Exteroceptive and Interoceptive Bodily Experiences Throughout the Perinatal Period

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Abstract

Pregnancy brings about significant physical changes over a relatively short period of time, influencing how women feel about their bodies, and their internal bodily signals known as interoception. The bodily experience during pregnancy, encompassing exteroceptive experiences such as body dissatisfaction and interoceptive experiences, understandably changes. Despite this, there is currently very little research into how these changes may influence mother and infant outcomes before and after birth. The main aim of my thesis was to investigate the relationship between pregnancy bodily experiences and postnatal outcomes such as maternal mental health, bonding and breastfeeding.

Following a thorough review and evaluation of the current knowledge in this field presented in Chapter 1, and before examining how the pregnancy bodily experience influences postnatal outcomes, Chapter 2 aimed to establish how body dissatisfaction and interoception relate to antenatal outcomes. Network analyses indicate that a lack of trust in internal bodily signals, and dissatisfaction with body weight during pregnancy negatively influence antenatal outcomes. Chapter 3 established relationships between pregnancy body dissatisfaction and postnatal mental health and bonding, using a cross-sectional design to develop a retrospective measure of pregnancy body dissatisfaction. Chapter 4 further confirms these connections using a longitudinal design and network analysis to investigate the pregnancy bodily experience and outcomes at 3- and 6- months postpartum. Finally, considering yoga as an intervention with potential to target the bodily experience, Chapter 5 presents a systematic review of current literature investigating the influence of yoga on postnatal maternal mental health and well-being. Chapter 6 consolidates all findings and concludes by highlighting key implications and directions for future research.

The research undertaken in this thesis underscores the importance of considering pregnancy bodily experiences. This in turn may help to identify mothers at risk of poorer postnatal outcomes, inform interventions and enhance the wider theoretical understanding of pregnancy experience.

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Author's Declaration

I, Lydia Beatrice Munns, confirm that this thesis represents original research, and I am its sole author, conducted under the normal supervision of Dr Catherine Preston and Dr MaryAnn Noonan. This work has not previously been presented for a degree or other qualification at this University or elsewhere. All sources are acknowledged as references. The research was funded by the University of York.

Chapter 2 of this thesis has been published in the following peer-reviewed journal. The formatting has been modified to align with the requirements of this thesis.

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Primary Supervisor's Statement

I, Catherine Preston, am listed as a co-author on the following four empirical papers that constitute four chapters of this thesis.

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In these papers, the work was primarily that of Lydia Munns. Lydia conducted all data collection and analysis, as well as writing the initial draft of each paper.

Collection of the data in Chapter 3 was conducted in collaboration with other members of the lab and at UCL. However, I am satisfied that Lydia's contribution to the data collection and analysis was substantial and meets the University's criteria for inclusion in a thesis.

Dr Catherine Preston

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Secondary Supervisor's Statement

I, MaryAnn Noonan, am listed as a co-author on the following empirical paper that constitutes one chapter of this thesis.

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1. Chapter 1: General Introduction

Pregnancy is a transformative time for women. Over a relatively short 9-month period, women experience rapid physiological, physical, social and psychological changes. Pregnancy is defined as the time between conception and birth and usually lasting approximately 40 weeks. During this time there are also rapid developmental changes for foetuses which themselves interact with the mother's experience of pregnancy. As pregnancy is an essential part of human life, it has the potential to directly impact all women across the world. Approximately 140 million children were said to be born in 2021 (UNICEF, 2020), and around 213 million pregnancies occur annually (Sedgh et al., 2014). Given its significance, a thorough understanding of pregnancy is essential and allows the development of effective support to enhance the health and well-being of both mother and baby.

Rapidly changing hormones are one reason for the significant changes that occur during pregnancy and have a direct impact on a woman's psychological well-being (Harja et al., 2023). Stress, and mood changes are commonly experienced during this period (Bjelica & Kapor-Stanulović, 2004) and in turn can influence infant neurodevelopment (Howland et al., 2021; Talge et al., 2007). With this, pregnancy can also co-occur with mental health difficulties, such as depression, which is the most common psychiatric disorder experienced during this time (Chandra et al., 2009). Research has indicated that the prevalence of antenatal depression and/or anxiety is as high as 30% (Satyanarayana et al., 2011), with similar rates postpartum (Field, 2018; O'Hara & McCabe, 2013). These disorders are known to negatively impact the health of the baby postnatally, through neurodevelopmental, behavioural, and emotional problems (Gentile, 2017; O'Connor et al., 2002). Hormonal changes also influence a women's internal physiology during pregnancy (Harja et al., 2023), including changes in cardiovascular (heart rate and cardiac output increasing), respiratory (increase in the amount of air in the lungs) and gastrointestinal systems (delay in gastric emptying) (Kumar & Magon, 2012).

Alongside these significant psychological and physiological changes, arguably the most noticeable are the alterations in physical appearance and body shape. Women are typically recommended to gain around 11-16kg throughout their pregnancy (Gilmore & Redman, 2015). This weight gain typically occurs alongside the appearance of a bump, enlarged breasts, swollen ankles and increased hair growth, highlighting just how physical the experience of pregnancy is. Such changes are often unexpected, with qualitative literature highlighting how

underprepared women feel for the impact pregnancy has (Hodgkinson et al., 2014), understandably impacting how women feel about their bodies (Crossland et al., 2023).

1.1. The Bodily Experience

1.1.1. Understanding body dissatisfaction

How pregnant women feel about their bodies requires an understanding of aspects of their body image, which includes overall affective, attitudinal, and perceptual components that form an internal representation of our own body (Grogan, 2021). One aspect of body image is body dissatisfaction, which is based on negative thoughts and feelings of one's body (Grogan, 2021). Despite a review by Grogan (2021) concluding that body dissatisfaction remains remarkably stable across the entire female lifespan, body image has been found to vary depending on demographic factors, with women having significantly greater body and weight dissatisfaction than men (Carey et al., 2019) and women from western cultures experiencing larger body discrepancies (difference between current and ideal body weight) than those from eastern cultures (Gluck & Geliebter, 2002).

Body dissatisfaction is said to occur via several mechanisms, including exposure to pictures of thin-ideal female bodies (Lin & Kulik, 2002; Ogden & Mundray, 1996) and the media (Jucker et al., 2017), the pressure women face to be thin with those who have a higher body mass being more dissatisfied with their body (Cattarin & Thompson, 1994), and the elevated internalisation of societal ideals of attractiveness (Stice et al., 2001). This latter concept, also known as 'thin-ideal internalisation', refers to the extent in which an individual cognitively invests in socially defined ideals of attractiveness and engages in behaviours aimed at conforming to these ideals (Thompson et al., 1999). Thompson & Stice (2001) concluded that this concept is an important causal risk factor for poor body image and eating disturbances.

Thin-ideal internalisation links closely with the construct of social reinforcement, where opinions that are accepted by respected members of society are internalised (Kandel, 1980). This can enhance body dissatisfaction as it encourages conformity to an unattainable ideal for most females (Thompson et al., 1999). Therefore, this 'ideal' is thought to promote disordered eating, such as anorexia nervosa, through its impact on body satisfaction (Thompson & Stice, 2001). Anorexia is characterised by emaciation, a disordered perception of body shape

and fear of putting on weight (Stice & Shaw, 2002). It is a common belief that dieting and withholding food is an effective weight-control technique, with the goal to improve attitudes towards one's body, which can lead to disordered eating, (Thompson & Stice, 2001).

Body dissatisfaction gives rise to other mental health conditions, with depressed patients also experiencing higher body dissatisfaction, and treatment for depression lowering body dissatisfaction scores (Scheffers et al., 2019). As body related experiences are common symptoms of depression e.g. decreased vitality, how people experience their body has been identified as a core characteristic of depression (Scheffers et al., 2019). Similarly, anxious individuals have higher body dissatisfaction, encouraged by a negative self-view and the propensity to worry (Pritchard et al., 2021). Body dissatisfaction is therefore potentially a vital factor when investigating mental health disorders, particularly during periods of rapid bodily change, such a puberty (McLean et al., 2022), pregnancy (Crossland et al., 2023) and the menopause (Riecher-Rössler, 2020).

1.1.2. *Body dissatisfaction during pregnancy*

Given the significant changes the body undergoes during pregnancy, it is understandable that perceptions and feelings towards the body may change. Previous research investigating body image during pregnancy has shown wide variation in women's opinions of the physical changes during pregnancy. Some women have been found to have positive or neutral feelings towards their body during pregnancy, suggesting that this can be a pleasurable and unique experience (Clark & Ogden, 1999; Duncombe et al., 2008). Similarly, women can find this period liberating (Bergbom et al., 2017), as pregnancy emphasises the importance of reproduction and the beginning of a new role for women, over any social pressures to conform to socially defined beauty (Davies & Wardle, 1994). This freedom from social expectations is understandable, given that pregnancy is arguably the only time in a woman's life when it is socially acceptable to be large (Ussher, 1989). Some early qualitative research by Richardson, (1990) suggested that some women see pregnancy as 'transient' and therefore not lasting a long period of time, which helped them deal with the bodily changes. Some research goes further to say that body dissatisfaction is significantly lower among pregnant women compared to non-pregnant women (Loth et al., 2011). However, body dissatisfaction during pregnancy has been found to vary, with a recent meta-analysis identifying both positive and negative experiences with the pregnant body (Crossland et al., 2023).

Whilst pregnancy is often a special time, the pressure to look a certain way is still present for many women. A recent poll of over 200,000 pregnant women by BabyCenter (2023) found 72% of women were not happy with or had mixed feelings about their pregnant bodies. Similarly, a study conducted in Japan found that pregnant women expressed dissatisfaction with their body, preferred to be thinner and perceived their body size as larger than their real size (Tsuchiya et al., 2019). Many of the bodily changes associated with pregnancy, such as increases in body size and body weight, are inconsistent with social ideals of female body appearance (Greer, 1984) and can be distressing (Fairburn & Welch, 1990), leaving women feeling pressured to maintain a socially desirable pregnant body shape (Hodgkinson et al., 2014). It is therefore unsurprising that two thirds of women report experiencing weight stigma during this time (Incollingo Rodriguez et al., 2020). Recent research by Heslehurst et al (2022) investigated how newspaper media frames obesity during pregnancy, analysing 442 articles. Three themes were identified: blame, responsibility and burden. Women with obesity during pregnancy were often blamed for their weight and the impact this had on the NHS, they were portrayed as solely responsible for solving their obesity, and as a burden on others, society, and healthcare services. From this review, it is clear that newspaper media are often framed to devalue and blame women, which could increase feelings of guilt and stigma among pregnant mothers. These external social pressures can impact how satisfied women are with their changing pregnant bodies (Kirk & Preston, 2019). However there is individual variation in susceptibility to these pressures, with women experiencing less social support from their family and partners, and lower self-esteem, being more likely to feel increased pressure to conform to social expectations (Morozumi et al., 2020).

Beyond pressure to conform to socially acceptable standards of pregnancy, body dissatisfaction can be further explained by the lack of control women feel over their bodies during pregnancy, given the rapid changes that occur seemingly without conscious effort. Qualitative research suggests that some women reject these changes during pregnancy ("I can't wait to get rid of it [the bump], I know that sounds horrible, just want to get back to normal."; Earle, 2003, p. 250). For some women, it may feel as though the baby develops independently, without any active contribution from the mother, which can make women feel like a vessel with no control over their body's appearance, weight, or physical abilities (Schmied & Lupton, 2001).

Attitudes towards weight gain and body shape have been found to change during different trimesters of pregnancy. Goodwin et al., (2000) found that women's body satisfaction significantly declined from pre-pregnancy to early pregnancy. They further discovered that attitudes towards the body improved between early and late pregnancy, suggesting that the first trimester is the peak time of body dissatisfaction during pregnancy. This is supported by research by Skouteris et al., (2005), who found that women were most likely to report body dissatisfaction during the earlier stages of pregnancy. A reason for this increase in body dissatisfaction in early pregnancy could be that women are not noticeably pregnant at this point but are putting on weight, undergoing other bodily changes and experiencing unpleasant symptoms (e.g., morning sickness) during this time. Pregnancy is also often kept secret during this early period, due to the higher risk of miscarriage (Lou et al., 2017), so others are not aware of the pregnancy, but may notice 'unexplained' weight gain. Concerns around weight gain also persist into the postnatal period, with pregnant women concerned about potential postpartum body dissatisfaction (Patel et al., 2005). Fairburn & Welch (1990) used retrospective accounts during the postpartum period and discovered that 40% of women were distressed by weight gain during pregnancy and 72% were concerned they would not be able to return to their body weight pre-pregnancy. This is in line with quantitative research by Singh Solorzano et al (2022), where higher self-reported body dissatisfaction was found among women postpartum, compared to those in early and late phases of pregnancy. Therefore, corroborating the notion that during pregnancy, women often accept bodily changes as necessary and indicative of the role of motherhood (Davies & Wardle, 1994) compared to the postnatal period, where there is a desire to return to the pre-pregnancy body (Hodgkinson et al., 2014; Silveira et al., 2015).

However, experiences of the body during pregnancy are not universally negative. Research on body dissatisfaction during pregnancy has produced heterogeneous results, with some studies finding that pregnant women view bodily changes positively, while others report negative perceptions (Crossland et al., 2023). This leaves us with conflicting results, which could be partly due to the use of non-pregnancy specific measures to assess body dissatisfaction. Previous measures used such as the Body Attitudes Questionnaire (Skouteris et al., 2005) and the Body Shape Satisfaction Scale (Loth et al., 2011) may fail to capture specific concerns associated with bodily changes during this time and, thus, lead to inconsistent results (Fuller-Tyszkiewicz et al., 2012). Furthermore, previous measures on body dissatisfaction that have attempted to capture the nuanced experiences of pregnancy have been created using poor sample sizes (Watson et al., 2017) or were not fully validated with independent samples (Brown

et al., 2015). Without validated scales, the construct of body dissatisfaction cannot be accurately captured. Kirk & Preston (2019) addressed this gap by creating BUMPs, the Body Understanding Measure during Pregnancy Scale, the first pregnancy specific body dissatisfaction measure to be validated with a large and independent sample. The creation of a valid measure allows research to accurately assess body dissatisfaction and fill a gap in the literature to understand the role it plays in maternal and infant well-being.

1.1.3. The concept of interoception

Alongside external body perception, or body dissatisfaction, the bodily experience also encapsulates internal bodily signals, or interoception. Interoception refers to the awareness of, or attention paid to, visceral (internal bodily) signals such as heart rate, hunger, thirst, and pain (Craig, 2002). Interoceptive signals are relayed to the brain via a range of neural pathways, often via the spinal cord (Arasappan et al., 2021). There are multiple types of interoceptive signals, including cardiovascular, respiratory, gastrointestinal, thermoregulatory, and affective touch, the latter of which refers to tactile signals with a hedonic or emotional component (Morrison, 2016). Interoception can be measured in 3 key ways; interoceptive awareness (the metacognitive recognition and understanding of internal bodily signals), interceptive accuracy (the objective ability to accurately detect these signals) and interoceptive sensibility (subjective experience and perception of interoceptive signals) (Garfinkel et al., 2015). The latter is most commonly assessed using the Multidimensional Assessment of Interoceptive Awareness (MAIA), which encapsulates different modes of self-reported attention to bodily signals, including constructs relating to listening to the body (e.g., noticing signs of tiredness) and trusting the body (e.g., viewing one's body as safe and trustworthy) (Mehling et al., 2012).

As well as being implicated in our physical health, with perceptions of interoceptive signals potentially lying at the heart of multiple illnesses (Farb et al., 2015), interoception also plays an important role in the relationship between the perception of physiological changes and emotions (Critchley & Garfinkel, 2017). Interoception has been implicated in multiple mental health disorders and is considered a transdiagnostic factor of mental ill-health (Khalsa et al., 2018). For example, those with anxiety have been found to have higher interoceptive accuracy, and experience a heightened discrepancy between observed and expected bodily states (Garfinkel et al., 2015). Similarly in eating disorders such as anorexia nervosa, disturbance in the interoceptive system results in individuals perceiving and interpreting internal bodily signals differently (Jacquemot & Park, 2020). An MRI study found that anorexia patients

reported fullness and no hunger signals even when the stomach was completely empty (Bluemel et al., 2017). Mindfulness, a contemporary treatment for mental health difficulties, is thought to have beneficial impacts on the mind and body through its encouragement of being aware of bodily signals (Mehling et al., 2012). Yoga, which incorporates multiple mindfulness practices, has been found to increase interoceptive sensibility and reduce symptoms of depression and anxiety in individuals with post-traumatic stress disorder (Neukirch et al., 2019), highlighting it as a promising potential intervention for mental health.

Given the involvement of interoception in both mental and physical health, it is not surprising that it plays a unique role during pregnancy.

1.1.4. Changes in interoception during pregnancy

During pregnancy, interoceptive signals are enhanced, such as thirst and hunger, due to the increased need for the foetus and amniotic fluid (Kirk & Preston, 2019; Malhotra & Deka, 2002). Increased feelings of fatigue are common (Lee & Zaffke, 1999), alongside increased blood flow (Longo, 1983) and body temperature (Beinder et al., 1990). Pregnancy also brings about new interoceptive experiences, such as pregnancy related pain (Almousa et al., 2018; Vermani et al., 2010), and more sensitive breasts (Hayati et al., 2020). Therefore interoception understandably influences how women experience their pregnant bodies. Clark et al., (2009) found that pregnant women spend more time tuning into their bodies to feel movement of their baby – presumably due to concern for the needs of the foetus -- and demonstrate less avoidance of bodily signals. This is encouraged by healthcare professionals, in order for women to monitor foetal movements and potential problems. However, qualitative reports suggest that women can feel out of control of their body and find it difficult to define a clear self-other boundary between themselves and the foetus (Schmied & Lupton, 2001). This understandably makes it more difficult for women to distinguish between their bodily needs and the needs of the foetus (Kirk & Preston, 2019), adding complexity to the bodily experience.

One aspect of interoception that is particularly important during pregnancy is body trust. Trusting the body to safely develop and protect the foetus is important during pregnancy (Crossland et al., 2022) and in trusting the body to give birth according to qualitative ethnographic literature (Cheyney, 2011). This may explain why pregnant women trust their bodies more and show less avoidance of interoceptive signals than non-pregnant women (Crossland et al., 2022). Research indicates that women who possess greater trust in their

bodies tend to have more positive pregnancy and birthing experiences (Crossland et al., 2022). However, negative bodily experiences during pregnancy may undermine confidence in the body, impacting birth and subsequent pregnancies. Indeed, reduced trust in the body's capabilities and feelings of fear have been associated with a higher likelihood of medical interventions and C-sections in qualitative reports (Flores, 2018).

Interoception also changes throughout the course of pregnancy. Subjective reports demonstrate an increased intensity in listening to interoceptive signals, such as pain, in the later stages of pregnancy (Singh Solorzano et al., 2022), likely due to the enhanced physical burden. Postnatally, the limited research thus far suggests that women tend to be less aware of interoceptive signals and are less able to regulate distress by focusing on the bodily sensations compared to during pregnancy (Singh Solorzano et al., 2022). This may be explained by the rapid biopsychosocial changes in a woman's life immediately postpartum (Obrochta et al., 2020).

1.1.5. The relationship between body dissatisfaction & interoception

Interoception, representing the internal body, and body dissatisfaction, representing the external body, are inextricably linked. According to cross-sectional quantitative literature, interoception is thought to play an important role in body satisfaction for both non-pregnant (Lewis & Cachelin, 2001) and pregnant women (Kirk & Preston, 2019). Lewis & Cachelin, (2001) identified low levels of body satisfaction among nonpregnant women to be associated with poor subjective accounts of interoceptive awareness, especially among women with high body mass index. This result is likely due to individuals with higher BMI's struggling to identify internal satiety cues (Herbert & Pollatos, 2014), and eating based on emotional and situation cues rather than listening to internal bodily signals of hunger (Birch et al., 2003). On the other hand, those suffering from clinical eating disorders have been identified as having lower levels of body satisfaction and less awareness of bodily signals, often due to a lack of acceptance around somatic and affective experiences which can encourage dietary restraint (Merwin et al., 2010). Similarly in pregnant women, low levels of body satisfaction during pregnancy have been linked with less awareness of bodily signals (Kirk & Preston, 2019). With pregnancy often feeling like a loss of control over one's body, trusting the body to grow and nourish a foetus without their active involvement may therefore help women to have a positive experience of their changing body (Kirk & Preston, 2019). Thus, women who listen to their bodies in order to detect foetal movements and bodily signals such as thirst and hunger have

been found to have a more positive experience with their changing bodies (Kirk & Preston, 2019).

The social expectations to maintain a socially desirable pregnant body are in direct conflict with internal sensations such as increased appetite and reduced physical activity due to fatigue and pain (Butte & King, 2005; Chien & Ko, 2004; Vermani et al., 2010). This leaves women to balance the needs of the foetus alongside pressures to conform to society's beauty standards (Nash, 2015). This balancing act is related to the Competition of Cues Hypothesis (Pennebaker & Lightner, 1980) which proposes that attention towards our body is limited, and therefore attention towards internal (interoceptive) and external (environmental) cues are in competition. The theory suggests conflict between theses cues can lead to a distorted body perception, such as in anorexia where there is difficulty integrating external and internal cues (Brizzi et al., 2023). This theory has also been implicated in the pregnancy bodily experience. Research by Stafford et al (2024) investigated the role of interoceptive sensibility and body dissatisfaction on antenatal attachment, the emotional bond that mothers develop toward their unborn baby during pregnancy (Condon & Corkindale, 1997). Results suggested that the relationship between antenatal attachment and body dissatisfaction was moderated by worry about interoceptive signals. Women with fewer concerns around bodily sensations had associations between high body dissatisfaction and low antenatal attachment scores. This demonstrates the potential involvement of interoceptive sensibility in the relationship between body dissatisfaction and well-being outcomes.

Despite the implication of both body dissatisfaction and interoceptive sensibility in both the pregnancy experience and general well-being, little research has been done to investigate how these constructs interact and impact maternal and infant health and well-being throughout the perinatal period.

1.2. The Impact of the Pregnancy bodily experience on Outcomes

1.2.1. *The impact of the pregnancy bodily experience on antenatal outcomes*

Body dissatisfaction and interoception have been implicated in antenatal mother-infant well-being, including attachment and maternal mental health. Those who have positive perceptions of the body during pregnancy have a stronger bond with their unborn infant

(Condon, 1985; Heidrich & Cranley, 1989). A recent paper examining the link between antenatal attachment and the pregnant body found body dissatisfaction to be the strongest predictor of antenatal attachment compared to other known predictors such as depression and accounted for up to 27% of the variance in antenatal attachment (Kirk & Preston, 2019). This finding, consistent with previous cross-sectional literature (Huang et al., 2004), demonstrates that the bodily experience during pregnancy can play a critical role in forming the antenatal bond, therefore influencing the well-being of both mother and baby. However, results within the literature are heterogeneous, with further findings indicating that women reporting more body dissatisfaction have stronger bonds with their unborn babies, potentially explained through heightened focus on the baby compared to the body (Małus et al., 2014).

Despite this, the importance of interoception in building the mother-infant relationship has been emphasised, with internal perceptual experiences such as the baby kicking being found to strengthen levels of foetal attachment (Heidrich & Cranley, 1989). This could be partly due to the encouragement given to pregnant mothers to listen to bodily signals during pregnancy in order to effectively assess the baby's needs and well-being. Enhanced concern around bodily signals has also been identified among pregnant women compared to postpartum (Singh Solorzano et al., 2022), with pregnant body trust being identified as particularly important in developing a strong antenatal bond (Stafford et al., 2024). These bodily influences on antenatal attachment have important onward implications for both mother and baby. For example, low levels of antenatal attachment can result in fewer positive health and safety practices during pregnancy (Lindgren, 2001).

