgekeurd mits wijziging van - *approved if modification of:*

Scriptie/*Thesis:*

O openbaar (beschikbaar in de document server van de universiteit)- *public (available in document server of university)*

O vertrouwelijk (niet beschikbaar in de document server van de universiteit) - *confidential (not available in document server of university)*

Juryverdediging/*Jury Defense:*

De promotor(en) geeft (geven) de student(en) het niet-bindend advies om de bovenvermelde masterproef in de bovenvermelde periode/*The supervisor(s) give(s) the student(s) the non-binding advice:*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

O de verdediging is openbaar/*in public*

O de verdediging is niet openbaar/*not in public*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK C - OPTIONEEL - IN TE VULLEN DOOR STUDENT, alleen als hij luik B wil overrulen
PART C - OPTIONAL - TO BE FILLED OUT BY THE STUDENT, only if he wants to overrule part B

In tegenstelling tot het niet-bindend advies van de promotor(en) wenst de student de bovenvermelde masterproef in de bovenvermelde periode/*In contrast to the non-binding advice put forward by the supervisor(s), the student wishes:*

O niet te verdedigen/*not to defend the aforementioned Master's thesis within the aforementioned period of time*

O te verdedigen/*to defend the aforementioned Master's thesis within the aforementioned period of time*

LUIK D - VERPLICHT - IN TE VULLEN DOOR DE STUDENT EN DE PROMOTOR(EN)
PART D - MANDATORY - TO BE FILLED OUT BY THE STUDENT AND THE SUPERVISOR(S)

Datum en handtekening student(en)
Date and signature student(s)

27/05/2021

Datum en handtekening promotor(en)
Date and signature supervisor(s)

Lotte JANSSENS vr 28 mei 22:13 (17 uur geleden)

aan mij, Margo

Beste Kaat en Margo,

Hierbij de formele goedkeuring van jullie ingestuurde documenten: inventarisatieformulier en inschrijvingsformulier verdediging (akkoord met wijziging titel en niet-bindend advies om te verdedigen).
Deze mail geldt als handtekening (dus er moet geen handtekening meer op de docs gezet worden).
Succes met de laatste rechte lijn.

Mvg,

Lotte Janssens

Op vr 28 mei 2021 om 22:09 schreef Kaat Verstraten <kaat.verstraten@student.uhasselt.be>:

•••

Beantwoorden Allen beantwoorden Doorsturen