The negative influence of body dissatisfaction during pregnancy has been further investigated within the context of maternal mental health, particularly depression. A literature review by Silveira et al, (2015) found an association between body dissatisfaction and perinatal depression, with antenatal prevalence rates lying between 5-25% (Gavin et al., 2005). Antenatal depression has been found to have significant negative consequences, with women more likely to engage in behaviours such as drinking and smoking, and less likely to engage in healthy antenatal behaviours, such as regular doctor appointments (Bowen & Muhajarine, 2006). Comparably prevalent at 4-15% (Dennis et al., 2017), antenatal anxiety has been linked to less interoceptive sensibility (Noda et al., 2022) and body dissatisfaction during pregnancy (Chan et al., 2020). As well as negatively impacting maternal well-being (Biehle & Mickelson, 2011), antenatal anxiety has been associated with poorer trajectories in child development

(Glover, 2014), behavioural and emotional problems in children under 4 (O'Connor et al., 2002) and attentional difficulties (Van Batenburg-Eddes et al., 2013). Research has identified poor maternal health behaviours e.g. poor diet (Bind et al., 2022), enhanced stress hormones (Costas & Gomes-Ferreira, 2023), and reduced placental blood flow (Helbig et al., 2014) as potential mechanisms behind this relationship between antenatal mental health and infant well-being and development.

Despite research suggesting the bodily experience influences antenatal well-being, women's feelings about their bodies are not addressed in antenatal healthcare appointments or interventions (Watson et al., 2016). Although some research has investigated the influence of pregnant body experiences on antenatal outcomes, very little research has investigated the impact of these physical and physiological changes on postnatal maternal and infant health and well-being.

1.2.2. *The impact of the pregnancy bodily experience on postnatal outcomes*

Antenatal experiences are essential to consider within the context of postnatal mother-infant well-being. Indeed, poor antenatal mental health can predict experiences of postnatal mental health difficulties (Silveira et al., 2015; Thiele et al., 2023) and levels of antenatal attachment can predict postnatal bonding (Trombetta et al., 2021), mother-infant interactions (Fuller, 1990) and depression (Rollè et al., 2020). Given that the antenatal period often predicts postnatal experiences, it is important to explore the relationship between how women feel about their bodies during pregnancy and postnatal outcomes. Postpartum prevalence of depression and anxiety is between 13-19% (O'Hara & McCabe, 2013), both of which have been associated with negative consequences such as poorer postnatal bonding (Dubber et al., 2015). Both postnatal depression and anxiety have knock-on effects on parenting behaviours, physical and cognitive child development and breastfeeding duration (Field, 2018; Hamdan & Tamim, 2012; O'Hara & McCabe, 2013).

During pregnancy, feelings such as feeling the baby kicking (Heidrich & Cranley, 1989) and interoception can influence postnatal caregiving behaviours. Bytomski et al., (2020) discovered that maternal heart rate was associated with mother-infant stroking (a form of affective touch and classified as interoception), with higher heart rates being associated with a faster rate of infant stroking, suggesting that certain caregiving behaviours can be moderated by the mother's internal bodily signals. The acts of affective touch are known to underpin the

development and maintenance of social bonds (Morrison et al., 2010), and can contribute to the infant's general development (Feldman et al., 2010; Field, 2010). It is important to note that data from research by Bytomski et al., (2020) was gathered from a limited sample of 30 mother and infant dyads, with little variance in questionnaire responses. A more heterogeneous sample is needed to better understand the impact of affective touch on mother and infant relationships. Donaghy et al (2024) addresses this and recruited over 200 mother-infant dyads to investigate interoception, caregiving behaviours and affective touch. Key findings highlighted that mothers with greater focus on their bodily states were more likely to engage in caregiving behaviours such as rocking and stroking, and had lower levels of body dissatisfaction, therefore implicating interoception and affective touch in parental engagement. However, this study used a retrospective measure originally designed to assess body dissatisfaction during pregnancy, making its validity in this context uncertain. Further research is needed to investigate the bodily experience within the context of postnatal attachment using a longitudinal design or validated retrospective measures.

Alongside interoception, body dissatisfaction has been found to negatively impact outcomes of pregnant women and their babies, such as depression (Schmied & Lupton, 2001), low birth weight (Conti et al., 1998) and low rates of breastfeeding (Brown et al., 2015). Exclusively breastfeeding is recommended by the World Health Organisation as the best way of feeding an infant for the first 6 months postpartum (World Health Organisation, 2003). Despite this, rates of breastfeeding in the UK fall sharply in the early weeks following birth with 81% of women breastfeeding initially and only 55% breastfeeding 6 weeks postpartum, according to national statistics (McAndrew et al., 2012). Potential reasons for this drop out include physical problems (e.g. pain, difficulty latching the infant on), social problems (e.g. lack of social and professional support) and psychological problems (e.g. lack of confidence) (Li et al., 2008; Schmied et al., 2011; Schmied & Lupton, 2001). Furthermore, qualitative investigations report that thoughts and concerns around the embarrassment of public breastfeeding can mean women are less likely to initiate or maintain it (Wambach & Cohen, 2009).

Beyond physical and social concerns, thoughts about the body also influence breastfeeding practices. Specifically, women are concerned with the physical changes to the breasts due to breastfeeding, feel the need to reclaim their body for themselves after pregnancy, and see the breast as sexual rather than a source of nutrition for infants (Brown et al., 2015;

Dyson et al., 2010). Body dissatisfaction has been more directly implemented in the rate and duration of breastfeeding in research by Brown et al., (2015) that used a longitudinal design to gather self-report questionnaires during pregnancy and 6 months postpartum. Findings indicated that women with higher body image concerns during pregnancy were more likely to use formula milk rather than breastfeeding and had a shorter breastfeeding duration. This effect was found independently of mother's weight during and after pregnancy, suggesting that it is body dissatisfaction rather than actual body size that influenced these feeding decisions (Brown et al., 2015). Although the research by Brown et al., (2015) sheds light on this relationship between body dissatisfaction and breastfeeding outcomes, the sample size used was particularly small (128), with a high attrition rate (50%) at follow up, and consisted of self-selecting, older than average and well-educated participants. These results cannot be extrapolated to the general population, particularly as high maternal educational status has been found to significantly increase the intention to breastfeed (Habtewold et al., 2020). Dyson et al., (2010) recruited younger mothers from lower socio-economic backgrounds, gathering data quantitatively and qualitatively (via focus groups). Results uncovered that participants viewed breastfeeding as a morally inappropriate behaviour, with lower breastfeeding rates associated with the sexualisation of breasts, embarrassment of public feeding and low self-esteem. However, there was no specific measure of body dissatisfaction used in this research, and the sample size was also relatively small (71). This highlights the need for larger and more diverse samples, to investigate breastfeeding within the context of both exteroceptive and interoceptive bodily experiences.

The mode of feeding postpartum is key for infant development, however nutrition received during pregnancy plays a significant role too. Conti et al, (1998) found that low maternal pre pregnancy body weight and low maternal weekly weight gain were predictors of low infant birth weight, suggesting the mother's weight before and during pregnancy plays an important role here. The authors suggest that body dissatisfaction can influence a mother's weight through its impact on unhealthy eating, dieting, and purging behaviours (Conti et al., 1998), which in turn can increase the risk of mothers delivering an infant with low birth weight for its gestational age (Olafsdottir et al., 2006). The research by Conti et al., (1998) used retrospective data on eating behaviours and body weight before and during pregnancy, which is susceptible to information bias and selective recall (Hedegaard et al., 1993). Understanding risk factors behind low infant birth weight is pivotal, as it has been associated with infant mortality and later childhood morbidity (Kramer, 1987). One such risk factor is women who

are suffering with anorexia nervosa or bulimia nervosa, disorders characterised by body dissatisfaction and interoceptive dysfunction, as these women are likely to gain less weight during pregnancy (Stewart et al., 1987). Furthermore, this research does not specifically look at the impact of body dissatisfaction, but rather eating behaviours, and so no firm conclusions can be drawn about the impact of feelings towards the body during pregnancy on infant birth weight. Research has identified that women with disordered eating during pregnancy are more likely to experience postnatal distress alongside body weight and shape concerns (Abraham et al., 2001), however this was not investigated within the context of infant birth weight, and retrospective measures were used. Therefore, further research is required to better understand how infant birth weight is influenced by the pregnancy bodily experience.

It is clear from the literature that the pregnancy bodily experience requires urgent investigation, given its impact on the health and relationship of both mother and baby. Literature has seldom focused on improving understanding of the impact of the bodily experience during pregnancy on long-term mother and infant outcomes. Where research exists, body dissatisfaction is often not the specific focus (rather body image as a whole) (e.g., Brown et al., 2015), interoceptive and exteroceptive bodily experiences are also not considered together (e.g., Chan et al., 2020) or retrospective data has been utilised rather than using a longitudinal design (e.g., Donaghy et al., 2024). This opens the opportunity for future research to study the bodily experience during pregnancy and its impact on mother and infants' postnatal well-being.

1.3. Identifying Research Gaps

1.3.1. Strategies for addressing research gaps

The current literature on this topic has provided some key findings and interesting avenues for future research. However, there is not enough quantitative investigation. Previous work has used small samples (Brown et al., 2015; Bytomski et al., 2020), measures that have not been validated among pregnant women (Singh Solorzano et al., 2022), and not considered both interoceptive and exteroceptive bodily experiences together (Brown et al., 2015). This is alongside a general lack of research investigating the long-term influence of body dissatisfaction and interoceptive sensibility during pregnancy on mother-infant outcomes, with

previous research looking at one point in time or using retrospective data (e.g., Donaghy et al., 2024). A better understanding of the role of bodily experiences during pregnancy, and how they might influence well-being and bonding, can provide important groundwork to improving mother-infant outcomes throughout the perinatal period.

The work presented in this thesis aims to fill this gap by investigating the effects of body dissatisfaction and interoceptive sensibility during pregnancy on antenatal and postnatal mother-infant outcomes. Data will be collected longitudinally, using pregnancy specific measures. Outcomes gathered will include maternal mental health, mother-infant bonding and breastfeeding intentions. In addition, at postnatal time points, infant birth weight, infant development and breastfeeding rate and experience will be gathered. It is hypothesised that high body dissatisfaction and low interoceptive sensibility will have a negative impact on antenatal and postnatal variables. This thesis further aims to establish a suitable measure assessing retrospective pregnancy body dissatisfaction, addressing high attrition rates in longitudinal perinatal studies and providing a tool specifically designed for retrospective analysis. In previous research, where unvalidated retrospective measures of body dissatisfaction have been used, there is uncertainty around the accuracy and reliability of the data. A retrospective measure can therefore facilitate investigations into the impact of pregnancy body dissatisfaction on postnatal outcomes. Finally, this thesis seeks to collate the current evidence on body focused yoga interventions and assess their effectiveness at enhancing postnatal well-being, potentially through improving exteroceptive and interoceptive bodily experiences.

It is anticipated that the current project will result in a better understanding of how to support women and their babies in the long term and could inform early interventions during pregnancy. It would also contribute to increased awareness in those supporting pregnant women on how these bodily changes might influence a mother's bond with their new-born babies, and themselves. Although work thus far has clearly implicated body dissatisfaction and interoceptive sensibility in mother and infant outcomes, the pregnancy bodily experience is still not considered when supporting women through routine antenatal care in clinical settings (Watson et al., 2016). Given that the experience of pregnancy is so overwhelmingly physical, it is surprising that little research has been conducted on how women's feelings towards their pregnant bodies contribute to the health and well-being of mothers and babies.

Finally, this work has the ability to advance theoretical models, such as the Competition of Cues Hypothesis, by providing empirical evidence that can refine and validate the assumptions underlying these models within the context of the perinatal period. This can lead to more a nuanced understanding of the cognitive and perceptual processes during periods of significant bodily changes. This understanding can inform practical implications, such as developing interventions to address negative bodily experiences during pregnancy. Network analysis offers a valuable method for exploring the complex relationships within psychological data that could underpin these interventions.

1.3.2. *Utilising network analysis to bridge the gap*

Network analysis will be used to investigate relationships and patterns between a set of variables or 'nodes'. Beyond being able to identify connections between multiple factors, it can identify central nodes, or the most influential variables within a network. Creating a network using psychological data is a novel way to unpack their associations and is gaining recognition as an effective approach to understand the wider context surrounding psychological concepts and disorders (Epskamp et al., 2018). Using a network analysis for the current research will identify constructs that are central to mother and infant outcomes during both the antenatal and postnatal period. It presents the opportunity to consider multiple facets of the bodily experience alongside multiple perinatal variables, resulting in complex concepts being better understood (Borsboom et al., 2021). Although network analysis cannot determine cause and effect and can produce complex outputs, this approach has the potential to uncover pivotal elements as focal points for intervention strategies (Yuqing et al., 2020).

1.4. Conclusions

Pregnancy is a transformative period for women, with their bodies undergoing multiple physical and physiological changes. The current literature suggests that how women feel about their bodily changes during this time, with little to no research considering the impacts that this may have on mother-infant outcomes postnatally. The literature presented in this chapter concludes that the role of body dissatisfaction and interoception during pregnancy is pivotal to our understanding of mother and infant outcomes during the perinatal period, such as maternal

mental health and well-being, the mother-infant relationship, and infant outcomes such as birth weight.

The role of the bodily experience during pregnancy is yet to be fully understood, with motivation behind this research stemming from the potential for effective interventions, such as yoga and mindfulness, to improve outcomes for women and their babies. Overall, this thesis seeks to provide a clearer insight into how pregnancy bodily experiences influence perinatal outcomes, informing valuable implications to support mothers during this period of transition.

1.5.   Thesis Overview

This thesis investigates the role of interoceptive and exteroceptive bodily experiences during pregnancy on antenatal and postnatal mother-infant well-being and attachment.

Chapter 1 offers a background to interoceptive and exteroceptive bodily experiences during pregnancy and summarises previous literature investigating these experiences within the context of antenatal and postnatal mother-infant outcomes. Research gaps are discussed and suggestions on how to bridge these gaps are made.

Chapter 2 uses cross-sectional data gathered as part of a longitudinal design to identify the relationship between antenatal bodily experiences and antenatal outcomes, including maternal mental health, attachment and breastfeeding intentions. Network analysis and linear regressions were utilised to analyse relationships between interoceptive sensibility, body dissatisfaction and antenatal variables.

Chapter 3 develops a retrospective measure of body dissatisfaction during pregnancy, with the aim to mitigate attrition issues arising from longitudinal research, and effectively assess pregnancy body dissatisfaction during the postnatal period. Cross-sectional data were used to conduct both exploratory and confirmatory factor analyses on a retrospective adaptation of the Body Understanding Measure for Pregnancy (BUMPs) scale, a previously validated scale originally developed to assess body dissatisfaction during pregnancy. Using this model, relationships between retrospective body dissatisfaction and postnatal anxiety, depression and bonding were investigated.

Chapter 4 reports longitudinal data to identify the relationships between antenatal bodily experiences and postnatal outcomes, including maternal mental health, bonding, breastfeeding rate and experience, infant weight and infant development. Two network analyses using data at 3 and 6 months postpartum aimed to uncover the interconnected relationships between interoceptive sensibility, body dissatisfaction and postnatal outcomes.

Chapter 5 presents a systematic review investigating the impact of yoga as an intervention to improve maternal well-being during the postnatal period. Considering the prevalence of body dissatisfaction and mental health issues postpartum, yoga as a potential intervention is significantly under-researched. This review identifies yoga as effective at improving maternal mental health and general well-being, potentially through mitigating body dissatisfaction and enhancing interoceptive sensibility.

Chapter 6 provides a summary of the findings presented in this thesis, offers a general discussion within a theoretical context, and suggests directions for future research.

This thesis is partly that of publication, therefore some chapters have been adapted from published papers. Consequently, there are slight variations in terminology throughout due to the relative journal guidelines, reviewer comments and the papers' wider contexts. For consistency and clarity, the terms 'outcomes' and variables' (referring to dependent measures) are used interchangeably. Additionally, the terms 'attachment' and 'bonding' are distinguished in this thesis. 'Antenatal attachment' refers to a mother's emotional bond with her unborn child, reported by the mother. After birth, the term 'postnatal bonding' is used to describe the mother's self-reported emotional bond with the child, rather than 'postnatal attachment' since the child's perspective is not assessed.

2. Chapter 2: Pregnancy Bodily Experiences and Antenatal Mother and Infant Outcomes

2.1. Abstract

Pregnancy is a transformative time for women and their bodies, and therefore thoughts and feelings about their body and internal bodily sensations may change during this period. Body dissatisfaction and interoception have been found to influence factors such as antenatal attachment and maternal mental health. However, mixed results in the literature suggest complex relationships between the bodily experience during pregnancy and antenatal mother-infant well-being, necessitating a broader investigative approach.

This chapter aims to examine the relationship between the pregnancy bodily experience and multiple mother-infant variables. Cross-sectional online survey data was collected from individuals at various gestations throughout pregnancy as part of a larger longitudinal study (N=253, mean age=32). Validated measures of pregnancy body dissatisfaction, interoception, antenatal attachment and mood, as well as intentions to breastfeed were analysed. Linear regressions were used to confirm findings from previous literature and a network analysis allowed for a more exploratory approach.

Multiple regressions found high body dissatisfaction and low levels of interoceptive body trusting was associated with higher levels of anxiety, depression, and lower levels of antenatal attachment. A network analysis supported these results and went further to identify dissatisfaction with body weight and interoceptive body trusting as the most central components of the network. These results highlight the significance of poor bodily experiences during pregnancy on a variety of variables. Understanding the impact of the pregnancy bodily experience can help identify at-risk individuals and inform interventions.

2.2.   Introduction

During pregnancy, women experience multiple changes simultaneously, including rapid hormonal shifts that result in physiological changes, such as increased cardiac output (Silversides & Colman, 2008). These changes go hand in hand with changes in physical appearance and body shape, including weight gain, enlarged breasts and swollen ankles, highlighting just how physical the experience of pregnancy is. Whilst pregnancy is often a special time, the pressure to look a certain way is present for many women (Kirk & Preston, 2019).

Body dissatisfaction encompasses negative thoughts and feelings about one's own body (Grogan, 2021), and is a pervasive issue for many women, with previous literature suggesting over 20% of females surpass clinical cut offs for weight and shape concerns (Carey et al., 2019). This is an issue given that dissatisfaction with the body is linked to negative effects on well-being, including disordered eating (Thompson & Stice, 2001), depression (Scheffers et al., 2019), anxiety (Lin & Kulik, 2002), and low self-esteem (Henriques & Calhoun, 1999), all of which may be particularly damaging during pregnancy.

Pregnancy can shift the focus away from societal pressures to conform to conventional beauty standards, highlighting the significance of reproduction and a new maternal role for women (Davies & Wardle, 1994). However, many of the bodily changes are conflicting with the social ideals of the appearance of the female body, leaving women pressured to maintain a socially desirable pregnant body shape (Hodgkinson et al., 2014). Pregnant women are having to balance the needs of the foetus with societal beauty standards amidst competing sensations, such as increased appetite (Butte & King, 2005) and reduced physical activity due to pain (Vermani et al., 2010) and fatigue (Chien & Ko, 2004). These pressures can impact on how satisfied women are with their changing pregnant bodies (Kirk & Preston, 2019). Previous research has highlighted the complexity of the bodily experience, and demonstrated significant variation in women's attitudes towards the physical changes that occur during pregnancy, with a recent meta-analysis suggesting some women view the changes as liberating while others find them distressing (Crossland et al., 2023). A recent systematic review explored postnatal bodily experiences and suggested that these were influenced by a variety of personal and societal factors, such as mental health and media influences (Lee et al., 2023). Thus, the authors emphasised the need for a holistic approach to understanding the complexities of women's

bodily experiences in the perinatal period, considering individual, social, and institutional factors, to improve antenatal care and policies.

Positive perceptions of the body during pregnancy have been found to help women adapt to the bodily changes (Clark et al., 2009) and have a stronger bond with their unborn child (antenatal attachment) (Kirk & Preston, 2019). Low levels of antenatal attachment are associated with fewer positive health and safety practices during pregnancy (Jussila et al., 2020) and less attuned mother-infant interaction after birth (Fuller-Tyszkiewicz et al., 2012). Further to this, a woman's dissatisfaction with her changing body during pregnancy has been identified as the strongest statistical predictor of antenatal attachment, accounting for up to 27% of the variance alongside depression and relationship satisfaction (Kirk & Preston, 2019). Although this is from cross-sectional data so cause and effect are only inferred, this may suggest the critical role that the bodily experience during pregnancy can play in maternal and infant well-being. In contrast, research has also shown negative feelings towards the body to be associated with higher levels of antenatal attachment, suggesting that building a strong bond with the baby and understanding the purpose and function of perinatal bodily changes might help women deal with negative emotions related to their body (Małus et al., 2014). However, these contrasting results might be explained by the lack of pregnancy specific measures in the literature. The lack of specificity could compromise the validity of the collected data and overlook important aspects unique to the pregnancy experience (Fuller-Tyszkiewicz et al., 2012). This gap in the literature has been addressed by research such as that done by Kirk & Preston (2019), who created the Body Understanding Measure for Pregnancy scale (BUMPs) to measure pregnancy body dissatisfaction.

Poor bodily experiences have also been related to negative experiences for pregnant women and their babies, such as low birth weights (Conti et al., 1998), low rates of breast feeding (Brown et al., 2015) and depression (Schmied & Lupton, 2001). Depression is very prevalent antenatally and postpartum with estimates varying between 5-25% (Gavin et al., 2005) and 13-19% respectively (O'Hara & McCabe, 2013). Additionally, experiencing antenatal depression heightens the likelihood of postpartum depression (Yu et al., 2023). Depressive symptoms during pregnancy have been linked to negative experiences for both mothers and babies, including emotional withdrawal, substance abuse and preterm delivery (Bowen & Muhajarine, 2006), as well as reduced breastfeeding (Hamdan & Tamim, 2012) potentially due to the hormonal imbalances associated with depression (O'Hara & McCabe, 2013). A review by Silveira et al (2015) concluded that not only was there an association

between body dissatisfaction and perinatal depression, but that body dissatisfaction could predict both antenatal and postpartum depression. Similarly, anxiety is prevalent during pregnancy, with around 15% of women reporting antenatal anxiety (Rubertsson et al., 2014). Body dissatisfaction has been significantly associated with higher levels of anxiety (Chan et al., 2020; Roomruangwong et al., 2017), which consequently has been associated with lower levels of prenatal attachment (Gioia et al., 2023), and poor psychological well-being in pregnant women (Allison et al., 2011).

As well as exteroceptive bodily experiences such as body dissatisfaction, internal bodily experiences (interoception) have been associated with antenatal anxiety and depression (Noda et al., 2022; Singh Solorzano et al., 2022; Singh Solorzano & Grano, 2023). Interoception refers to the awareness of, or attention paid to, visceral (internal bodily) signals such as heart rate, hunger, thirst, and pain (Craig, 2002), and can influence how women feel about their bodies, and their babies, during pregnancy. Examining interoception during pregnancy, Clark et al (2009) gathered qualitative data via interviews, where they reported unique pregnancy experiences that helped pregnant women cope with bodily changes. For example, tuning into their bodies to feel movement of their baby – presumably due to concern for the needs of the foetus – and demonstrating less avoidance of bodily signals such as pain and discomfort, which has also been found quantitatively (Crossland et al., 2022). Signals from within the body during pregnancy have also been implicated in the parent-infant relationship. Perceptual experiences such as the baby kicking being associated with stronger levels of foetal attachment (Heidrich & Cranley, 1989) and interoceptive sensibility, an individual's subjective experience of internal bodily sensations, influencing the mother and infant relationship during pregnancy (Stafford et al., 2024) and postpartum (Suga et al., 2022). This highlights that the bodily experience transcends external appearance.

It is therefore unsurprising that a strong connection has been established between body dissatisfaction and interoception. Notably, Kirk & Preston (2019) found that higher levels of body dissatisfaction during pregnancy are associated with reduced interoceptive sensibility, specifically lower levels of trust in bodily signals (body trusting) and decreased ability to attend to and listen to bodily sensations (body listening). In addition, variations in body dissatisfaction between pregnant and non-pregnant women have been observed to be fully mediated by their respective levels of body trusting (Crossland et al., 2022). This suggests that interoceptive sensibility could potentially be involved in the relationship between pregnancy and body dissatisfaction.

Together, body dissatisfaction and interoception have been linked to breastfeeding, with research suggesting that women with more concerns around their body appearance are less likely to breastfeed, and of those that do, will breastfeed for a shorter duration compared to those who have fewer concerns around their body (Brown et al., 2015). Concerns among women included fear that breastfeeding would damage their breasts or significantly alter their appearance (Brown et al., 2015). However, breastfeeding offers numerous benefits, including lowering stress levels, thus increasing levels of hormones involved in mother-infant attachment such as oxytocin and prolactin (Jansen et al., 2008). Consequently, decisions regarding breastfeeding play a crucial role in understanding the postnatal bond between mother and baby (Linde et al., 2020). Interoceptive body trusting is one mechanism by which body dissatisfaction could influence breastfeeding. During pregnancy, women commonly experience a sense of losing control over their bodies, with rapid physical changes occurring without conscious effort (Schmied & Lupton, 2001). This can lead to feelings of mistrust in the body, which have the potential to negatively impact the pregnancy and birth experience (Crossland et al., 2022). This holds significant implications for breastfeeding, with qualitative research indicating that when mothers trust in their body's capabilities, it results in a positive and fulfilling breastfeeding experience (Flacking et al., 2021).

Overall, the literature suggests that both body dissatisfaction and interoception could be closely related within the context of perinatal well-being. The importance of considering these concepts together comes from The Competition of Cues Hypothesis (Pennebaker & Lightner, 1980), suggesting that as attention towards the body is limited, both internal cues (interoception), and external cues (such as body dissatisfaction) are in competition with each other. In line with this hypothesis, it is suggested that body dissatisfaction may divert attention from crucial internal bodily signals which is associated with increased anxiety and depression (Noda et al., 2022; Singh Solorzano et al., 2022; Singh Solorzano & Grano, 2023), and a reduction in antenatal attachment (Heidrich & Cranley, 1989). Despite this, to date no study has comprehensively investigated both interoceptive and exteroceptive body experiences concurrently in the antenatal period with all these variables. It is hoped that a better understanding of the pregnancy bodily experience will improve awareness surrounding how women feel about their bodies during pregnancy, as currently, a woman's bodily experience is not considered in routine antenatal care settings (Watson et al., 2016). This knowledge could lead to investigations into interventions that target maternal pregnancy body dissatisfaction with the aim of improving the pregnancy experience and antenatal well-being.

2.2.1. *Aims & hypotheses*

The present study seeks to use pregnancy specific measures to assess pregnancy body dissatisfaction and interoception to identify any potential associations with key mother-infant antenatal variables, including antenatal attachment, anxiety, depression, and breastfeeding intentions. Regressions aim to replicate previous quantitative findings, whereas the primary analyses of a network analysis strives to expand upon this by investigating the relationships among different aspects of the bodily experience and antenatal variables simultaneously. It is predicted that regressions will find higher levels of body dissatisfaction and lower levels of interoception to be associated with lower levels of antenatal attachment, and increased levels of depression and anxiety. As the network analysis is exploratory, beyond the predictions assumed for the regression analyses, no additional predictions are made regarding potential associations. It is expected that there will be a complex display of relationships between body dissatisfaction, interoception, and various mother-infant variables, in the hope that this will shed light on the critical role of the bodily experience in maternal well-being and the mother-infant relationship during the antenatal period.

2.3.   Method

2.3.1. *Participants*

This research is part of a larger project that aims to investigate the long-term impact of body dissatisfaction during pregnancy on postnatal variables. The current study received ethical approval from the University of York Departmental Ethics Committee (ref: 122) and was preregistered on OSF (https://osf.io/57kc2/). All participants provided informed consent prior to taking part. Participants responded to online advertisements to take part in an online survey hosted by Qualtrics (https://www.qualtrics.com). The advertisements were distributed via social media sites (Instagram, Facebook), parenting websites (Mumbler, Mumsnet), groups and classes, and local nurseries and GP surgeries.

Overall, 260 pregnant women completed this antenatal questionnaire. See Table 2.1 for a summary of participant demographics following exclusions. Exclusion criteria included women under 18, those diagnosed with depression or anorexia (self-disclosed as having a clinical diagnosis assessed via online consent form), incomplete data (those who didn't provide

data for any key variables), and past due dates. Two participants were excluded due to incomplete responses and 5 were excluded due to them not being pregnant at the time of completion. This left 253 participants.

Table 2.1. Sample demographics.

Demographics	Mean (SD)/%
Mean maternal age (SD)	31.9 (5.0)
Gender Female (%)	100
Mean number of weeks pregnant (SD)	27.6 (10.0)
% first pregnancy	55.7
Number of children including pregnancy (SD)	1.6 (0.8)
Trimester (%)	
First trimester (weeks 1-12)	8.2
Second Trimester (weeks 13-26)	38.1
Third Trimester (weeks 27-40+)	53.7
Relationship status (%)	
Married/civil partner	58.9
Living with partner	36.8
In a relationship living apart	2.4
Single	2.0
Ethnicity (%)	
White	95.7
Mixed	2.8
Asian	0.8
Black, African, Caribbean or Black British	0.8
Education Level (%)	
School leaver	0.4
GCSEs	6.7
NVQ (Level 1-2)	2.0
NVQ (Level 3-5)	8.7
A levels/IB	7.1
HND or BTEC	5.1
Undergraduate Degree	37.2
Postgraduate Degree	27.7
Doctoral Degree	5.1

Employment (%)		
Full time		61.3
Part Time		28.5
Student		2.0
Unemployed		8.3
Single births (%)		98.8
Pre pregnancy BMI (SD)		25.9 (6.0)

N=253

2.3.2. Materials

Qualtrics (Qualtrics, 2020) was used to create and distribute the surveys to participants. Appropriate information, consent and debrief forms were used and presented to participants within the survey.

2.3.3. Measures

2.3.3.1. Self-report questionnaires

Pregnancy body dissatisfaction, interoceptive sensibility, anxiety, depression, and antenatal attachment were all measured using validated self-report questionnaires. Please see further details of these in Table 2.2.

Table 2.2. Self-report questionnaires.

Measure	Items	Subscales	Responses	Scoring	Reliability
Body Understanding Measure for Pregnancy Scale (BUMPs; (Kirk & Preston, 2019)	19	*Appearance* (9 items) - dissatisfaction with appearing pregnant; *Weight* (7 items) - concerns about weight gain; *Physical* (3 items) - the experience of the physical burdens of pregnancy	Recorded on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).	Sum items for individual subscale scales and all 19 items for a global score. Higher scores indicate more dissatisfaction.	Internal consistency (α = .71 - .91). Test-retest reliability (.78 - .93). (Kirk & Preston, 2019)
Multi-dimensional Assessment of Interoceptive Awareness for Pregnancy (MAIA-Preg;	19	*Emotional Awareness* (4 items) - awareness of bodily signals; *Not-distracting* (3 items) - tendency not to distract from sensations of pain or discomfort; *Attention regulation* (6 items) - ability to sustain and control attention to bodily sensations; *Self-regulation*	Responses are recorded on a 6-point Likert scale ranging from 0 (*never*) to 5 (*always*).	The score for each scale is calculated by the mean of its individual items. There is no global score.	Internal consistency (α = .63 - .87) (Crossland et al., 2024).

Crossland et al., 2024)[a]		(3 items) - ability to regulate psychological distress by attention to bodily sensations; *Trusting* (3 items) - the experience of one's body as safe and trustworthy.			
Maternal Antenatal Attachment Scale (MAAS; (Condon, 1993)[b]	19	*Quality of Attachment* (10 items) - feelings of closeness and pleasure in interaction; *Strength of Intensity of Preoccupation* (8 items) - extent to which the foetus occupies a central place in the woman's emotional life	Responses are provided on a 5-point Likert.	A Global Attachment Score is calculated from the sum of all 19 items (one item does not load on either subscale)	Reliability (α = .82) for the total scale (Condon, 1993)
the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983)	14	*Anxiety* (7 items); *Depression* (7 items)	Statements are rated on a 4-point Likert scale of 0 – 3.	Subscales are summed to generate an overall subscale score. Higher scores indicate higher anxiety and depression.	Internal consistency in pregnant samples (α = .74 - .81 (Kirk & Preston, 2019)

[a]*The MAIA-Preg was adapted from the Multi-dimensional Assessment of Interoceptive Awareness scale (MAIA; Mehling et al., 2012). Questions that were not pertinent to pregnant women were removed, and the subscales underwent refinement through a factor analysis. Consequently, the MAIA subscales of 'not worrying,' 'body listening,' and 'noticing' were eliminated from the scale.*

[b]*For ethical reasons the current study omitted two items contributing to the intensity scale relating to feelings of wanting to punish the foetus and feelings if the pregnancy were to be lost.*

2.3.3.2. Feeding Intentions

Feeding intentions were gathered by asking participants how they intended to feed their baby (with response options including breastfeeding, formula or combination feeding). Similar questions on breastfeeding have been included in previous research by Brown et al (2015). Those who did not select breastfeeding were coded as 0. If breastfeeding was selected, a follow up question was presented asking how long women intended to breastfeed for. Responses were standardised on a Likert scale consisting of 6 responses coded 1 (less than 1 month), 2 (between 1 and 3 months), 3 (between 3 and 6 months), 4 (between 6 and 9 months), 5 (between 9 and 12 months) and 6 (more than 12 months).

2.3.4. Procedure

2.3.4.1. Survey

Participants were invited to complete the surveys online via a Qualtrics link. They were presented with an information sheet and provided with tick boxes to consent to taking part. They were then presented with the questions, followed by a debrief form.

2.3.5. *Data analysis*

2.3.5.1. *Regression analyses*

Global and subscale scores were appropriately calculated for all the measures according to the relevant scoring guidelines. Data was checked for assumptions for a linear regression, including normality, multicollinearity, linearity, and homoscedasticity. All possible theory-based covariates were included in initial regression models, with those not showing statistical significance (>0.05) being removed to maintain model parsimony. Possible covariates included gestation (weeks pregnant), age, parity, BMI, education level and relationship status.

Linear regressions were used to assess the relationship between the regressors (body dissatisfaction and interoceptive body trusting) and antenatal variables, including attachment, anxiety, and depression, in order to directly replicate previous findings. Due to the lack of a comprehensive global interoception score in the MAIA-Preg, the 'body trusting' subscale was used. This decision was informed by its established association with body dissatisfaction among pregnant women (Crossland et al., 2022) and antenatal attachment (Stafford et al., 2024). Further to this, its consistency as a subscale in both the MAIA and MAIA-Preg frameworks (Crossland et al., 2024) demonstrates its reliability and relevance in this context. Single forced entry regressions were used as covariates were considered as potential bias variables, rather than additional regressors. Analyses were conducted using Python Jupyter Lab (Kluyver et al., 2016) and the OLS module from the statsmodels package (Perktold et al., 2023).

2.3.5.2. *Partial correlation network analyses*

A partial correlation network analysis was conducted to explore the relationships between all the data gathered during the antenatal period including body dissatisfaction, antenatal attachment, interoceptive sensibility, anxiety, depression and feeding intentions. This was done using a partial correlation matrix using the 'qgraph' package in RStudio (Epskamp et al., 2012; RStudio Team, 2020). A mixed graphical model using partial correlation was used instead of gaussian models due to the lack of multivariate normality across the data (p=0.025) and due to the inclusion of categorical and continuous data. Regularisation was not implemented to the network due to the violation of the assumption of sparsity. Although the network is exploratory, all included nodes are predicted to play a role in the network. Thus, implementing regularisation, which imposes sparsity on the network, may miss some meaningful associations

between nodes of interest. The network was bootstrapped 1000 times using the Bootnet package in RStudio, allowing us to calculate confidence intervals for each of the partial correlations (or edge weights) in the network. To assess the stability of the network, case-dropping bootstrapping using the Bootnet package in RStudio was conducted, enabling us to evaluate the robustness of the network by systematically removing cases and analysing its impact on the results. Due to the exploratory nature of this analysis, potential covariates were added as nodes due to their relationship with body dissatisfaction in previous literature, including age (Tiggemann & McCourt, 2013), gestation (Skouteris et al., 2005) and BMI (Quittkat et al., 2019).

2.4. Results

2.4.1. Descriptive statistics

Overall, 253 participants were included in analyses. See Table 2.3 for detailed descriptives.

Table 2.3. Descriptive statistics.

Measure	Mean (SD)	Range
BUMPs (SD) [1]	59.7 (13.6)	33-95
BUMPs Appearance	26.4 (6.8)	9-45
BUMPs Physical	11.5 (3.1)	3-15
BUMPs Weight	21.8 (6.8)	7-35
AA (SD) [2]	66.6 (7.2)	45-81
AA Intensity	27.5 (4.4)	14-38
AA Quality	34.6 (3.5)	22-40
MAIA_Preg (SD) [3]		
MAIA_Preg Emotional Awareness	11.9 (4.2)	0-20
MAIA_Preg Not Distracting	6.0 (2.9)	0-14
MAIA_Preg Attention Regulation	15.7 (5.3)	0-30
MAIA_Preg Self-Regulation	8.0 (3.2)	0-15
MAIA_Preg Trusting	8.6 (3.7)	0-15
HADS (SD) [2]		
Anxiety	8.0 (3.7)	1-18
Depression	5.7 (3.1)	0-17

Feeding intention (%) [1]	
Breastfeeding	68.4
Formula feeding	20.5
Combination feeding	11.1
Intended breastfeeding duration (%) [4]	
Less than 1 month	25.3
Between 1 and 3 months	24.9
Between 3 and 6 months	22.7
Between 6 and 9 months	16.0
Between 9 and 12 months	7.6
More than 12 months	3.6

[1]N=253, [2]N=201, [3]N=197, [4]N=225

2.4.2. Linear regressions

Linear regressions were conducted to examine the relationship between the regressors (body dissatisfaction and interoceptive body trusting) and multiple variables including antenatal attachment, anxiety, and depression, in order to replicate previous findings. See Table 2.4 for results considering covariates and Figure 2.1 and 2.2 for visualisations of the variables of interest. There was no change in significance levels for regression results without covariates (see Appendix A.1).

Table 2.4. Regression results with body dissatisfaction and body trusting as regressors.

	df	Beta	t value	*p* value	F	F *p* value	Adjusted R^2
Body dissatisfaction							
Antenatal attachment[a,b]	197	-0.098	-2.61	0.010	7.81	<0.001	0.093
Anxiety[d]	199	0.057	2.92	0.004	8.51	0.004	0.036
Depression[a,c]	197	0.093	6.27	<0.001	18.85	<0.001	0.211
Body trusting							
Antenatal attachment[a,b]	140	1.506	3.26	0.001	9.56	<0.001	0.152
Anxiety[d]	145	-1.297	-5.47	<0.001	29.88	<0.001	0.165
Depression[a,c]	143	-0.825	-4.22	<0.001	10.02	<0.001	0.156

Distinct regression models were employed for each variable. Beta coefficients pertain specifically to the relationship between the body dissatisfaction or interoceptive body trusting and the mentioned variable.
[a]Parity as a covariate, [b]Gestation as a covariate, [c]Age as a covariate, [d]No covariates
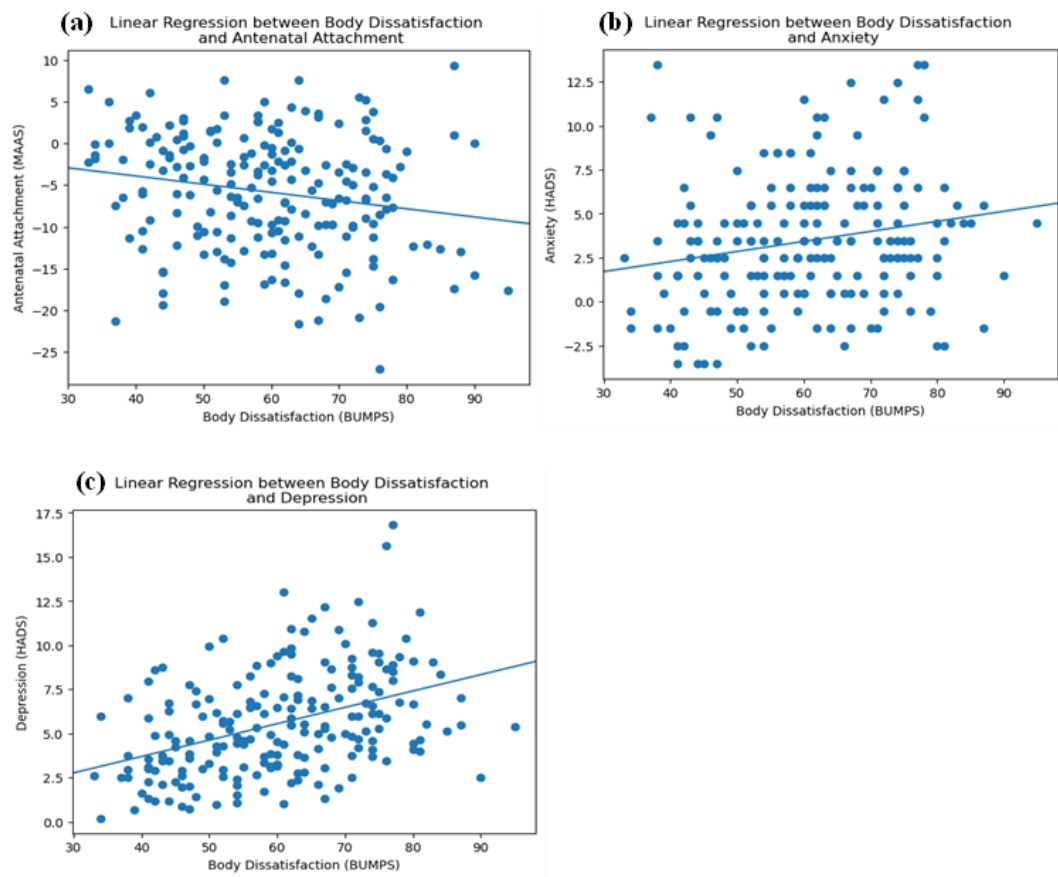
Figure 2.1. Regression plots showing the relationship between interoceptive body dissatisfaction and antenatal attachment (a), anxiety (b), and depression (c).
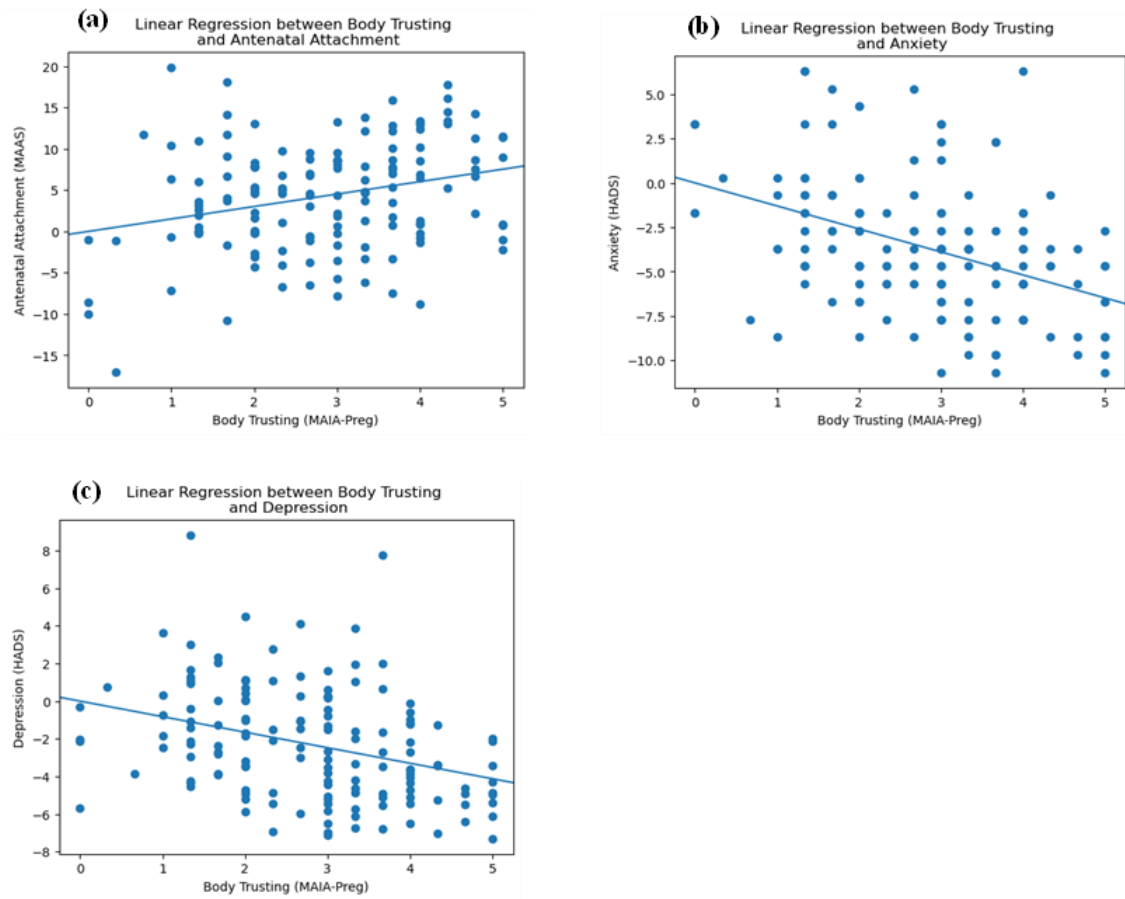
Figure 2.2. Regression plots showing the relationship between interoceptive body trusting and antenatal attachment (a), anxiety (b), and depression (c).

2.4.3. *Partial correlation network analysis*

The network in Figure 2.3 examines the relationships between the BUMPs subscales and multiple variables. The network consisted of 16 nodes representing individual variables and their connections. The decision was made to include the subscales of all the measures collected, particularly those of the BUMPs, in order to further delve into the relationships outlined by the regression analyses above. Resample and case-drop bootstrapping were applied, showing a robust and stable network. Please see further details in Appendix A.2.
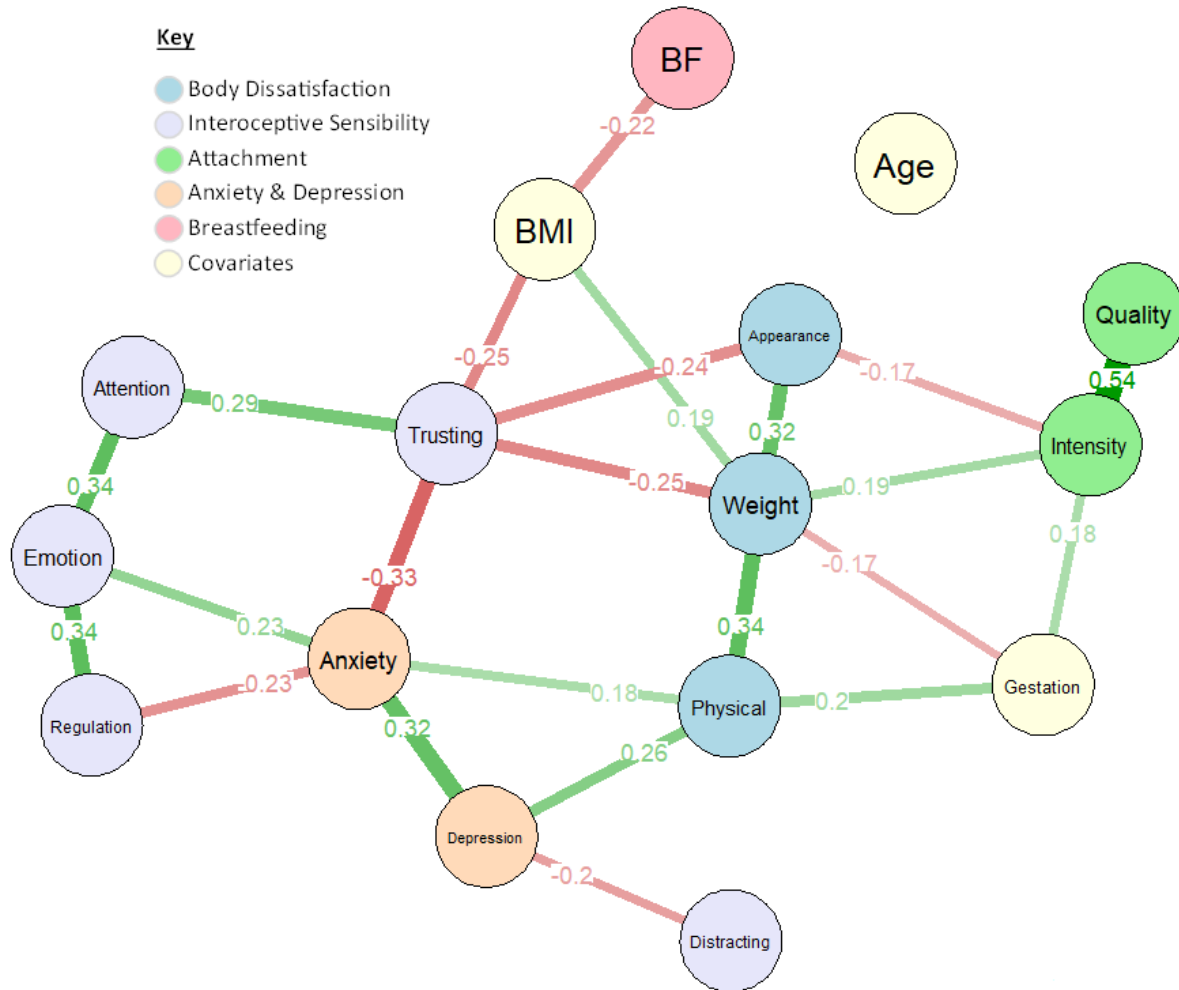
Figure 2.3. A partial correlation network analysis to show the relationships between body dissatisfaction during pregnancy and mother-infant variables. Nodes represent variables, and edges represent the strength of the connections between nodes. Green edges represent positive relationships and red edges represent negative relationships.

Four key network properties were investigated: edge weights, degree centrality, strength centrality, betweenness centrality and clustering.

2.4.3.1. Edge weights

Edge weights are the values assigned to the connections or 'edges' within a network. The edge density (ratio between the actual and possible number of edges) was calculated as 0.192, suggesting a relatively sparse network.

The edge weights show significant negative relationships between the appearance BUMPs subscale and antenatal attachment intensity and interoception (body trusting), suggesting that higher dissatisfaction with the body's appearance is related to lower levels of attachment and body trust. The weight BUMPs subscale was positively associated with

antenatal attachment intensity and negatively associated with body trusting, suggesting that higher dissatisfaction with the body's weight is related to higher levels of attachment and lower levels of body trust. The physical BUMPs subscale showed positive relationships with depression, gestation and anxiety, suggesting that higher dissatisfaction with the body's physical ability is associated with higher levels of depression, anxiety, and longer gestation.

Interoceptive subscales were found to be associated with anxiety and depression, but none directly with antenatal attachment. Specifically, higher levels of anxiety were linked with lower levels of interoceptive self-regulation and body trusting, and higher levels of interoceptive emotional awareness. Higher levels of depression were associated with the interoceptive not-distracting subscale.

2.4.3.2. Centrality

Analysis into the degree centrality of nodes (how well connected one node is to other nodes), found that nodes varied in their number of connections, ranging from 0 to 6. The BUMPs weight subscale and body trusting nodes had the highest degree centrality, with 6 and 5 connections respectively.

Strength centrality (how well connected one node is to other nodes, considering the weights associated with those connections), suggests that the BUMPs weight subscale was the strongest (1.46), closely followed by body trusting (1.35).

Betweenness centrality shows the extent to which a certain node lies on the shortest paths between other nodes, with high betweenness centrality indicating that the node acts as a 'bridge' to other nodes, encouraging the connections within the network analysis. Our results suggest that body trusting was the node with the highest betweenness centrality (35), followed closely by the BUMPs weight subscale (32). See Appendix A.3 for all node centrality coefficients.

2.4.3.3. Clustering

The node clustering coefficient measures the extent to which the neighbours of a specific node are connected to each other. Nodes with the highest clustering coefficient indicate a large density of connections around them. Interoceptive self-regulation had the highest clustering coefficient of 1, suggesting that all its neighbouring nodes were directly connected to each other. This node was followed by the BUMPs appearance subscale and gestation, both with clustering coefficients of 0.67. This suggests that these variables have a relatively high local

clustering pattern within the network, and a significant proportion of the nodes they connected with connect with each other. Nodes exhibiting higher clustering coefficients may assume a less pivotal role within the broader network, as their neighbouring nodes are interconnected. Consequently, these nodes can be viewed as contributing less unique or distinctive information to the network (Costantini & Perugini, 2014). See Appendix A.3 for all node clustering coefficients.

2.5.   Discussion

The current findings reveal associative relationships between aspects of the bodily experience, specifically body dissatisfaction and interoceptive body trusting, and antenatal factors, such as antenatal attachment, anxiety, and depression. These associations suggest that the way women feel about their bodies and internal signals during pregnancy relates to aspects of their mental well-being, and their relationship with their unborn baby. A clearer understanding of these relationships has provided insight into the importance of the bodily experience in mother-infant well-being and highlights a rationale for more in-depth research into the mechanisms behind these relationships.

Examining the regressions reveals that lower levels of body dissatisfaction and higher interoceptive body trusting are associated with higher levels of antenatal attachment, and lower levels of anxiety and depression. This is in agreement with the previous literature (Kirk & Preston, 2019; Stafford et al., 2024) and supports our hypotheses, confirming the importance of the bodily experience during pregnancy. The amount of variance explained by the bodily experience was particularly interesting, with body dissatisfaction accounting for more variance in depression scores compared to anxiety and attachment. Body dissatisfaction during pregnancy has been found to be more strongly associated with depression than anxiety (Kirk & Preston, 2019), likely attributed to the physiological demands placed upon the body, consequently limiting women from engaging in activities they previously enjoyed prior to pregnancy. In comparison, interoceptive body trusting accounted for more consistent variance across attachment, anxiety, and depression, potentially suggesting a more fundamental role in mother and infant factors. While the regression analyses offered valuable insights into the overarching connection between the bodily experience and mother-infant variables, there was

a lack of depth surrounding the intricate interactions among subscales within the broader constructs.

The holistic approach of the network analysis shed light on this matter by revealing the facets of body dissatisfaction and interoception that exhibited stronger connections with specific variables of interest. Notably, dissatisfaction regarding body appearance, weight, and physical ability were distinctively linked to maternal and infant well-being. Concern with body weight and appearance were associated with lower body trusting, thus being dissatisfied with the body may lead to less trust in bodily sensations, or vice versa. Research has already suggested that body dissatisfaction and interoception are inherently linked both in pregnant and non-pregnant samples (Crossland et al., 2022), and that body weight concerns may play a key role in interoceptive sensations during pregnancy (Kirk & Preston, 2019). It is therefore understandable that the network implicates body mass index (BMI) in the relationship between body dissatisfaction and interoception, with women who reported higher BMIs before pregnancy reporting increased levels of weight dissatisfaction and body trusting. This is consistent with previous literature, with high BMI being associated with poorer interoception (Robinson et al., 2021) and body dissatisfaction (Quittkat et al., 2019).

As pregnancy progresses, body weight typically increases due to the growing foetus. The network suggests dissatisfaction with body weight tends to decrease as gestation increases supporting previous literature (Crossland et al., 2022), however contrary to the link between weight dissatisfaction and pre-pregnancy BMI. Skouteris et al., (2005) found that women in their 3rd trimester felt less fat compared to those earlier in pregnancy, suggesting that this may be due to looking more noticeably pregnant at later gestation. This could explain why individuals in the current study experienced fewer weight concerns as pregnancy progressed, suggesting a distinct disparity between how body dissatisfaction is viewed between pregnant and non-pregnant bodies. This disparity further supports the use of pregnancy specific measures to capture the bodily experience which were used in the current research via the Body Understanding Measure for Pregnancy (Kirk & Preston, 2019) and the Multidimensional Assessment of Interoceptive Awareness for Pregnancy (Crossland et al., 2024). Measures for use among the general population may fail to capture nuanced aspects of the bodily experience during pregnancy, and so may make data more specific and relevant to the unique bodily changes and experiences, thus enhancing the accuracy and validity of findings.

The network was able to further clarify the involvement of intentions to breastfeed within the wider context of the bodily experience, revealing that breastfeeding intention was indirectly related to weight and physical dissatisfaction and interoceptive body trusting, through BMI. Therefore, those with higher BMI's had less intention to breastfeed, and for those that did intend to breastfeed, this was for a shorter period. This aligns with previous literature which has linked both body dissatisfaction (Brown et al., 2015) and BMI (Amir & Donath, 2007) with breastfeeding intentions. It has been suggested that this could be due to socio-cultural factors, with obese women being more likely to come from lower socio-economic backgrounds and engage in fewer health and safety practices during pregnancy (Amir & Donath, 2007), as well as cultural factors, such as embarrassment of breastfeeding in public and concerns around the impact of breastfeeding on the appearance of breasts (Brown et al., 2015). Although these results were consistent with our hypotheses, the current sample were self-selecting, majority white and well-educated, with 79.5% intending to breastfeed. Therefore, firm conclusions cannot be drawn from such a limited sample. Further research is also needed to uncover what happens postnatally, as some mothers may change their mind or never start breastfeeding or breastfeed for a shorter or longer period than they initially planned.

Interestingly, not all the relationships displayed within the network were consistent with our predictions, for example, high levels of dissatisfaction with body weight was associated with higher levels of antenatal attachment intensity (frequency of thoughts about the baby), but not attachment quality (affective valence of the thoughts about baby). Małus et al, (2014) studied the relationship between body dissatisfaction during pregnancy and antenatal attachment by gathering self-report data from 100 women in their 2nd trimester. Their analysis showed that greater dissatisfaction with the body during pregnancy was related to stronger attachments, concluding that despite body dissatisfaction, it is still possible to develop a positive bond with the foetus. This could be explained by women who are more dissatisfied with their body weight focusing more on their body, which could lead to them thinking more about the baby (attachment intensity), but not necessarily thinking more negatively about the baby (attachment quality). Therefore women who spend more time thinking about their bodies may be more likely to have a stronger relationship with their babies (Kirk & Preston, 2019). Alternatively, focusing on the baby's well-being and anticipating the joy of motherhood could help alleviate any negative feelings about their weight, and serve as an emotional coping mechanism. However, the relationship between body weight dissatisfaction and antenatal attachment is in contrast with the networks finding that dissatisfaction with body appearance

was associated with lower attachment intensity, supporting the majority of previous literature looking at body satisfaction and antenatal attachment (e.g. Kirk & Preston, 2019). Appearance and weight related body dissatisfaction subscales may have different effects since weight gain may be more directly related to physical changes and health of the unborn baby (e.g. "I feel like my bump is too big"), compared to general body appearance (e.g. "It upsets me when people comment on my changing body"). A third variable that could be playing an important role here is parity, with body dissatisfaction being elevated (Crossland et al., 2022) and antenatal attachment being lower among those who already have children (Condon & Esuvaranathan, 1990), suggesting this should be considered in further analyses.

Overall, the network implicates the bodily experience in attachment intensity rather than quality. This suggests that thoughts and feelings towards the body are more strongly associated with how often women think about the baby rather than whether those thoughts are positive or negative. Incorporating the Competition of Cues Hypothesis (Pennebaker & Lightner, 1980) could shed light on this, as it suggests individuals who focus more on external cues, such as societal standards of body image during pregnancy, may pay less attention to signals from within the body, which as well as interoception, could also incorporate sensations directly from the foetus. Future research should gain a more comprehensive understanding of whether metrics assessing bodily experiences encompass concepts that impact the mental capacity to think about the foetus. This exploration could reveal whether dissatisfaction with appearance potentially diminishes this cognitive capacity, while a strong sense of body trusting might enhance it by preventing excessive worry and hypervigilance.

As well as the network revealing how body weight and appearance dissatisfaction relate to the mother-infant relationship, it highlights the significance of dissatisfaction with the body's physical abilities in maternal mental well-being, supporting existing research findings (e.g. Kirk & Preston, 2019). Changes during pregnancy can result in women being unable to do things that they had done pre-pregnancy potentially due to fatigue (Chien & Ko, 2004) and pain (Vermani et al., 2010). Dissatisfaction around the bodies physical abilities could contribute to feelings of depression and anxiety due to a reduction in endorphin release, socialising, and stress relief activities (Marín-Jiménez et al., 2022). Interoception also seems to play an important role in levels of anxiety and depression, with low levels of trusting and self-regulatory interoception, and high emotional awareness being associated with increased anxiety symptoms. Previous literature has implicated interoception in anxiety, with anxious individuals more likely to pay attention to internal bodily signals (as a way of protecting

themselves from danger), and less able to self-regulate interoceptive signals and trust the body (Garfinkel et al., 2015; Hsueh et al., 2023).

Looking more holistically at the network, the centrality of nodes suggests that body weight dissatisfaction and interoceptive body trusting were the most significant nodes in the network. Therefore, these nodes play a crucial role in mediating the connections and information flow within the network, exerting a substantial influence on other variables, and contributing significantly to the overall dynamics and interactions. The network showed a high clustering coefficient for the node of interoceptive self-regulation, suggesting its neighbouring nodes - interoceptive emotional awareness and anxiety - are highly interconnected. While this supports the established link between interoception and anxiety (Garfinkel et al., 2015), it also implies that interoceptive regulation's role in anxiety is not unique, underscoring the importance of considering interoception's multifaceted nature and its varied contributions to anxiety across different contexts (Costantini & Perugini, 2014). The use of a partial correlation network analysis, a novel statistical technique in this research area, has allowed for a comprehensive exploration of the interconnectedness between body dissatisfaction, interoception and various mother and infant variables. The network analysis technique captures the holistic nature of the bodily experience during pregnancy and goes beyond simple associations. By examining the frequency, strength, and direction of connections between variables, while accounting for other variables in the network, the analysis provides a nuanced understanding of their complex relationships and highlights the importance of both body dissatisfaction and interoception in the wider context of mother-infant well-being.

The inherent connection between body dissatisfaction and interoception, as observed in our pregnancy network analysis, holds implications not only for the well-being of expectant mothers but also for broader contexts of general well-being and other critical life stages characterised by significant physical transformations, such as menopause and puberty. This model, although specific to pregnancy, can serve as a lens through which complex associations between body dissatisfaction, mental health and well-being are examined. The significant bodily changes experienced during pregnancy make it an ideal focal point for investigating these dynamics. Consequently, heightened interoceptive attention could potentially impact the relationships between body dissatisfaction and well-being.

As is the nature of research, there were limitations to the methodology of the current study. Firstly, the use of self-report measures relies on the honesty and accuracy of participant

responses, with participants potentially providing socially desirable answers. This is a particular issue when gathering data on levels of antenatal attachment, as negative feelings towards their unborn babies is something many women feel uncomfortable disclosing, partly due to the social stigma (Filippetti et al., 2022). Further to this, the self-report format may result in sampling bias, as it may attract a certain population who have the time to complete the research and find the research easily accessible. This can be seen in the current sample, with 70% being educated to degree level or above.

Another issue is the lack of ethnic diversity among the participants, with most participants taking part being from a white background. Lack of representation of ethnic minority groups is a wide-reaching issue across healthcare research (Redwood & Gill, 2013), which may partly contribute to poorer experiences within maternity settings for non-white individuals (Henderson et al., 2013). Previous literature has suggested differences between ethnicities when it comes to body dissatisfaction among the general population (Miller et al., 2000) and further research is needed to better understand the differences in pregnancy body dissatisfaction between different ethnic groups.

Finally, due to the nature of the analyses conducted, and the cross-sectional design, causality and directionality cannot be established, it cannot be definitively confirmed whether lower scores on our measures are partly caused by low levels of body dissatisfaction, or vice versa. The decision was made not to employ statistical regularisation (to protect against overfitting) in our network analysis, as detailed in the methods section. While this decision aligns with our assumptions and objectives, it is essential to recognise it as a potential limitation, as it may lead to the exclusion of certain less robust associations between variables. However, the edge density and bootstrapping statistics suggest that overfitting is unlikely to be an issue in the current network.

2.6.   Conclusions

These findings highlight the importance of integrating discussions on the bodily experience into antenatal healthcare appointments, ensuring that the emotional and psychological aspects of pregnancy are also considered. This could also contribute to reducing the stigma around discussing body dissatisfaction during pregnancy, with the physical health of both mother and baby often prioritised over maternal mental well-being (Hodgkinson et al.,

2014). Furthermore, this research suggests a need for interventions aimed at improving the bodily experience during pregnancy. For example, yoga has been found to improve well-being through improving mindfulness, feelings towards the body and interoceptive awareness (Tihany et al., 2016), and has shown promise for improving maternal well-being both antenatally (Jiang et al., 2015) and postnatally (Munns et al., 2024).

To conclude, the results clearly illustrate that the bodily experience is multifaceted and significantly relates to various factors, with dissatisfaction with pregnant body weight and interoceptive body trusting being strongly associated with maternal and infant well-being. Looking at body dissatisfaction and interoception in a one dimensional or simplistic way may limit our understanding of the nuanced connections between bodily experiences and maternal and infant well-being. The network analysis shows us how central these concepts are to our understanding of the wider context regarding mother and infant well-being. Future research needs to investigate the long-term impacts of the perinatal bodily experience and how interventions promoting the bodily experience during pregnancy could improve the well-being of mother and baby.

3. Chapter 3: Retrospective Body Dissatisfaction - Links to Postnatal Bonding and Psychological Well-being

3.1. Abstract

Pregnancy is a transformative time for women and their bodies, and therefore thoughts and feelings about the body understandably change during this period. While previous research has established the impact of body dissatisfaction on factors like antenatal attachment and maternal mental health, there is a notable gap in understanding its long-term effects on postnatal factors. This is often due to high attrition rates in longitudinal studies. Using retrospective measures could address this issue, however a measure of retrospective pregnancy body dissatisfaction has not yet been identified. This paper aimed to create a retrospective measure of pregnancy body dissatisfaction by adapting a previously validated measure. It also aimed to investigate the relationship between retrospective accounts of body dissatisfaction during pregnancy and postnatal anxiety, depression, and bonding.

Cross-sectional online survey data was collected from women postnatally (N=404). An exploratory and confirmatory factor analysis identified a two-factor model of retrospective body dissatisfaction, adapted from the Body Understanding Measure for Pregnancy Scale (BUMPs), which was equivalent to two of the original subscales. Using this factor structure, linear regressions demonstrated that higher levels of retrospective pregnancy body dissatisfaction were associated with elevated rates of postnatal anxiety and depression and lower bonding scores.

This study successfully established a measure for assessing retrospective pregnancy body dissatisfaction, potentially aiding future research. Links between pregnancy body dissatisfaction and postnatal levels of depression, anxiety, and bonding have been highlighted. Improving the pregnancy bodily experience may therefore have the potential to enhance postnatal mental health and bonding.

3.2.   Introduction

With pregnancy comes many changes, physiologically, physically, and psychologically. The most obvious of these changes relate to a woman's body and appearance, which can include weight gain, hair loss and swollen ankles, all of which are out of the woman's control (Neiterman & Fox, 2017), in addition to the expected changes such as growing abdomen and larger breasts. Pregnancy is often a unique and special experience for women; however, there is still pressure to adhere to social expectations of what the female pregnant body should look like, such as having a 'neat bump', or not looking pregnant from the back (Kirk & Preston, 2019). Therefore, it is important to consider how women feel about their body.

It is also crucial to consider the impact of women's feeling towards their body due to the relationships between body dissatisfaction and maternal psychological well-being. Body dissatisfaction is defined as negative thoughts and feelings about one's own body (Grogan, 2021), and has been linked to mental ill-health such as depression (Scheffers et al., 2019), eating disorders (Romano et al., 2021) and anxiety (Chan et al., 2020). This may arise from societal pressures to be thin, exposure to harmful media ideals (Huang et al., 2021) and higher body mass (Eck et al., 2022). These negative feelings towards the body can also exist during pregnancy, as many bodily changes that occur are in direct conflict with the ideal female appearance and there are still societal pressures to look a certain way (Hodgkinson et al., 2014), for example, maintaining a slim physique with the exception of a bump (Gow et al., 2012). Women often struggle to maintain a balance between the foetus's needs and beauty standards, due to increased appetite and reduced physical activity (often due to pain) (Butte & King, 2005; Vermani et al., 2010). Therefore, it is understandable that these social pressures can impact how satisfied women are with their pregnant body (Kirk & Preston, 2019).

However, for some, societal ideas regarding appearance decrease during pregnancy, with more focus on the importance of reproducing, where the act of bringing new life into the world and the maternal role are seen as fundamental aspects of human nature (Clark et al., 2009). Research corroborates these contrasting feelings towards the pregnant body, with some women viewing the physical changes as liberating, and others distressing (Crossland et al., 2023). Despite this, body dissatisfaction is still not considered or addressed when supporting women through routine antenatal care in clinical appointments (Watson et al., 2016).

Research shows that women who experience negative pregnancy bodily experiences often have poorer psychological outcomes, such as higher levels of anxiety and depression

(Scheffers et al., 2019). Indeed, body dissatisfaction can predict antenatal and postnatal experiences of depression (Silveira et al., 2015). This can have detrimental impacts on both mother and baby by influencing parenting behaviours such as responsiveness to the baby's needs and breastfeeding duration (Brown et al., 2015). It can also affect the baby's physical (Hamdan & Tamim, 2012) and cognitive development (O'Hara & McCabe, 2013). A similar pattern has been found between pregnancy body dissatisfaction and the developing bond between mother and infant. Bonding is defined as a mother's tie to her infant (Jansen et al., 2008). During pregnancy, concern around the body was found to be the strongest factor associated with bonding (sometimes referred to as antenatal attachment), above and beyond other factors such as depression (Kirk & Preston, 2019). This research found that body dissatisfaction measured by a questionnaire, specifically developed to capture feelings towards the body during pregnancy, was associated with the strength of the maternal bond. In contrast, a generic body dissatisfaction measure did not show this association, suggesting that using pregnancy specific measures could help clarify previous inconsistencies in research findings surrounding the role of pregnancy body dissatisfaction in perinatal well-being (Condon, 1985; Heidrich & Cranley, 1989; Małus et al., 2014) and highlighting the importance of using sample-specific measures.

3.2.1. Aims & hypotheses

Existing literature highlights the significance of accurately measuring pregnancy body dissatisfaction for maternal and child well-being. Although longitudinal studies are ideal for investigating the long-term impact of body dissatisfaction on psychological well-being, they face challenges due to high attrition rates, particularly among vulnerable groups (Brown et al., 2015; Hense et al., 2013). Therefore, retrospective methods have been used to assess body dissatisfaction throughout the perinatal period (Abraham et al., 2001; Crossland et al., 2023). As pregnant women respond differently to body dissatisfaction measures compared to non-pregnant women (Fuller-Tyszkiewicz et al., 2012; Kirk & Preston, 2019). It is important to consider potential retrospective biases, including the challenge of accurately recalling past experiences and the influence of having a different body state at the time of recollection. To date, no validated retrospective measure for pregnancy body dissatisfaction exists. Therefore, this research aims to address this gap by adapting and statistically validating the factor structure of a retrospective measure of pregnancy body dissatisfaction and explore its relationship with postnatal anxiety, depression, and bonding. It is hypothesised that lower retrospective body

dissatisfaction will correlate with increased postnatal anxiety and depression, and poorer maternal bonding.

3.3. Methods

3.3.1. Design and participants

A cross-sectional design was used. All participants provided informed consent prior to taking part. Participants responded to advertisements to take part in an online survey. The advertisements were distributed via social media sites, parenting websites, groups and classes, local nurseries and community and health centres. Participants over the age of 18, without any clinical mental health diagnoses and between 0 and 18 months postpartum were invited to participate. Please see exclusion criteria in Appendix B.1.

Following exclusions, data from 404 pregnant women were included, see participant demographics in Table 3.1.

Table 3.1. Sample demographics.

Demographic	Mean (SD)/%
Mean maternal age (years)	31.7 (4.4)
Mean infant age (months)	8.6 (4.1)
% first pregnancy[1]	41.8%
Relationship status (%)[1]	
Married/civil partner	72.6
Living with partner	24.3
Single	1.5
In a relationship living apart	0.8
Other	0.8
Ethnicity (%)[2]	
White	90.9
Black, African, Caribbean or Black British	3.9
Mixed	3.1
Asian	1.3
Other	0.8
Education Level (%)[1]	
Secondary Education	1.2
Vocational Qualifications	6.8
Further Education	7.6
Higher Education	84.0
Prefer not to say	0.4

[1]*N=263,* [2]*N=388*

3.3.2. Ethics and open research

The current study received ethical approval from both the University of York (ref: 22203) and University College London (ref: 22829/001) Departmental Ethics Committees. Please see Appendix B.2 for further information on ethics and open research.

3.3.3. Measures and materials

Qualtrics (Qualtrics, 2020) was used to create and distribute the surveys, which included three self-report questionnaires (see Table 3.2). The completion rate was 85.96%.

Table 3.2. Self-report questionnaires.

Measure	Items	Subscales	Responses	Scoring	Reliability
Retrospective Body Understanding Measure for Pregnancy Scale (rBUMPs)* Adapted from BUMPs (Kirk & Preston, 2019)	19	*Appearance* (9 items) - dissatisfaction with appearing pregnant; *Weight* (7 items) - concerns about weight gain; *Physical* (3 items) - the experience of the physical burdens of pregnancy.	Recorded on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).	Sum items for individual subscale scales and all 19 items for a global score. Higher scores indicate more dissatisfaction.	Internal consistency (α = .71 - .91). Test-retest reliability (.78 - .93). (Kirk & Preston, 2019)
The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983)	14	*Anxiety* (7 items); *Depression* (7 items).	Statements are rated on a 4-point Likert scale of 0 – 3.	Subscales are summed to generate an overall subscale score. Higher scores indicate higher anxiety and depression.	Internal consistency in pregnant samples (α = .74 - .81 (Kirk & Preston, 2019)
Maternal Postnatal Attachment Scale (MPAS; Condon & Corkindale, 1998)	19	*Quality of Attachment* (9 items) – feelings of closeness in interaction; *Absence of Hostility* (5 items) – hostile feelings towards the baby; *Pleasure in Interaction* (5 items) – pleasantness of interactions.	Responses were provided on a range of 2- to 5-point Likert scales, and weighted accordingly.	Responses scored by summing items together to form global and subscale scores, considering reverse scored items.	Reliability (α = .78) for the total scale (Condon & Corkindale, 1998)

* Questions adapted from the original BUMPs to be phrased retrospectively. For example, 'I feel like my bump is too big', changed to 'I felt like my bump was too big'.

3.3.4.   Procedure

Participants were invited to complete the surveys online via a Qualtrics link. They were presented with an information sheet and provided with tick boxes to consent to taking part. They were then presented with the questions, followed by a debrief form. The average competition time was 15 minutes (SD=14.5).

3.3.5.   Data analysis

3.3.5.1. Exploratory & confirmatory factor analysis

The overall sample of 404 were split using a computer-generated random sampling technique, with the first half utilised in the exploratory factor analysis (EFA), and the second in the confirmatory factor analysis (CFA). There were no significant differences in demographics between the samples.

The EFA was performed in R (lavaan, psych, GPArotation packages). To determine the data's appropriateness for factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was examined (ideal value of .80; acceptable threshold of .60; Kaiser, 1974) and Bartlett's test of sphericity was conducted. According to best practice, parallel analysis and assessment of fit indices were used to determine the optimal number of factors to extract from the EFA (Swami et al., 2021). To retain items, loadings exceeding .40 and low inter-item correlations were considered (Stevens, 2012).

Model fit was assessed in accordance with established criteria (e.g., Hu & Bentler, 1999) for both the EFA and the CFA. This included SRMR (Standardized Root Mean Square Residual) being below .08, CFI (Comparative Fit Index) and TLI (Tucker-Lewis Index) both approximating .95, and RMSEA (Root Mean Square Error of Approximation) being below .06 suggesting a good fit or between .07 and .08 suggesting adequate fit.

3.3.5.2. Regression analyses

Global and subscale scores were appropriately calculated for all the measures according to the relevant scoring guidelines, and data were checked against linear regression assumptions. Single forced entry linear regressions were used to assess the relationship between retrospective body dissatisfaction and postnatal bonding, anxiety and depression. Covariates (maternal and infant age) were considered as potential confounding variables, rather than additional regressors. Analyses were conducted in Python Jupyter Lab (Kluyver et al., 2016) using the OLS module from the statsmodels package (Perktold et al., 2023).

3.4.   Results

3.4.1. Descriptive statistics

Overall, 404 participants were included in analyses. See Table 3.3 for descriptives.

Table 3.3. Descriptive statistics.

Measure	Mean (SD)	Range	Cronbach's α
BUMPs(SD)[1]	52.6 (14.9)	22-95	0.90
BUMPs Appearance	23.3 (7.8)	9-45	0.87
BUMPs Weight	19.4 (7.5)	7-35	0.88
BUMPs Physical	9.9 (3.2)	3-15	0.73

HADS (SD)			
Anxiety[2]	7.4 (4.6)	0-21	0.87
Depression[3]	5.8 (3.5)	0-18	0.73
MPAS (SD)[4]	72.5 (9.4)	39-86	0.91
Quality	34.6 (4.6)	19-40	0.86
No Hostility	16.1 (3.9)	6-22	0.82
Pleasure	21.9 (2.2)	13-25	0.62

[1]N=404, [2]N=394, [3]N=366, [4]N=132

The results in Table 3.3 show average levels (in line with community norms; Kirk & Preston, 2019) of retrospective body dissatisfaction, low levels of mental health issues and high levels of attachment.

3.4.2. EFA

For the EFA dataset, Barlett's test of sphericity, $\chi 2$ (171) = 1903.79, $p<0.01$, and KMO (Kaiser-Meyer-Olkin; Kaiser, 1974) (global KMO = .89, item level KMO >.75 for all items) indicated sufficient variance for factor analysis.

The number of potential factors according to the scree plot, parallel analysis, and Eigenvalues of >1 and >.7 were 4, 4, 3 and 2 respectively, so 2, 3 and 4 factors were assessed. Results demonstrated a 2-factor model is a borderline good fit, ($\chi 2$ (105) = 174.9, $p< 0.001$, TLI = 0.89, RMSEA = 0.08 (90% CI = 0.07, 0.10), SRMR = 0.05) retaining 15 questionnaire items and accounting for 49% of the variance, which is within acceptable levels (Streiner, 1994). In comparison, the 3-factor model removed 10 items after 6 rounds leaving 1 factor with only 1 item, which would not make for a viable subscale (Raubenheimer, 2004). Similarly, following 6 rounds, the 4-factor model had 2 factors with only 1 item each, so was disregarded.

In light of the advice cautioning against dismissal of models that do not strictly adhere to predefined cutoffs (Morrison et al., 2017), the decision was made to proceed with the 2-factor model, retaining 15 items (see Table 3.4). Items 9, 12, and 18 were excluded due to their double loadings or lack of loadings, alongside item 10 due to its factor loading of <.40. The two factors that emerged related to dissatisfaction with appearance and weight, which align with the original 3-factor model, but omitting the third factor related to dissatisfaction with the body's physical abilities. See Table 3.5 for the descriptive statistics of the EFA defined 2-factor retrospective BUMPs (rBUMPs), showing average levels of retrospective pregnancy body dissatisfaction (relative to community norms for BUMPs; Kirk & Preston, 2019) for both appearance and weight.

Table 3.4. Factor loadings for the EFA derived 2 factor rBUMPs.

Item*	Weight dissatisfaction	Appearance dissatisfaction
Q1 – I felt good about my changing body	0.238	**0.572**
Q2 – I got embarrassed that I can't do as much physically as I could before I was pregnant	**0.614**	-0.044
Q3 – When I compared the shape of my body to other women, I was dissatisfied with my own	**0.748**	0.060
Q4 – I enjoyed taking photos of my changing body	0.047	**0.765**
Q5 – I was concerned about the amount that I am eating and the effect this has on my physical appearance	**0.791**	-0.017
Q6 – I liked it when people comment on the size of my bump	-0.158	**0.693**
Q7 – I worried about getting my figure back after pregnancy	**0.554**	-0.025
Q8 – I wore clothes to accentuate my bump	-0.061	**0.764**
Q11 – I liked it when people noticed I'm pregnant	0.122	**0.608**
Q13 – I looked overweight	**0.807**	0.030
Q14 – I felt like my bump was too big	**0.635**	-0.095
Q15 – I enjoyed changing my wardrobe during pregnancy	-0.100	**0.675**
Q16 – I was worried about the amount of weight I was putting on	**0.726**	0.016
Q17 – When I compared the shape of my body to other non-pregnant women, I was dissatisfied with my own	**0.804**	0.029
Q19 – I enjoyed my new curves in pregnancy	0.084	**0.772**

Question numbers under 'Item' refer to the original BUMPs item number; Numbers in bold indicate the highest factor loadings, showing which factors the questions most strongly correlate with.

Table 3.5. Descriptive statistics for the EFA derived 2 factor rBUMPs.

Measure	Mean (SD)	Range
rBUMPs (SD)[1]	37.4 (11.4)	14-70
BUMPs Appearance	18.2 (6.4)	7-35
BUMPs Weight	19.1 (7.3)	7-35

[1]N=404

3.4.3. CFA

For the CFA dataset (N=202), Barlett's test of sphericity, $\chi^2 (171) = 1879.09$, $p<0.01$, and the KMO (global KMO = .88, item level KMO >.81 for all items) indicated sufficient variance for factor analysis.

A bifactor model was applied to assess fit of the 2-factor model for retrospective body dissatisfaction during pregnancy. This model considers a global scale and multiple subscales, indicating one latent variable of overall body dissatisfaction and additional sub latent variables for each subscale (Weight and Appearance). A non-bifactor model was also reported for comparison.

Results suggest that the 2-factor model fits the data well and performs slightly better than the original 3-factor model. Notably, the bifactor model displayed superior fit compared to the non-bifactor model. See Table 3.6 for CFA results of all assessed models. See Appendix B.3 for means and standard deviations from the CFA sample for both the 2 and original 3 factor models. The rBUMPs scale is provided in Appendix B.4.

Table 3.6. CFA results showing the goodness of fit of the 2 factor rBUMPs and original 3 factor BUMPs in both bifactor and non-bifactor models.

Model	χ^2	CFI[1]	TLI[2]	RMSEA[3]	RMSEA CI	SRMR[4]	AVE[5]
Bifactor							
2 factor, 15 items	χ^2 (75)= 121.70, p=0.001	0.97	0.95	0.06	0.04 – 0.07	0.04	Factor 1[a] = 0.43 Factor 2[b] = 0.47
3 factor, 19 items	χ^2 (133)= 232.15, p<0.001	0.94	0.93	0.06	0.05 – 0.07	0.05	Factor 1[a] = 0.40 Factor 2[b] = 0.50 Factor 3[c] = 0.46
Non-bifactor							
2 factor, 15 items	χ^2 (89)= 272.06, p<0.001	0.87	0.84	0.10	0.09 – 0.12	0.08	Factor 1[a] = 0.43 Factor 2[b] = 0.47
3 factor, 19 items	χ^2 (149)= 446.41, p<0.001	0.83	0.81	0.10	0.09 – 0.11	0.09	Factor 1[a] = 0.40 Factor 2[b] = 0.50 Factor 3[c] = 0.46

[1]Comparative Fit Index, [2]Tucker-Lewis Index, [3]Root Mean Square Error of Approximation, [4]Standardized Root Mean Square Residual, [5]Average Variance Extracted, [a]Factor 1=Appearance, [b]Factor 2=Weight, [c]Factor 3=Physical burdens

3.4.4. Linear regressions

The linear regression analysis for postnatal bonding (N=132), anxiety (N=394), and depression (N=366) with rBUMPs added as a predictor, found rBUMPs to be associated with increased anxiety and depression, and lower levels of bonding. Visualisations are presented in

Figure 3.1, and regression results are in Table 3.7. Follow-up regressions revealed the Appearance rBUMPs subscale was significantly associated with all postnatal outcomes, while the Weight rBUMPs subscale was not significantly associated with bonding (see Table 3.8).

Table 3.7. Regressions between global rBUMPs and postnatal variables, including covariates.

rBUMPs regression models	df	Beta	t value	p value	F	F p value	Adjusted R^2
rBUMPs-Global							
Anxiety[1]	392	0.128	6.666	<0.001**	44.43	<0.001	0.100
Depression[2]	364	0.097	6.275	<0.001**	39.38	<0.001	0.095
Bonding - Global[3]	130	-0.461	-4.443	<0.001**	19.74	<0.001	0.125
Bonding - Quality[3]	130	-0.226	-4.336	<0.001**	18.80	<0.001	0.120
Bonding - No hostility[3]	130	-0.146	-3.625	<0.001**	13.14	<0.001	0.085
Bonding - Pleasure[3]	130	-0.089	-3.144	0.002*	9.883	0.002	0.064

*Significant at 0.05, **Significant at 0.001, [1]N=394, [2]N=366, [3]N=132*

Table 3.8. Follow up regressions between rBUMPs subscales and postnatal variables, including covariates.

rBUMPs regression models	df	Beta	t value	p value	F	F p value	Adjusted R^2
rBUMPs-Appearance							
Anxiety[1]	392	0.219	6.394	<0.001**	40.88	<0.001	0.092
Depression[2]	364	0.183	6.711	<0.001**	45.04	<0.001	0.108
Bonding - Global[3]	130	-0.847	-5.760	<0.001**	33.18	<0.001	0.197
Bonding - Quality[3]	130	-0.387	-5.158	<0.001**	26.61	<0.001	0.164
Bonding - No hostility[3]	130	-0.342	-6.232	<0.001**	38.84	<0.001	0.224
Bonding - Pleasure[3]	130	-0.118	-2.783	0.006*	7.75	0.006	0.049
rBUMPs-Weight							
Anxiety[1]	392	0.143	4.666	<0.001**	21.77	<0.001	0.050
Depression[2]	364	0.094	3.806	<0.001**	14.49	<0.001	0.036
Bonding - Global[3]	130	-0.136	-0.951	0.369	0.81	0.369	-0.001
Bonding - Quality[3]	130	-0.090	-1.192	0.235	1.42	0.235	0.003
Bonding - No hostility[3]	130	0.019	0.334	0.739	0.11	0.739	-0.007
Bonding - Pleasure[3]	130	-0.065	-1.649	0.102	2.72	0.102	0.013

*Significant at 0.05, **Significant at 0.001, 1N=394, 2N=366, 3N=132
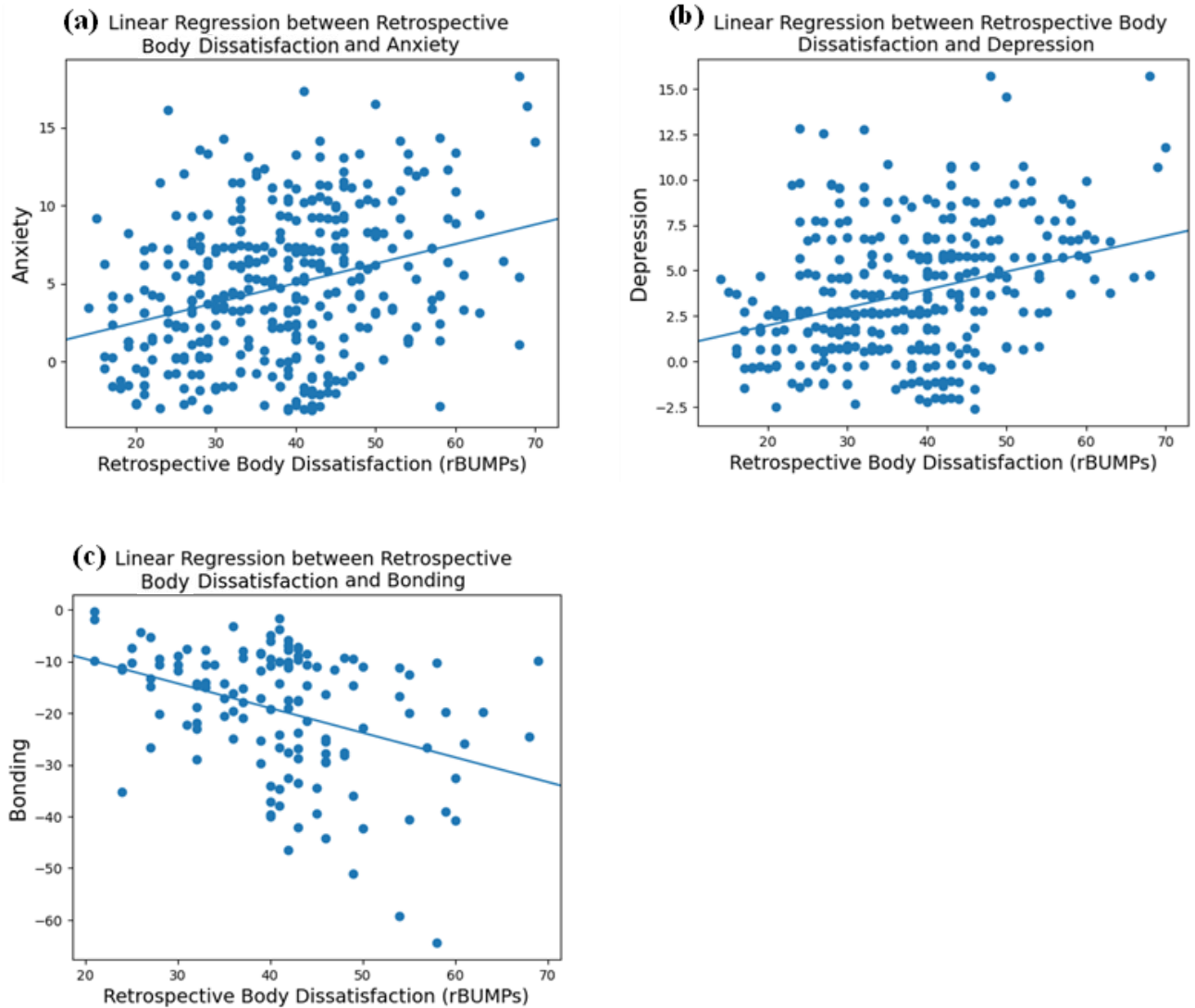
Figure 3.1. Regression plots showing the relationship between global retrospective body dissatisfaction and postnatal anxiety (a), depression (b), and bonding (c).

3.5. Discussion

This paper aimed to adapt a retrospective measure of pregnancy body dissatisfaction based on the Body Understanding Measure of Pregnancy (BUMPs) (Kirk & Preston, 2019), and to examine the relationship between retrospective body dissatisfaction and postnatal well-being and bonding. The Retrospective Body Understanding Measure for Pregnancy Scale (rBUMPs), a new 15 item 2-factor model, demonstrated superior fit compared to the original 19 item 3-factor BUMPs, and was associated with postnatal depression, anxiety, and bonding.

The subscales of the 2-factor model are consistent with two of the subscales from the original BUMPs model, Appearance, and Weight. The similarity between the retrospective factor structure and that of the original measure indicates consistency in evaluating body dissatisfaction, regardless of whether it involves reflecting on past perceptions or assessing current ones. However, four of the items were dropped from the original measure to fit the retrospective dataset, two of which contributed to the 3rd factor of 'physical burdens' in the original scale. Given that only 3 items were included in the original physical burden's subscale, it is unsurprising that it did not persist in the retrospective measure.

The importance of creating measures capturing the perinatal bodily experience has been previously identified (Kirk & Preston, 2019). Now, adapting a scale to measure levels of body dissatisfaction retrospectively enables a more consistent and reliable assessment of pregnancy body dissatisfaction during the postnatal period, and allows for a single time point for data collection. This could mitigate issues surrounding high attrition rates (e.g. Brown et al., 2015) and therefore, can strengthen the validity of future research.

Using the rBUMPs, increased levels of retrospective pregnancy body dissatisfaction were associated with higher levels of postnatal anxiety and depression, and lower levels of postnatal bonding. This extends findings from the antenatal literature that identified higher levels of body dissatisfaction during pregnancy to be associated with higher levels of antenatal depression and anxiety, and lower levels of antenatal bonding (Kirk & Preston, 2019).

Given that pregnancy body dissatisfaction has been linked to postnatal well-being and bonding, it is important to consider the wider context and potential mechanisms behind this association. One such consideration is breastfeeding, which can have important benefits for infant development (Binns et al., 2016). Research suggests that women with higher body concerns during pregnancy have significantly lower breastfeeding rates, and of those mothers who did breastfeed, more negative attitudes towards their pregnant body were associated with shorter breastfeeding durations (Brown et al., 2015). Consequently, this can negatively impact bonds between a mother and infant (Linde et al., 2020), potentially due to missing the benefits associated with breastfeeding. For example, reduced feelings of stress, which lead to an increase in the hormones oxytocin and prolactin, indirectly improving postnatal bonding (Jansen et al., 2008).

The association between breastfeeding duration and body dissatisfaction may be influenced by levels of trust in the body. Although women may be more likely to listen to and

trust their body when they are pregnant (Kirk & Preston, 2019), poor levels of trust in the body's internal signals (a form of interoception) has been linked to more dissatisfaction with the pregnant body (Crossland et al., 2022; Kirk & Preston, 2019). Therefore, speculative suggestions have been made that encouraging women's trust in their bodies throughout the perinatal period could decrease levels of body dissatisfaction (Crossland et al., 2022), and therefore facilitate an improvement in related outcomes such as depression, bonding, and breastfeeding. This is important within the context of healthcare, as often perinatal medical practices involve a reliance on external validation, such as the need for midwives to assess how the pregnancy is progressing. This could undermine women's confidence in their own bodily signals and by association, undermine their trust in internal bodily signals. Ensuring that healthcare providers listen to and validate these experiences could therefore enhance feelings of trust in the body. In addition, body dissatisfaction is currently not considered or addressed when supporting women through routine antenatal care in clinical appointments (Watson et al., 2016). Having a retrospective measure to assess this in clinical settings could therefore identify women after birth who may need support, provide a clearer understanding of the contribution that feelings about the pregnant body might have on their postnatal experiences and suggest vulnerabilities in any future pregnancies.

The literature indicates a connection between internal experiences (interoceptive body trusting) and external experiences (body dissatisfaction). The Competition of Cues Hypothesis (Pennebaker & Lightner, 1980) suggests that as attention towards the body is limited, there is competition between internal and external cues. This is important, given the potential for feelings of body dissatisfaction to distract from internal bodily signals (such as the baby kicking) that are instrumental in developing maternal-foetal bonds during pregnancy (Heidrich & Cranley, 1989). Supporting this, subjective feelings about interoception are found to moderate the relationship between pregnancy body dissatisfaction and antenatal bonds, such that greater focus on interoception lessens the negative impact of body dissatisfaction on bonding (Stafford et al., 2024). Therefore, if promoting the awareness of internal cues in pregnancy extends postnatally, this may also enhance the mother-infant bond following birth. This is supported by research linking the subjective noticing of interoceptive signals to postnatal mother-infant relationships (Suga et al., 2022). Understanding the competition between internal and external cues may inform interventions targeting pregnancy body dissatisfaction, with the potential for interoception to improve feelings towards the body. For example, Yoga can increase interoceptive attention (Neukirch et al., 2019) and improve

maternal well-being during both antenatal (Jiang et al., 2015) and postnatal periods (Munns et al., 2024).

Although the current study expands our understanding and provides important implications, however, there are limitations that should be considered before results are generalised. Firstly, gathering thoughts and feelings during the postnatal period about the bodily experience during pregnancy opens the results up to retrospective bias due to the inaccuracy of memories recalled (Rolan et al., 2022). This means that retrospective responses on pregnancy body dissatisfaction may be influenced by women's current level of body dissatisfaction and/or their mental health. For example, negative postnatal bodily experiences, which can arise due to the lack of awareness around postpartum bodily changes, less focus on the mothers due to the baby's arrival, and the pressure to return to a pre-pregnancy body shape (Fairburn & Welch, 1990; Hodgkinson et al., 2014), could all result in more negative recall of the pregnancy bodily experience and "maturation threat" (when natural changes in participants over time affect study results) (Tofthagen, 2012). This could shed light on the low levels of variance in postnatal outcomes explained by the current retrospective measure. Recent literature does support using retrospective accounts of the perinatal period due to their consistency with prospective measures (Rolan et al., 2022), and given the similarity in score means and standard deviations between our retrospective measure and the original BUMPs, this may also suggest equivalency with this measure. However, it is important to ensure this consistency can also be applied to measures of body dissatisfaction going forward.

In addition, the current sample has limited ethnic diversity, with the participants being primarily white, middle-class, and highly educated women, despite efforts to recruit from other groups. This is particularly relevant given the differences between ethnic groups in perinatal experiences among maternity settings, such as access to and perceptions of healthcare services, and birth outcomes (Henderson et al., 2013). This is in addition to differences in levels of body dissatisfaction within the general population, with black women having poorer levels of body satisfaction compared to white women (Kronenfeld et al., 2010). Further research is needed to better understand how ethnicity might influence bodily experiences during pregnancy and their impact on postnatal well-being.

3.6.   Conclusions

This study establishes a measure for assessing retrospective pregnancy body dissatisfaction, which going forward can enable a more consistent and reliable assessment of pregnancy body dissatisfaction during the postnatal period and mitigate high attrition rates in longitudinal research. Beyond this, the current investigation has implicated pregnancy body dissatisfaction in postnatal factors, including depression, anxiety, and bonding. However, a cause-and-effect relationship needs to be confirmed with longitudinal investigations. Breastfeeding, body trusting and competing cues may all play a role in facilitating the associations between the pregnancy bodily experience and postnatal maternal mental health and bonding. The results show an encouraging perspective that improving the bodily experience during pregnancy could improve the postnatal experience. Further research into interventions, such as yoga and improved awareness across midwifery services, is required to identify their efficacy going forward. The use of a retrospective measure to assess body dissatisfaction during pregnancy will aid future research by accurately capturing retrospective accounts of the bodily experience, and could allow clinical professionals to better support women during the perinatal period through considering the impact of these experiences on postnatal psychological well-being.

4. Chapter 4: Pregnancy Bodily Experiences and Postnatal Mother and Infant Outcomes

This chapter has been adapted from: Munns, L. B., Noonan, M., Romano, D. L., & Preston, C. E. J. (2024). Interoceptive and exteroceptive pregnancy bodily experiences and postnatal well-being: A network analysis. British Journal of Health Psychology. (Under review).

4.1.   Abstract

Pregnancy involves rapid physical and physiological changes that may affect feelings towards the bodily experience. This experience, including body dissatisfaction and interoceptive sensibility, is linked to antenatal attachment and maternal mental health. However, the long-term relationships between pregnancy bodily experiences and postnatal outcomes remain unknown. This study aimed to explore the complex relationships between the perinatal bodily experience and postnatal variables.

Longitudinal online survey data were collected at 3 time points, during pregnancy (N=253), and at 3 (N=137) and 6 (N=107) months postpartum. Pregnancy-validated measures assessed body dissatisfaction and interoception, alongside measures of postnatal bonding, maternal anxiety and depression, breastfeeding behaviours, and infant birth weight and development. A partial correlation graphical lasso network analysis was used to explore the relationships between the bodily experience and these postnatal variables.

Antenatal bodily experiences linked to postnatal anxiety, body dissatisfaction and interoceptive trust, with poorer postnatal experiences going on to correlate with higher anxiety, depression and breastfeeding rates at 3 months. Antenatal body weight dissatisfaction was linked to increased breastfeeding and depression, less trust in bodily signals and a lower quality mother-infant bond at 6 months postpartum.

These findings underscore the importance of pregnancy bodily experiences for maternal postnatal health and mother-infant bonding, helping to identify mothers at risk of poorer postnatal outcomes.

4.2. Introduction

Pregnancy is often a time of joy and anticipation for many women, as it marks the beginning of the journey into motherhood with a new child. There are multiple bodily changes that occur during pregnancy, including the appearance of a bump, enlarged breasts and increased hair growth, emphasising just how physical the experience of pregnancy is. These bodily changes can affect the way women feel about their bodies and their bodily experience.

One aspect of the bodily experience is body dissatisfaction, which involves negative thoughts and feelings about body appearance (Grogan, 2021). This can have profound impacts on mental health and well-being including anxiety (Lin & Kulik, 2002), depression (Scheffers et al., 2019), and disordered eating (Thompson & Stice, 2001). Previous work reveals a variation in responses to the physical changes that occur during pregnancy. For example, while pregnancy can temporarily liberate women from conforming to societal beauty standards (Crossland et al., 2023; Davies & Wardle, 1994), feelings of body dissatisfaction can persist or develop due to changes such as weight gain that conflict with societal ideals of the female appearance (Hodgkinson et al., 2014). Additionally, for many there is still pressure to look a certain way (Crossland et al., 2023; Kirk & Preston, 2019).

Alongside feelings about the external body, internal factors are also part of the bodily experience. Interoception is defined as the awareness of, or attention paid to, internal signals such as thirst, pain and heart rate (Craig, 2002). During pregnancy, interoceptive signals often increase in order to sustain the foetus (Butte & King, 2005; Lee & Zaffke, 1999). There is emphasis placed on recognising foetal movements in order to assess the baby's growth and well-being (Frøen et al., 2008), and so it is understandable that women focus more on their internal body during this time. Additionally, trust in bodily signals and the body's ability to support foetal development is linked to more positive pregnancy and birth experiences (Crossland et al., 2022), which can have a direct impact on how women feel about their bodies (Crossland et al., 2022; Munns & Preston, 2024).

The importance of how women feel about the pregnancy bodily experience and its impact on their well-being has been examined, suggesting that both interoception and exteroception play a key role in antenatal maternal mental health (Noda et al., 2022; Singh Solorzano et al., 2022) and attachment (Kirk & Preston, 2019). The significance of both these aspects has been underscored by a recent network analysis, which identified that less trust in internal bodily signals during pregnancy, alongside feelings of body dissatisfaction, were

associated with poorer maternal mental health and antenatal attachment (Munns & Preston, 2024). Network analysis provides a comprehensive view of the interconnections between different psychological variables, enabling research into complex concepts (Borsboom et al., 2021) and identifying the most influential variables within the network as potential targets for interventions (Yuqing et al., 2020). Through this method, Munns & Preston (2024) identified interoceptive body trust and body weight dissatisfaction to be central to antenatal outcomes. These relationships may develop through unrealistic expectations to maintain a slim figure during pregnancy (Huang et al., 2021) and the mother's need to assess the baby's movements and respond appropriately (Heidrich & Cranley, 1989; Stafford et al., 2024).

Despite bodily experiences during pregnancy being implicated in antenatal attachment and well-being, the associations between pregnancy bodily experiences and downstream postnatal factors are yet to be fully understood. Exploring the factors contributing to postnatal well-being is critical, given the high prevalence of anxiety (13-40%) and depression (13-19%) in postnatal populations (Field, 2018; O'Hara & McCabe, 2013), and the impact this has on postnatal bonding (Dubber et al., 2015). Both postnatal mental health and bonding have wide reaching influences, being implicated in parenting behaviours (Mascheroni & Ionio, 2019; Seymour et al., 2015), breastfeeding (Coo et al., 2020; Roth et al., 2021) and infant development (Hamdan & Tamim, 2012; Mascheroni & Ionio, 2019; O'Hara & McCabe, 2013). A recent study has demonstrated associations between higher levels of pregnancy body dissatisfaction and poorer postnatal mental health and bonding outcomes (Munns, Crossland, McPherson, et al., 2024). However, this research used cross-sectional data, gathered postnatally using a retrospective measure of body dissatisfaction and did not consider the full bodily experience including interoception. Therefore, there is a need for longitudinal research considering multiple potential variables, which enable a more robust assessment of body experiences over the course of pregnancy and postpartum.

Considering the established relationship between body dissatisfaction and postnatal bonding, it is understandable that breastfeeding is also intimately connected to the bodily experience. Breastfeeding can strengthen the mother-infant bond (Linde et al., 2020; Roth et al., 2021) and its link to bodily experience. There are common concerns around how breastfeeding can significantly change or damage breasts (Brown et al., 2015), with women who are more dissatisfied with their bodies being less likely to breastfeed (Brown et al., 2015). Additionally, women who have greater trust in their body's capabilities are more likely to have positive breastfeeding experiences (Flacking et al., 2021). Further research into breastfeeding

within the context of the bodily experience and postnatal well-being would allow for a deeper understanding of how these factors interact, potentially leading to improved support and interventions for mothers.

4.2.1. *Aims & hypotheses*

This current study will examine the relationship between pregnancy bodily experiences and postnatal mother and infant well-being. Addressing gaps in previous work, this research uses a longitudinal approach and a large sample of pregnant women to examine pregnancy bodily experience in relation to measures of maternal anxiety and depression, bonding, breastfeeding and infant birthweight and development at 3 and 6 months postpartum. An exploratory network analysis will be used to identify the interconnectivity between the bodily experience and postnatal variables, due to this method's potential to elucidate complex interrelationships between psychological factors (Hevey, 2018). Here, two networks are presented. First, the 3-month data, which includes all variables gathered. Second, the 6-month data takes a hypothesis driven approach, given the anticipated smaller sample size common in perinatal longitudinal studies due to high attrition rates (e.g., Brown et al., 2015), and thus includes only key variables of interest identified through previous literature. Overall, this research aims to give deeper insights into the role of pregnancy bodily experiences.

4.3. Methods

4.3.1. *Participants*

Participants were invited to take part through advertisements online (via social media and parenting websites), and posters at local nurseries, health centres and antenatal groups. Ethical approval was provided by the University of York Departmental Ethics Committee (ref:122), and all participants provided informed consent before completing the online surveys, anonymously, at each timepoint. This research was preregistered on OSF (https://osf.io/57kc2/).

Postnatal data was gathered at two time points (3 and 6 months postpartum), with bodily experience during pregnancy being captured at an antenatal time point (Munns & Preston, 2024). In total 147 women completed the 3-month follow-up, and 117 women completed the 6-month follow-up. Individuals under 18 and those who self-disclosed a clinical diagnosis of

depression or anorexia were screened for and excluded from the experiment. Participants with incomplete data (no responses to any outcome measures, 6 month n=3), duplicate responses (3 month n=4, 6 month n=3), and those where their unique participant code could not be matched across time points (3 month n=6, 6 month n=4) were excluded. This left 137 participants and 107 participants at 3 and 6 months respectively. See Table 4.1 for participant demographics at each time point.

Table 4.1. Sample demographics.

Demographic	3-months Mean (SD)[a]	6-months Mean (SD)[b]
Mean maternal age[2]	33.1 (4.6)	32.7 (4.5)
Gender Female (%)[1]	100	100
No. weeks pregnant[1]	27.1 (8.4)	27.2 (8.5)
Weeks postnatal[2]	13.1 (7.6)	27.8 (2.6)[c]
First pregnancy (%)[1]	50.4	53.3
Number of children inc. pregnancy[1]	1.7 (0.9)	1.6 (0.7)
Trimester (%)[1]		
First (1-12 weeks)	6.9[d]	6.9[e]
Second (13-26 weeks)	38.9[d]	37.6[e]
Third (27-40+ weeks)	54.2[d]	55.4[e]
Relationship status (%)[1]		
Married/civil partner	65.0	64.5
Living with partner	32.1	32.7
In a relationship living apart	0.7	0
Single	2.2	2.8
Ethnicity (%)[1]		
White	94.9	95.3
Mixed	2.9	1.9
Asian	1.5	1.9
Black, African, Caribbean	0.7	0.9
Education Level (%)[1]		
School leaver	0	0
GCSEs	4.4	5.6
NVQ (Level 1-2)	1.5	0
NVQ (Level 3-5)	6.6	8.4

A levels/IB	8.8	7.5
HND or BTEC	3.6	1.9
Undergraduate Degree	41.6	41.1
Postgraduate Degree	27.7	29.0
Doctoral Degree	5.8	6.5
Employment (%)[1]		
Full time	61.3	65.4
Part Time	31.4	27.1
Student	1.5	1.9
Unemployed	5.8	5.6
Single births (%)[1]	97.7[f]	98.0[g]
Pre pregnancy BMI[1]	26.7 (5.8)[h]	25.7 (5.5)[i]
BMI[2]	28.7 (6.8)[j]	27.1 (5.7)[i]

[a]N=137, [b]N=107, [c]N=89, [d]N=131, [e]N=101, [f]N=131, [g]N=102, [h]N=124, [i]N=95, [j]N=115;
[1]Data gathered at antenatal time point, [2]Data gathered at respective postnatal time point.

4.3.2. Procedure, materials and measures

Surveys were created and distributed using Qualtrics (Qualtrics, 2020). Participants were invited to complete an online survey via a Qualtrics link. They were then presented with the relevant information sheet and consent form prior to completing the survey, followed by a debrief form. Self-report questionnaires were used to measure body dissatisfaction, interoceptive sensibility, anxiety, depression, and postnatal bonding. See Table 4.2 for further details.

Table 4.2. Self-report questionnaires.

Measure	Items	Subscales	Responses	Scoring	Reliability
Body Understanding Measure for Pregnancy Scale (BUMPs; (Kirk & Preston, 2019)	19	*Appearance* (9 items) - dissatisfaction with appearing pregnant; *Weight* (7 items) - concerns about weight gain; *Physical* (3 items) - the experience of the physical burdens of pregnancy	Recorded on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).	Sum items for individual subscale scales and all 19 items for a global score. Higher scores indicate more dissatisfaction.	Internal consistency (α = .71 - .91). Test-retest reliability (.78 - .93). (Kirk & Preston, 2019)
Multi-dimensional Assessment of Interoceptive Awareness for Pregnancy (MAIA-Preg; Crossland et al., 2024)[a]	19	*Emotional Awareness* (4 items) - awareness of bodily signals; *Not-distracting* (3 items) - tendency not to distract from sensations of pain or discomfort; *Attention regulation* (6 items) - ability to sustain and control attention to bodily sensations; *Self-regulation* (3 items)	Recorded on a 6-point Likert scale ranging from 0 (*never*) to 5 (*always*).	The score for each scale is calculated by the mean of its individual items. There is no global score.	Internal consistency (α = .63 - .87) (Crossland et al., 2024). Internal consistency in

		- ability to regulate psychological distress by attention to bodily sensations; *Trusting* (3 items) - the experience of one's body as safe and trustworthy.			current 3-month sample (α = .67 - .86)
Maternal Postnatal Attachment Scale (MPAS; Condon, 2015)	19	*Quality of Bond* (9 items) - feelings of closeness in interaction; *Absence of Hostility* (5 items) – levels of hostility in the relationships; *Pleasure in Interaction* (5 items) – feelings of pleasure in interaction.	Recorded on a range of Likert scales (with between 2 and 5 points).	A Global Bonding Score is calculated from the sum of all 19 items	Reliability (α = .78) for the total scale (Condon & Corkindale, 1998)
the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983)	14	*Anxiety* (7 items); *Depression* (7 items)	Recorded on a 4-point Likert scale ranging from 0 – 3.	Subscales are summed to generate an overall subscale score. Higher scores indicate higher anxiety and depression.	Internal consistency in pregnant samples (α = .74 - .81 (Kirk & Preston, 2019)
Postpartum Mind & Body Scale (Preston & Kirk, 2020)	41	*None*	Recorded on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).	A global score is calculated by summing all 41 items.	Internal consistency in current 3-month sample (α = 0.92)

[a]The MAIA-Preg was adapted from the Multi-dimensional Assessment of Interoceptive Awareness scale (Mehling et al., 2012). Questions that were not pertinent to pregnant women were removed, and the subscales underwent refinement through a factor analysis. Consequently, the MAIA subscales of 'not worrying,' 'body listening,' and 'noticing' were eliminated from the scale.

4.3.2.1. Breastfeeding

Participants were asked whether they were breastfeeding. Those who did not select breastfeeding were coded as 0, and those who did were coded as 1. Women who were currently breastfeeding, or had previously breastfed and since stopped, were asked how positive/negative they had found their breastfeeding experience (on a 5-point Likert scale ranging from 1 - 'extremely positive' to 5 - 'extremely negative').

4.3.3. Data analysis

4.3.3.1. Partial correlation network analyses

Two partial correlation network analyses investigated the relationships between bodily experience measures gathered during pregnancy and postnatal variables at 3 and 6 months. The 3-month network included variables measuring the bodily experience, anxiety, depression, bonding, breastfeeding rate and experience, and infant birth weight and development. Subscales of all variables were included, where available, rather than global scores to provide a more in-depth analysis, capturing any nuanced relationships. Age (Tiggemann & McCourt,

2013), BMI (Quittkat et al., 2019) and gestation (Mokhtar Abdelsalam, 2017) were integrated as nodes within the 3-month network due to their established relationships with bodily and antenatal experiences.

In order to maintain network stability with an expected smaller sample size, the 6-month network focused on a priori nodes of interest. These nodes consisted of antenatal trusting and dissatisfaction with body weight, which have previously been found to be central to the antenatal bodily experience (Munns & Preston, 2024). Given the importance of body trust and body dissatisfaction in antenatal outcomes, postnatal body trust and body dissatisfaction were also included. Due to their associations with the bodily experience at both antenatal and postnatal timepoints, breastfeeding rate (Brown et al., 2015), anxiety and depression (Noda et al., 2022; Singh Solorzano et al., 2022) and attachment quality (Munns & Preston, 2024; Stafford et al., 2024) were also included.

For both networks, five network properties were explored: edge weights, degree centrality, strength centrality, betweenness centrality and clustering. Edge weights are the partial correlation coefficients between nodes whilst controlling for all other nodes in the network, after the application of the regularisation parameter. Only edge weights that survive the regularisation procedure are shown in the network, and for these edge weights, basic Pearson's correlation coefficients are presented. Degree centrality is defined as how well connected one node is to other nodes, while strength centrality is the degree to which a node is explained by the rest of the network as it corresponds to the sum of all edges associated with a node. Betweenness centrality reflects the frequency in which a node appears on the shortest paths connecting other nodes within the network. A node with high betweenness centrality serves as a critical 'bridge' or intermediary, facilitating connections and the flow across the network. Finally, clustering coefficients show the extent to which the neighbours of a specific node are connected to each other. Nodes that exhibit the highest clustering coefficients are characterised by dense connections surrounding them and may offer a less vital role within the network, as due to their interconnected neighbouring nodes, they can be perceived as providing less unique and nuanced information (Costantini & Perugini, 2014).

Mixed graphical models were constructed using the graphical lasso (GLASSO) method with the qgraph package in Rstudio (Epskamp et al., 2012; RStudio Team, 2020). GLASSO applies statistical regularisation, which is particularly beneficial in dealing with dense networks to help identify nuanced relationships. The regularisation process used the Least Absolute

Shrinkage and Selection Operator (LASSO) algorithm (Friedman et al., 2008), adopting the extended Bayesian Information Criterion (eBIC; Schwarz, 1978) for criterion selection, effectively controlling overfitting and contributing to the accuracy of the model. The gamma value that controls the eBIC was set at 0.25. To assess the network's stability and robustness, the networks underwent 1000 bootstrap iterations to compute confidence intervals for each partial correlation. Additionally, case-drop bootstrapping was used by removing cases and re-analysing the relationships in the network. Both of these techniques were applied using the Bootnet package within RStudio (Epskamp et al., 2018).

4.3.3.2. Post-hoc analyses

T-tests (for continuous data) and McNemar's test (for binary data) aimed to identify differences between two time points (3 and 6 months postpartum). ANOVAs examined differences between three time points (antenatally, and 3 and 6 months postpartum). If assumptions of normality or homogeneity of variance were violated according to Shapiro wilk and Levene's tests, non-parametric tests were employed (Wilcoxon test and Friedman's test). The variables with the three highest strength and betweenness centrality coefficients in the networks were selected for analysis, as these measures reflect the intensity and strategic position of connections between nodes.

4.4. Results

4.4.1. 3-month partial correlation network analysis
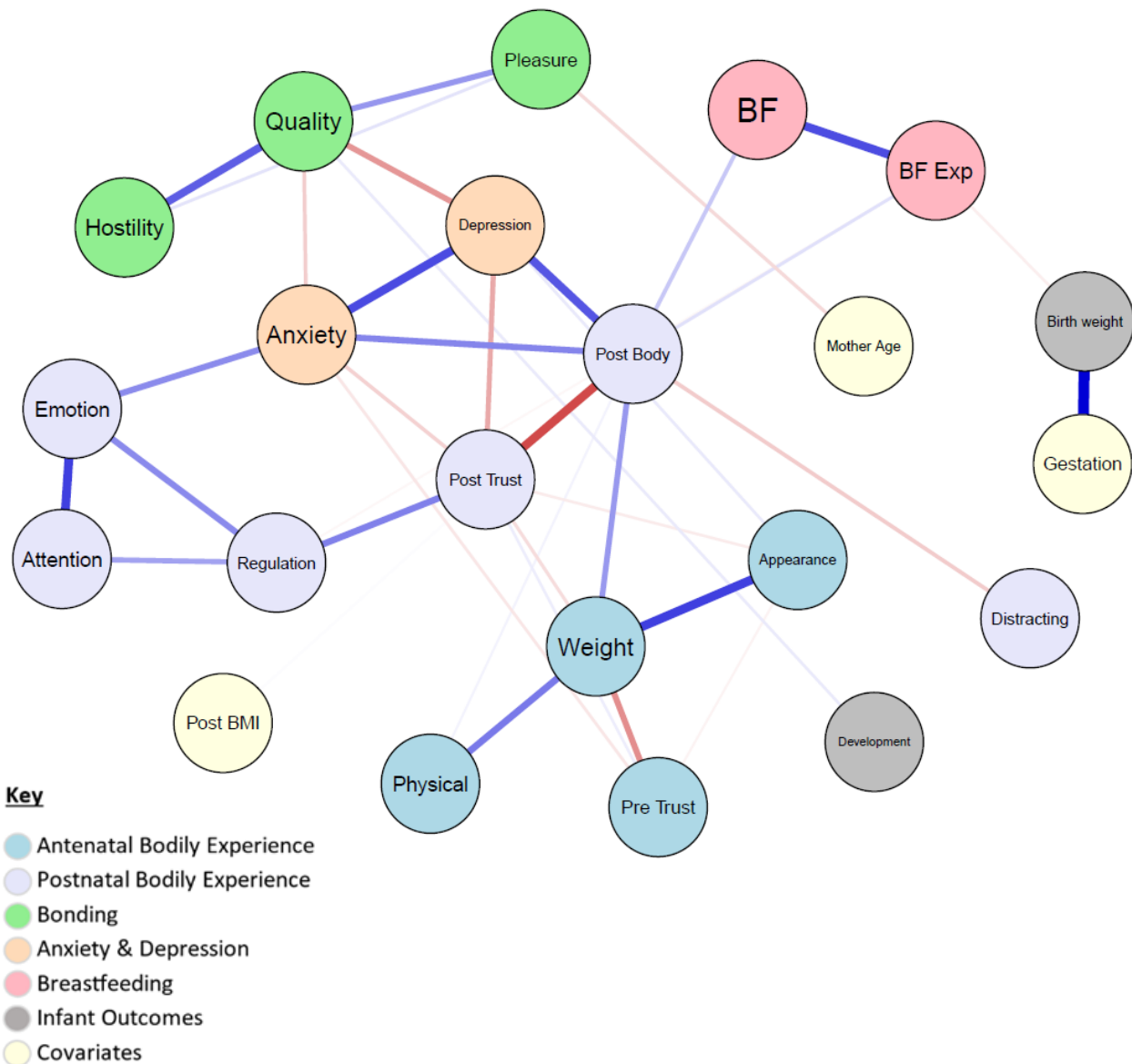
Figure 4.1. A partial correlation network analysis to show the relationships between body dissatisfaction and interoception during pregnancy and mother-infant variables at 3 months postpartum. Nodes represent variables, and edges represent the strength of the connections between nodes. Blue edges represent positive relationships and red edges represent negative relationships.

The network in Figure 4.1 examines the relationships between the bodily experience during pregnancy (body dissatisfaction and interoception) and multiple postnatal variables. The network is comprised of 22 nodes and 37 edge weights (edges), the latter of which reflect the partial correlations between nodes. Network sparsity, a measure of edge density calculated as the ratio between the number of possible and actual edges, was low (0.156) suggesting a

relatively sparse network. According to stability indices derived from bootstrapping analyses the network was reasonably stable (Appendix C.2). To achieve a correlation coefficient of ≥ 0.7 in at least 95% of the sample in the 3-month network, 28.5% of cases could be dropped without significantly impacting edge weights or edge strength. Descriptive statistics and sample sizes for all variables can be found in Appendix C.1.

4.4.1.1. Edge weights

The network portrays a collection of edge weights between antenatal and postnatal bodily experience. Antenatal dissatisfaction with body weight and appearance were negatively associated with postnatal body trust suggesting dissatisfaction with the body during pregnancy links with body trust postpartum. Antenatal body trusting was positively associated with postnatal body trusting, connecting levels of body trust across the perinatal period. Similarly, higher antenatal body weight dissatisfaction and physical abilities were associated with heightened postnatal body dissatisfaction.

High levels of postnatal body dissatisfaction were associated with multiple variables of interest, including increased breastfeeding rate, more positive breastfeeding experiences, and higher levels of anxiety and depression. Further links were found between breastfeeding experiences and infant birth weights, suggesting that those with smaller infants had more negative breastfeeding experiences. Birth weight was also understandably linked to gestation period.

Alongside postnatal body dissatisfaction, reduced levels of postnatal body trusting was associated with increased anxiety and depression at 3 months. High depression and anxiety scores were associated with a reduction in bond quality, which then went on to associate with child development, suggesting a link between stronger bond quality and more developmental milestones reached at 3 months old. See Appendix C.2 for all edge weights and basic Pearson's correlation coefficients.

4.4.1.2. Centrality

Across all measures of centrality, postnatal body dissatisfaction was consistently identified as the most central node. Furthermore, the nodes with the highest degree centrality were postnatal body dissatisfaction (9 connections), postnatal body trust (7 connections) and postnatal anxiety (6 connections). This was followed by depression, antenatal body weight dissatisfaction and bonding quality, all with 5 connections. The nodes with the highest strength

centrality were postnatal body dissatisfaction (0.96), antenatal body weight dissatisfaction (0.76) and postnatal depression (0.74). Similarly, for betweenness centrality, postnatal body dissatisfaction had the highest coefficient (156), followed by postnatal depression (80) and postnatal bonding quality (73). See Figure 4.2 and Appendix C.3 for all centrality coefficients.
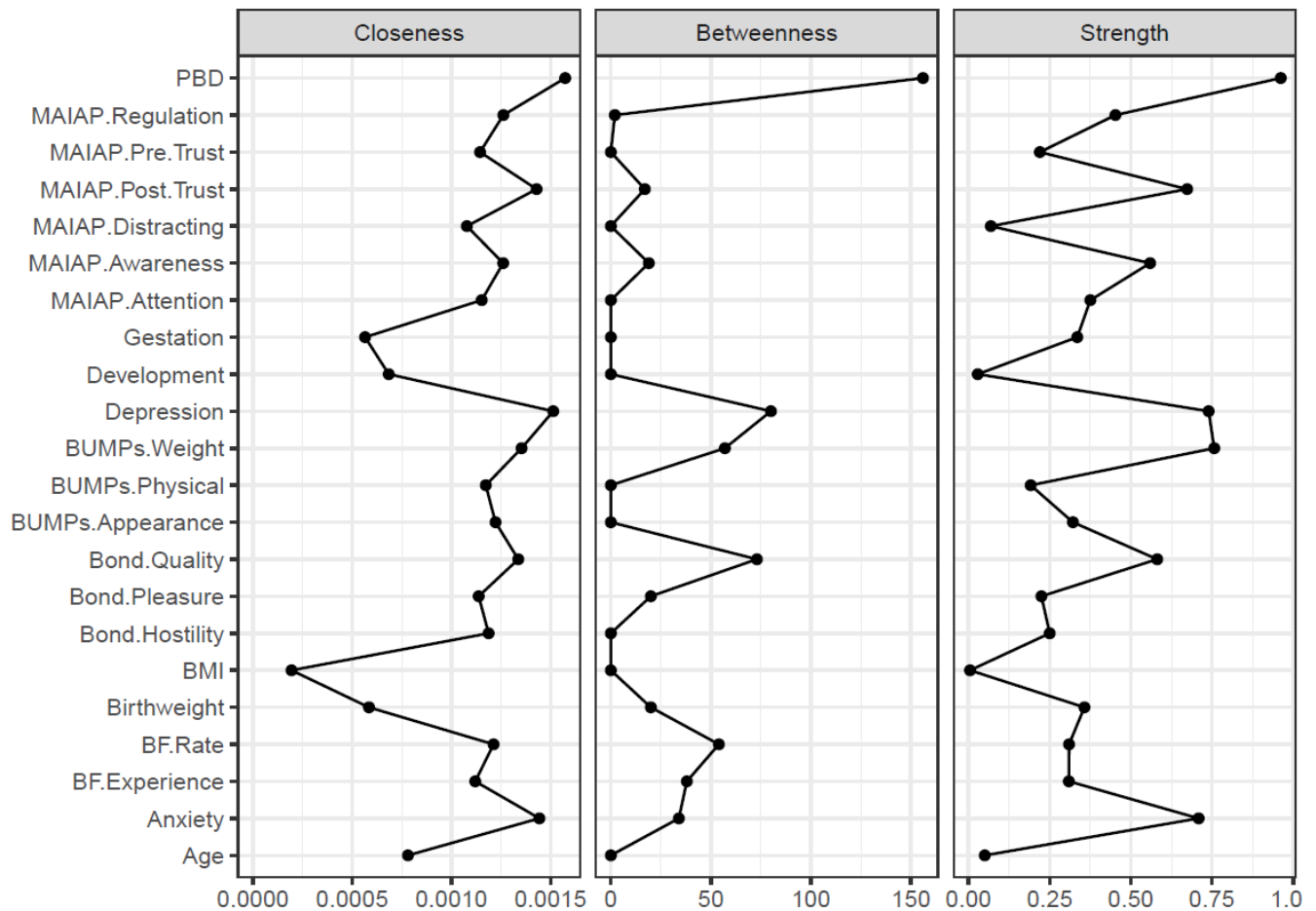
Figure 4.2. Plot showing the centrality coefficients for each node within the 3-month network. BF= Breastfeeding, PBD = Postnatal body dissatisfaction, BMI = Body mass index.

4.4.1.3. Clustering

Breastfeeding rate, absence of bond hostility, interoceptive attention regulation and antenatal body dissatisfaction with physical ability had the highest clustering coefficient (1). See Appendix C.3 for all clustering coefficients.

4.4.2. 6-month partial correlation network analysis
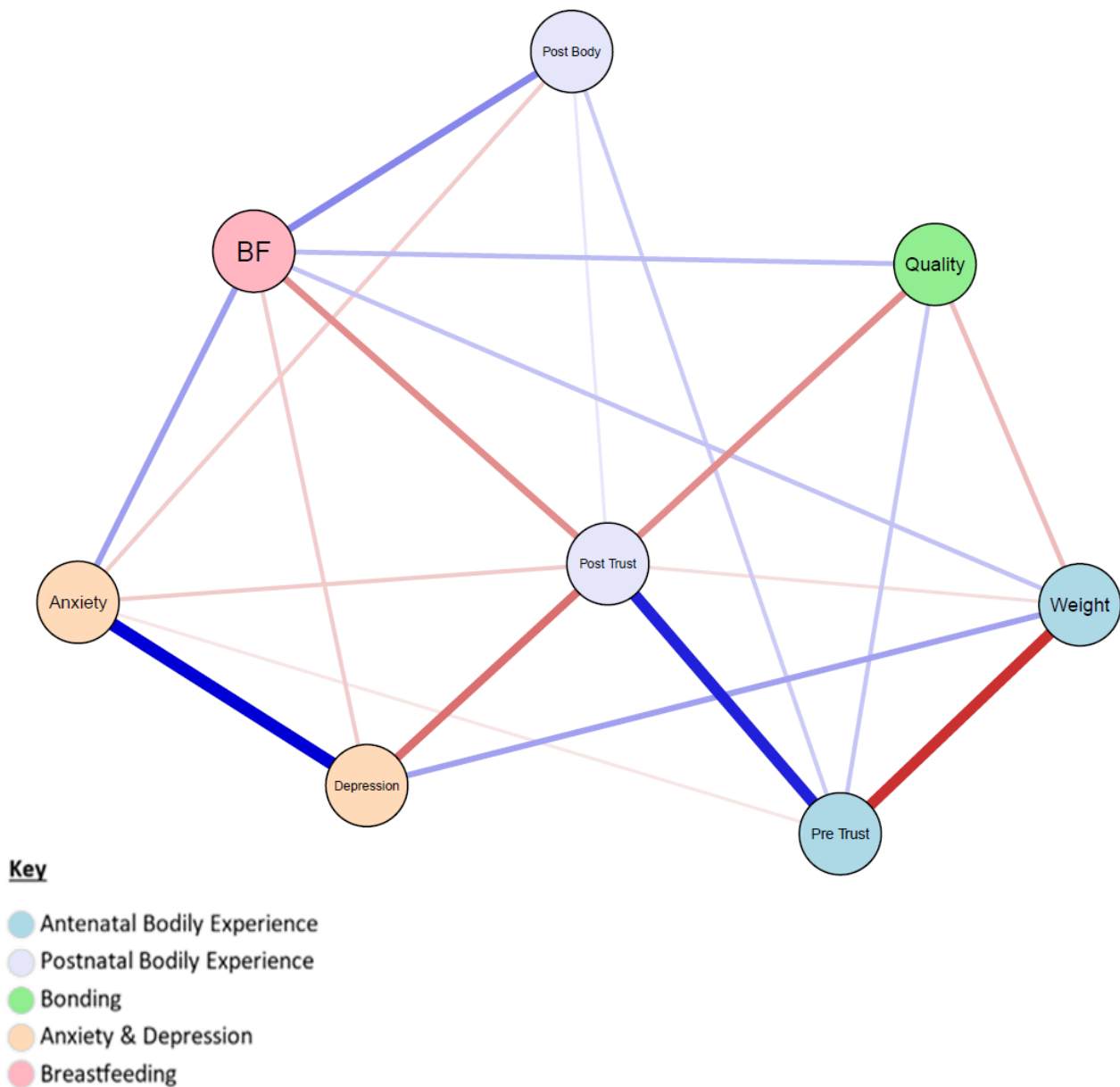
Figure 4.3. A partial correlation network analysis to show the relationships between body dissatisfaction and interoception during pregnancy and mother-infant variables at 6 months postpartum. Nodes represent variables, and edges represent the strength of the connections between nodes. Blue edges represent positive relationships and red edges represent negative relationships. BF= Breastfeeding rate, Weight = Antenatal body dissatisfaction with weight.

The 6-month network in Figure 4.3 included 20 edges and 8 nodes (antenatal body dissatisfaction with weight, postnatal body dissatisfaction, antenatal and postnatal interoceptive trust, bonding quality, breastfeeding rate, anxiety, and depression). The sparsity of 0.714 suggests a relatively dense network. Bootstrapping analyses found the network to be

reasonably stable according to stability indices (see Appendix C.2). It was found that to achieve a correlation coefficient of ≥ 0.7 in at least 95% of the sample in the 6-month network, 28% of cases could be dropped without significantly impacting edge weights or edge strength. Descriptive statistics and sample sizes for all variables can be found in Appendix C.1.

4.4.2.1. Edge weights

Overall, the 6-month network shows that the bodily experience is associated with breastfeeding rate, anxiety, depression, and attachment quality. Higher levels of dissatisfaction with body weight during pregnancy were associated with lower levels of trust in the body antenatally and postnatally, higher levels of depression and a lower quality bond between mother and baby. High levels of antenatal body trusting were linked to higher levels of trust postnatally, a stronger bond quality between mother and infant, and a higher level of body dissatisfaction postnatally.

High levels of postnatal body dissatisfaction were associated with lower levels of anxiety, higher levels of antenatal and postnatal body trust, and an increased rate of breastfeeding. High levels of postnatal body trust were correlated with lower bond quality, reduced anxiety and depression, and lower breastfeeding rates. Among the variables of interest, breastfeeding was linked to a stronger bond quality, higher levels of anxiety and lower levels of depression, with higher anxiety scores being linked to higher depression scores. See Appendix C.2 for all edge weights and basic Pearson's correlation coefficients.

4.4.2.2. Centrality

The node with the most connections was postnatal body trusting with 7 connections, followed by breastfeeding rate, antenatal body weight dissatisfaction and anxiety, all with 5 connections. Depression had the highest strength centrality (1.08), followed by postnatal body trust (0.97) and antenatal body trust (0.92). Depression had the highest betweenness centrality (5), followed by breastfeeding rate (4) and postnatal body trust (3). See Figure 4.4 and Appendix C.3 for all centrality coefficients.
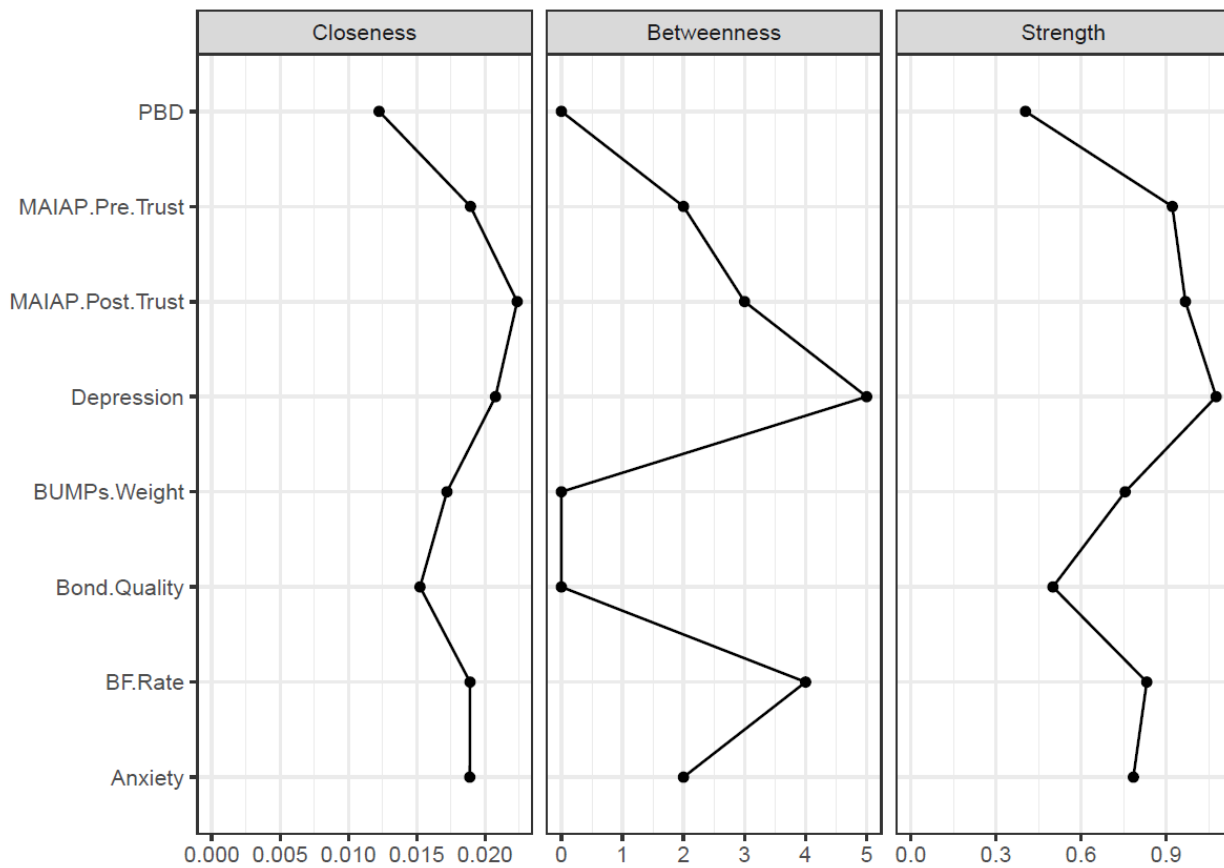
Figure 4.4. Plot showing the centrality coefficients for each node within the 6-month network. BF= Breastfeeding rate, PBD = Postnatal body dissatisfaction.

4.4.2.3. Clustering

Postnatal body dissatisfaction had the highest clustering coefficient (0.83), followed by anxiety, depression, and antenatal dissatisfaction with weight, all with a clustering coefficient of 0.7. See Appendix C.3 for all clustering coefficients.

4.4.3.   Post-hoc analyses

Post-hoc tests were conducted to identify any significant differences in variables over time. The top three variables with the highest strength and betweenness centrality in the networks were chosen. Within the 3-month network, these variables were postnatal body dissatisfaction, antenatal body weight dissatisfaction, depression, and postnatal bonding quality. Within the 6-month network, these variables were postnatal and antenatal body trust, depression, and breastfeeding rate. Body weight dissatisfaction was only measured at one time point and was therefore left out of these analyses, thus leaving postnatal body dissatisfaction, breastfeeding rate, depression, bond quality and body trust.

Assumption testing showed that not all variables were normally distributed, therefore non-parametric tests were employed. Wilcoxon and McNeamar's tests show no significant difference in postnatal body dissatisfaction ($Z=1824.5$, $p=1$), bond quality ($Z=1115.0$, $p=0.790$), or breastfeeding rate ($X^2=9.0$, $p=1$), between 3 and 6 months postpartum. Friedman's tests show no significant differences in interoceptive body trust ($X^2=1.29$, $p=1$) or depression ($X^2=2.68$, $p=1$) between antenatal, 3-month and 6-month time points. All p values were Bonferroni corrected.

4.5.   Discussion

Network analysis, a relatively novel approach in psychological research, has allowed the exploration of the antenatal bodily experience and postnatal maternal well-being and bonding. These findings highlight a significant link between women's perceptions of their internal and external bodies during pregnancy and their postnatal experiences. The 3-month network encouraged a more holistic approach, allowing a better understanding of which facets of the pregnancy bodily experience are involved with postnatal variables, and through which pathways. At 3 months, both antenatal body dissatisfaction and interoception were directly associated with postnatal bodily experiences and maternal mental health, whilst being indirectly associated with bonding, breastfeeding, and infant outcomes. The 6-month network gives us a smaller, hypothesis led analysis, and identified direct connections between the antenatal bodily experience and maternal mental health, mother-infant bonding, and the postnatal bodily experience. Postnatal body dissatisfaction appears more central to the network at 3 months becoming less significant by 6 months. Conversely, antenatal and postnatal body trust are more central at 6 months compared to 3 months. Overall, both networks show the interconnectedness between antenatal bodily experiences and postnatal health and well-being.

Antenatal body weight dissatisfaction was consistently influential across both networks, having high strength centrality at 3-months, and high degree centrality at 6 months. This extends previous literature that identified body weight dissatisfaction to be a central construct within the context of antenatal mother and infant well-being (Munns & Preston, 2024), emphasising its lasting influence across pregnancy and early motherhood. During pregnancy, body weight dissatisfaction may increase due to societal pressures and expectations around what a woman's body should look like, leading women to strive towards a desirable pregnant body shape (Hodgkinson et al., 2014). However, this is in competition with sensations

such as an increase in appetite (Butte & King, 2005) and a reduction in physical activity, often due to fatigue (Chien & Ko, 2004) and pain (Vermani et al., 2010), which can lead to an increase in weight. The results from the networks suggest dissatisfaction with weight during pregnancy is highly influential early in the postnatal period but becomes more widely connected and less impactful over time. This may suggest that dissatisfaction with body weight negatively affects a mother's confidence immediately after childbirth, but as mothers adapt to their postnatal bodies and routines, other factors may start to play a more significant role in their well-being.

Network indices at 3 months highlight the particular significance of postnatal body dissatisfaction, which has the highest degree, strength and betweenness centrality. This suggests that how satisfied women feel about their postpartum bodies is widely influential across multiple outcomes, highlighting the potential for postnatal body dissatisfaction to be a 'bridge', impacting the relationship between antenatal bodily experiences and postnatal variables. This advocates for greater consideration of body dissatisfaction across the whole perinatal period, especially considering that previous literature has found antenatal body dissatisfaction predicts postnatal body dissatisfaction (Roomruangwong et al., 2017). At 6 months, internal rather than external bodily experiences seem more central, with postnatal body trusting emerging as the most connected node in the network and both postnatal and antenatal body trusting exhibiting high strength centrality. Antenatal body trusting has been previously associated with more positive birthing experiences (Flores, 2018), lower body dissatisfaction (Munns & Preston, 2024) and higher levels of antenatal attachment (Stafford et al., 2024). The current findings suggest that benefits continue postpartum as postnatal body trust links with lower levels of anxiety and depression, with this factor acting as a bridge between antenatal bodily experiences and postpartum outcomes. Similar to postnatal body dissatisfaction, postnatal trust could influence the relationship between antenatal bodily experiences and postnatal well-being, supporting previous research within pregnant populations (Munns & Preston, 2024).

Considering the transition in influence from postnatal body dissatisfaction at 3 months, to interoceptive body trust at 6 months, different bodily experiences could be pivotal at different time points. Body dissatisfaction may be more influential at 3 months postpartum, as women are adjusting to the physical changes from pregnancy and childbirth. Pressures to return to a pre-pregnancy state may be heightened during this period, combined with the unrealistic expectations women often hold about the postpartum body (Hodgkinson et al., 2014), may enhance feelings of body dissatisfaction. Consistent with the current results, previous work has

identified the detrimental impact that postnatal body dissatisfaction has on maternal mental health (Chan et al., 2020), and breastfeeding outcomes (Brown et al., 2015). By 6 months, where physical recovery is generally more advanced, mothers may be more focused on the functionality of their bodies in caring for their infants. This is particularly salient as the baby grows, when more demands are placed on the mother's physical abilities for breastfeeding, sleep regulation and physical activity. Enhanced trust in bodily signals may encourage mothers to more confidently and effectively respond to their baby's needs, benefiting bonding (Crossland et al., 2022; Stafford et al., 2024). This varied influence between dissatisfaction and trust emphasises their dynamic and transient influences and suggests that targeted, time-dependent interventions may be most effective and could have downstream effects.

The change in prominence between body dissatisfaction and body trusting interoception over time fits with the Competition of Cues Hypothesis (Pennebaker & Lightner, 1980). This hypothesis suggests that there is competition between internal cues (e.g., interoception) and external cues (e.g., body dissatisfaction), and conflict can lead to a distorted perception of our bodily states and body image. This hypothesis has been previously implicated in the pregnancy bodily experience (Munns & Preston, 2024; Stafford et al., 2024), suggesting that a balance between external and internal experiences is optimal. Given the current network results, this theory can be built upon by suggesting that this balance is disrupted postpartum, with external cues being more influential in the months following birth, and internal cues being more central at later postpartum stages. The transition from pregnancy to postpartum may initially render internal signals less reliable due to physiological changes, leading to their downregulation. By contrast the physical changes in appearance, often perceived negatively, become more salient. While, post-hoc tests on the current dataset show no significant differences in body dissatisfaction and trust over time, this is consistent with work that suggests body dissatisfaction is a relatively stable construct from mid-adolescence onwards (Quittkat et al., 2019; Wang et al., 2019). Therefore, it seems the perceived importance of these bodily experiences may be what is most influential at 3 and 6 months postpartum, and understanding the shift in influence from different aspects of the bodily experience could raise awareness and encourage tailored support for women. This is particularly important given that a lack of support for women is a recurring theme across postpartum research (Brown et al., 2015; Hodgkinson et al., 2014).

The emphasis on body trust as time progresses could have wider implications for infant feeding, with higher levels of body trust at 6 months associated with lower rates of

breastfeeding. Postpartum, difficulties with breastfeeding are well known (Brown et al., 2015) and may explain the lack of trust associated with higher breastfeeding rates. This is likely to be particularly pivotal for women who feel like their body failed them during pregnancy (e.g., birth complications, unmet expectations). Societal expectations often portray breastfeeding as a natural and effortless process, however when reality falls short of these ideals, it can lead to feelings of inadequacy or failure (Brown et al., 2015), further reducing body trust. However, this association potentially suggests the importance of infant feeding in the regaining of trust in the body. Given the strong associations between breastfeeding and stronger bonding postpartum in the current network and previous literature (Ondrušová, 2023), these explanations may provide some clarity on the negative relationship between body trusting and the mother-infant bond.

Although bonding was associated with both the antenatal and postnatal bodily experience, no associations were found between bonding and maternal mental health at 6 months. Despite previous links between maternal mental health and the mother-infant bond (Borji et al., 2018), this network highlights the potential for the bodily experience to influence this relationship. This is particularly important given the rates of postnatal mental health difficulties, and the implication of interoception and body dissatisfaction in maternal depression and anxiety (Munns & Preston, 2024; Singh Solorzano et al., 2022; Singh Solorzano & Grano, 2023).

While the study provides a comprehensive and novel view of the pregnant and postnatal bodily experience, there are several challenges. Due to a relatively small sample size, direct comparisons between the networks could not be conducted, therefore no firm conclusions can be drawn around how these interconnected relationships change over time. Post-hoc analysis enabled temporal comparisons of specific variables but did not account for interrelationships. While visual observations can highlight areas of interest, larger samples are needed for statistical network comparisons. Additionally, although network analysis is suitable for exploratory research, it indicates associations between nodes rather than causality.

Another key limitation is the lack of diversity within the sample, which is predominantly white and well-educated, despite active efforts to recruit more broadly. This is pertinent given the differences in the perinatal experience among women of different ethnicities (Henderson et al., 2013) and socio-economic backgrounds (Nicholls-Dempsey et al., 2023). Underrepresentation of diverse backgrounds within healthcare research is a significant concern

(Redwood & Gill, 2013) and impacts the potential to improve health outcomes for these populations.

4.6.   Conclusions

The current results highlight the importance of both pregnancy and postnatal bodily experiences within the context of maternal and infant well-being. Considering this, the current findings highlight the need to consider the bodily experience within perinatal healthcare settings and research. Within the network analyses, the bodily experience has been identified as complex and multifaceted. Acknowledging the differential influence on outcomes from both internal and external signals suggests that the bodily experience shouldn't be reduced to simplistic or one-dimensional assessments. The centrality of these experiences emphasises their contribution to maternal mental health, mother-infant bonding, and breastfeeding outcomes. The benefit of examining the bodily experience longitudinally has allowed the identification of positive antenatal bodily experiences as a potential preventative measure for negative postnatal experiences. Further implications come from highlighting the potential of postnatal bodily experiences to bridge relationships between the antenatal body and postnatal variables. Given the role of interoception in moderating the relationship between antenatal body dissatisfaction and attachment (Stafford et al., 2024), further research is needed to identify whether this carries over to postnatal experiences. These networks emphasise the evolving importance of bodily experiences over time, with body dissatisfaction being more significant than trust at 3 months, and the reverse occurring at 6 months. This dynamic and transient postnatal period means interventions can be applied in a temporally sensitive way to maximise the impact on postnatal outcomes. More accurate expectations of the postpartum body achieved through psychoeducation may negate body dissatisfaction in the early months. Where interventions such as yoga, which has shown promising benefits for maternal postnatal well-being (Munns et al., 2024), can encourage focus on internal sensations and body trust later on in the postpartum period. Beyond being able to identify which factors are most integral in the bodily experience, this temporal aspect is something that few other studies can offer and enables the opportunity for future research to investigate causality between interventions and downstream impacts.

Overall, our results have important implications for healthcare professionals and interventions aimed at supporting pregnant women. Promoting body satisfaction and

interoceptive body trusting during pregnancy and postpartum could contribute to stronger maternal-infant relationships, reduce the risk of depression and anxiety, and improve breastfeeding outcomes postnatally.

5. Chapter 5: The Effects of Yoga-Based Interventions on Postnatal Mental Health and Well-being: A Systematic Review.

5.1.   Abstract

The postnatal period is a critical time for maternal mental health, presenting unique challenges and vulnerabilities. Identifying effective and accessible strategies to improve postnatal mental health and well-being is therefore crucial and could have substantial benefits for both mothers and babies, alongside broader implications for healthcare systems. Yoga is a potential intervention that has demonstrated notable benefits; however, a gap exists in systematically evaluating the existing literature on postnatal yoga-based interventions. This systematic review aims to comprehensively assess the impact of postnatal yoga on maternal mental health and well-being.

Six databases were searched using keywords "yoga", "yogic", "postnatal", "postpartum", "perinatal", "maternal", "mother*". Articles were considered if they were quantitative and evaluated a yoga or yoga-based intervention in postnatal samples. Study outcomes were extracted and synthesised descriptively. A quality assessment of studies was also conducted.

Of the 383 non-duplicated records that were identified, nine met criteria for full-text review. Only 6 met the inclusion criteria and so were included. Across the 6 studies within this review, data from 377 adult women were included and looked at the outcomes of women in the USA, Northern Ireland, Taiwan and Turkey. The findings of the studies suggest that taking part in postnatal yoga is associated with decreased symptoms of depression, an increase in psychological well-being and quality of life.

Yoga-based interventions may offer a promising and effective intervention for maternal mental health and well-being. However, due to the limited number of studies, and a lack of consistency in study design and measures, more high-quality research is required to establish these effects and explore the potential benefits on other aspects of maternal well-being and infant outcomes.

5.2.   Introduction

The postnatal period is linked to vulnerabilities in mental health with substantial social and economic consequences. Postnatal depression is thought to affect between 6.5% to 20% of women within a year of giving birth (Mughal et al., 2023), and perinatal mental health issues are estimated to cost the UK £8.1 billion per annum (Petersen et al., 2018). Poor postnatal mental health and well-being is linked to problems with physical health and recovery, including postpartum weight retention, pain and physical functioning (Slomian et al., 2019). There is a known bidirectional relationship between physical and mental health among postpartum women, suggesting the importance of concurrently targeting both physical and mental health to promote perinatal health (Gómez-Pérez et al., 2020). Furthermore, mental health difficulties in the mother/birthing parent can also negatively impact cognitive and psychosocial developmental and psychological outcomes for the infant such as anxiety, depression and externalising problems (Sanger et al., 2015; Sui et al., 2016). Thus, effective and deliverable strategies for improving postnatal mental health and well-being could have substantial benefits to mothers, babies, the healthcare system, and wider society.

One such strategy is yoga, a form of mind-body exercise combining physical posture, meditation, and breathing techniques (Gothe et al., 2019). The popularity of yoga as part of healthcare in western culture is increasing (McCall, 2014), and so the need to effectively assess its efficacy is becoming more important. There have been recent systematic reviews and meta-analyses assessing research on the efficacy of yoga during the prenatal period (Jiang et al., 2015; Kwon et al., 2020; Ng et al., 2019; Rong et al., 2020). These reviews, focusing only on the prenatal period, have found yoga to have positive impacts on mood, stress, pain, and social relationships, showing support for yoga during pregnancy as a promising non-pharmacological intervention to improve mental health and well-being (Jiang et al., 2015; Ng et al., 2019; Rong et al., 2020). However, no reviews have focused on the benefits of yoga solely in the postnatal period. This is concerning given the fact that historically, pregnancy has been suggested as protective against depression, with postpartum carrying an increased risk for developing major depressive disorder (Payne, 2012). Although this theory has been called into question (Meltzer-Brody, 2011), current postnatal depression rates continue to highlight the importance of research examining postnatal interventions.

The potential benefits of postnatal yoga-based interventions could act through multiple mechanisms. For example, yoga can help regulate the hypothalamic-pituitary-adrenal (HPA) axis that plays a role in how people respond to stressors (Chen et al., 2017). The review by

Chen and colleagues (2017) found four studies across multiple countries that revealed consistently lower salivary cortisol levels in pregnant women after they had regularly practiced yoga (Chen et al., 2017). These findings strongly suggest a positive impact of yoga on reducing stress levels, which can lead to better mood and reduced anxiety. It is also thought that yoga can improve aspects of physical health, with a recent review identifying multiple studies that reported pregnancy yoga increased women's pain tolerance (Corrigan et al., 2022), highlighting the potential for postnatal yoga to result in similar benefits. Finally, yoga has been linked with the bond between a mother and her unborn baby (antenatal attachment). A recent paper found that women who completed an 8-week pregnancy yoga course scored significantly higher on measures of antenatal attachment compared to controls (Akarsu & Rathfisch, 2018). Neurobiological mechanisms behind this link have been suggested, with yoga being found to enhance levels of oxytocin in psychiatric samples (a hormone involved in emotional and social bonding) (Mehta & Gangadhar, 2019). However, this potential mechanism has not yet been investigated in the context of the perinatal period.

To date, assessment of the literature surrounding studies on yoga interventions during the postnatal period is lacking. Although reviews have looked generally at nonpharmacological interventions to improve well-being during the perinatal period (Domínguez-Solís et al., 2021; Taylor et al., 2016), none focus solely on yoga, and/or consider the postnatal period in isolation. Nonpharmacological treatments are particularly preferable for addressing postnatal mental health difficulties due to their potential for longer term benefits and fewer side effects (Chow et al., 2021). By homing in on yoga interventions specifically, the distinct benefits it may offer in promoting postnatal well-being can be investigated, particularly because the antenatal and postnatal periods are significantly different. Therefore, this review examines quantitative studies that assess yoga-based interventions in postnatal samples.

5.3.   Methods

This review was registered in Prospero (ID: CRD42022366873) prospectively, before data extraction. The methodology of this systematic review follows the Joanna Briggs Institute Methodology for Effectiveness Reviews (Tufanaru et al., 2020). A systematic review specialist was consulted for general advice around conducting a systematic searches. Literature searches were conducted to identify all published articles on interventions involving yoga during the

postnatal period. A meta-analysis was considered if enough papers (2+) incorporating equivalent outcome measures, population sample and interventions were identified.

5.3.1. Search strategy

The databases searched included: Scopus, PubMed, Web of Science, PsychInfo, Medline & Embase. These electronic databases were searched in April 2022. Grey literature was not searched to ensure all studies were peer-reviewed. Our search strategy across all databases was the following: TITLE-ABS-KEY (postnatal OR postpartum OR perinatal OR maternal OR mother*) AND (Yoga OR Yogic). English language and human research limits were set. See Appendix D.1 to see further information on search strategies for each database. All searches were uploaded to Rayyan (www.rayyan.ai; Ouzzani et al., 2016) through which titles and abstracts were examined for potentially relevant articles.

See Figure 5.1 for the PRISMA diagram of the screening process, in accordance with the PRISMA 2020 statement (Page et al., 2021).
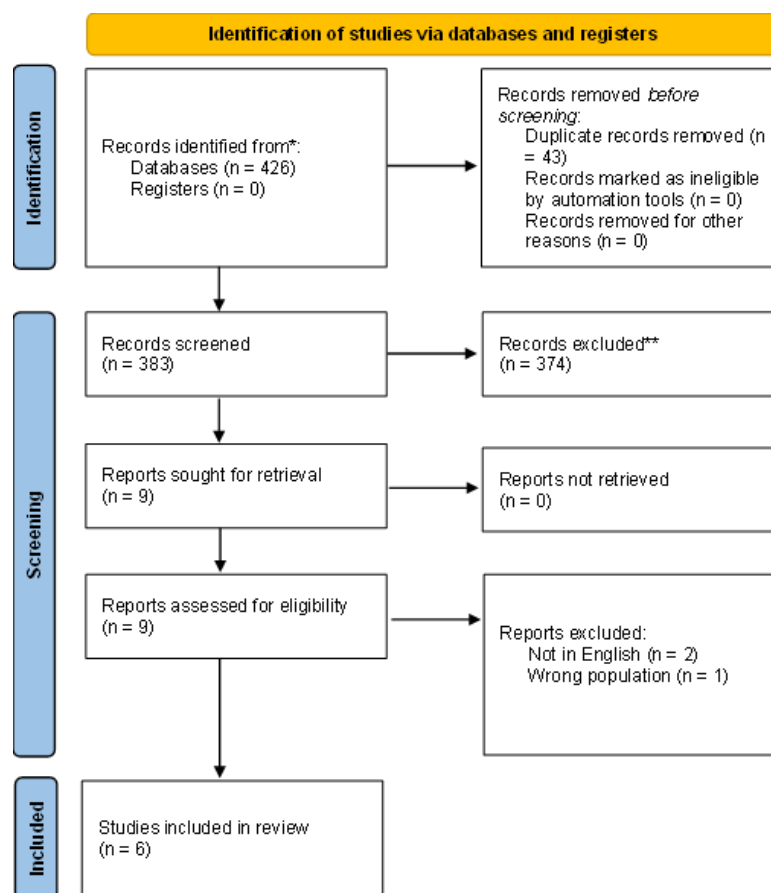
Figure 5.1. A PRISMA flow diagram of the systematic screening process, in accordance with PRISMA 2020 guidelines (Page et al., 2021).

5.3.2. Inclusion & exclusion criteria

This review aimed to identify any quantitative study that investigated the relationship between yoga-based interventions and maternal postnatal mental health and well-being. Only experimental designs were considered, including either a comparison/control group, or comparing outcome measures pre and post intervention. No specific outcomes were identified before the systematic search and any studies that considered outcomes related to maternal postnatal mental health and well-being were included. Only postnatal outcomes were considered in research where the whole perinatal period was studied and only quantitative studies, which directly tested an intervention that included yoga activities for the mother and/or infant in a postnatal sample were included. For the purpose of this review, the postnatal period was considered as up to 12 months following birth, given that recent literature suggests women should receive postpartum care for up to 1 year following the birth of their child (Saldanha et al., 2023). The independent variable had to be a yoga-based intervention for mother and/or baby and the dependent variable needed to be postnatal mental health and well-being. Papers not written in the English language were not included to ensure that the review was feasible given the available resources, time constraints and the fact that all authors were English speaking. Refer to Appendix D.2 for information on the inclusion and exclusion criteria.

5.3.3. Quality assessment

The quality of studies was assessed by two reviewers using the Joanna Briggs Institute Critical Appraisal Checklist for Quasi-Experimental Studies (Tufanaru et al., 2020) or Randomised-Controlled Trials (Barker et al., 2023) depending on the design of the study.

5.4. Results

Six papers were included in this review. A meta-analysis wasn't possible due to the limited number of papers identified and the variability in outcome measures, samples and interventions between papers. Three studies specifically measured depression but varied in sample characteristics—one used a community sample (Ko et al., 2013), another focused on high depression scores (Buttner et al., 2015), and the third included individuals throughout the perinatal period without separating postnatal data (Miklowitz et al., 2015). This variation hinders a meta-analysis. Similarly, two studies that assessed quality of life studies using the same measure (SF-36) had differing populations—one from a community sample (Unver &

Timur Tashan, 2021) and the other exclusively with high depression scores (Buttner et al., 2015), making meta-analysis unsuitable. See Table 5.1 for further study information.

5.4.1. Description of studies

5.4.1.1. Date and location
The studies identified were published between 2012 and 2021. Two of the studies were conducted in the USA (Buttner et al., 2015; Miklowitz et al., 2015), two in Northern Ireland (Cameron & Shepherd, 2018; Timlin & Simpson, 2017), one in Taiwan (Ko et al., 2013) and one in Turkey (Unver & Timur Tashan, 2021).

5.4.1.2. Participants and attrition
One study was conducted on individuals with a clinical diagnosis for major or bipolar depression (Miklowitz et al., 2015) and one study was conducted on a sample with current depressive symptoms (Buttner et al., 2015). The other studies were conducted on community samples (Cameron & Shepherd, 2018; Ko et al., 2013; Timlin & Simpson, 2017; Unver & Timur Tashan, 2021). One study included participants throughout the perinatal period, from conception to post-birth (Miklowitz et al., 2015). All other studies were conducted on exclusively postnatal samples.

All studies reported a relatively low attrition rate when excluding individuals who did not meet inclusion criteria and did not give consent (<= 20%). One study required participants to attend at least one session for their data to be included (Miklowitz et al., 2015).

5.4.1.3. Intervention
One study included a yoga intervention aimed only at the infant, where yoga was only delivered in half of the eight sessions (Cameron & Shepherd, 2018). All other studies included interventions aimed exclusively at the mother/birthing parent. The type of yoga was specified in three of the studies: Dru (Hatha) (Timlin & Simpson, 2017), Vinyasa (Ashtanga) (Buttner et al., 2015), and Mindful-yoga (Miklowitz et al., 2015). The other studies did not specify. The duration of the yoga-based intervention varied, from 4 weeks (Cameron & Shepherd, 2018; Timlin & Simpson, 2017) and 8 weeks (Buttner et al., 2015; Miklowitz et al., 2015), to 10 weeks (Unver & Timur Tashan, 2021) and 12 weeks (Ko et al., 2013). Three studies used yoga only in conjunction with other exercises/activities (Cameron & Shepherd, 2018; Ko et al., 2013; Miklowitz et al., 2015), and two studies also provided participants with a DVD to

practice yoga at home (Buttner et al., 2015; Timlin & Simpson, 2017), although this was only taken up by a minority of participants.

Half of the studies included mothers that were between six weeks to one year following the birth (Buttner et al., 2015; Miklowitz et al., 2015; Timlin & Simpson, 2017), with the other half selecting participants within a shorter postpartum period, of between two and six months (Ko et al., 2013; Unver & Timur Tashan, 2021) and zero and three months (Cameron & Shepherd, 2018) following birth.

Four of the studies had control groups (Buttner et al., 2015; Cameron & Shepherd, 2018; Timlin & Simpson, 2017; Unver & Timur Tashan, 2021), which were treated as usual (no yoga) or waiting list controls (waiting for yoga intervention).

5.4.1.4. *Measurement tools*

Measures assessing depression, physiological changes, the mother-infant relationship, and quality of life were identified among the 6 studies.

Depression was measured by 3 of the studies (Buttner et al., 2015; Ko et al., 2013; Miklowitz et al., 2015), using different assessments, including The Hamilton Depression Rating Scale (HDRS), The Beck Depression Inventory (BDI-II), The Inventory of Depression and Anxiety Symptoms (IDAS), and The Centre for Epidemiological Studies Depression Scale (CES-D), with a 4th study (Timlin & Simpson, 2017) assessing mood more generally using the Positive and Negative Affect Scale (PANAS).

Physiological changes were assessed by one study (Ko et al., 2013), using The Fatigue Symptoms Checklist (FSC) and a body composition analyser. The mother-infant relationship was similarly only assessed by one study (Cameron & Shepherd, 2018) and measured using the Infant CARE-Index (ICI) and the Mother to Infant Bonding scale. Quality of life was assessed by two studies (Buttner et al., 2015; Unver & Timur Tashan, 2021) using the same measurement, the study 36-Item Short-Form Health Survey (SF-36).

Psychological well-being was also measured in many of the studies using different validated measurement tool. For further study details see Table 5.1.

5.4.2. Effects of the interventions

5.4.2.1. Depression

All but two studies (Cameron & Shepherd, 2018; Unver & Timur Tashan, 2021) measured maternal depression (Buttner et al., 2015; Ko et al., 2013; Miklowitz et al., 2015) or mood (Timlin & Simpson, 2017) as a primary outcome variable.

Statistical analysis varied between studies. Comparisons to a control group revealed that yoga practice demonstrated a decline in negative affect (p=0.001) (Timlin & Simpson, 2017) and a steeper linear decline in depressive symptoms over the course of the intervention compared to controls (p<0.001) (Buttner et al., 2015). In the one-sample studies comparing pre and post-intervention measures, there were significant reductions in depressive symptoms for individuals with diagnoses of major or bipolar depression (p=0.008) (Miklowitz et al., 2015), or in non-clinical samples with high-levels of depressive symptoms at baseline (p=0.021) (Ko et al., 2013). In the clinical sample (Miklowitz et al., 2015) mean scores of depression at pre and post-intervention reflect participants moving from a mildly to a minimally depressed state.

The same study also examined depressive symptoms at one and six months post intervention and found only 7 out of 32 participants, who had follow-up data at six months, met criteria for major depression, with none meeting criteria for mania or mixed disorder (Miklowitz et al., 2015). However, there was no control group for comparison and this study didn't separate their results by perinatal stage (pre, during and post pregnancy). Despite this, no significant differences were found in the reduction of depression scores between perinatal stage.

5.4.2.2. Maternal psychological well-being

All studies included other measures of maternal psychological well-being, although all utilising different measures. When compared to a wait-list control group it was found that the intervention group demonstrated a greater reduction in stress, negative affect and dysfunctional coping, and an increase in problem focused coping (p=0.001) (Timlin & Simpson, 2017), as well as a steeper decline in traumatic intrusions (p=0.021) and social anxiety (p=0.006) (Buttner et al., 2015). Post traumatic growth, which is defined as transformations that occur following a traumatic experience (i.e. birth trauma), was assessed in one study, which found that this was higher in the yoga group compared to the control group (p<0.001) (Unver & Timur Tashan, 2021). This was also the case for the post-traumatic growth inventory subscales of:

change in self-perception, the philosophy of life and relationships with others (all *p* values <0.001).

One study, whose intervention included mindful yoga (Miklowitz et al., 2015) found that mindfulness tendencies increased from pre- to post intervention. Furthermore, the same study also found that those who had greater increases in mindfulness tendencies also demonstrated greater reductions in depressive symptoms (*p*=0.048).

No significant effects were found for feelings of panic (Buttner et al., 2015), fatigue (Ko et al., 2013), general anxiety or mania symptoms (Miklowitz et al., 2015) and no improvements in mental well-being (assessing feelings of self-acceptance and positive affect) were found with baby yoga (Cameron & Shepherd, 2018).

5.4.2.3. Physiological changes

One study (Ko et al., 2013) measured changes in body composition including weight, BMI, body fat, fat-free mass and total body water. Comparing pre- and post-intervention measures they found a significant reduction in weight (*p*<0.001), fat mass (*p*<0.001) and fat loss (*p*<0.001), but not BMI, fat-free mass or total body water. However, this study did not have a control group for comparison.

5.4.2.4. Mother-infant relationship

One study (Cameron & Shepherd, 2018) took measures concerning the mother/birthing parent-infant relationship. This included videoed interactions which were coded for dyadic synchrony as well as measures of subjective feelings about the mothers' bond with their baby. None of these measures revealed any significant effects compared to the control group.

5.4.2.5. Quality of life

Two studies (Buttner et al., 2015; Unver & Timur Tashan, 2021) gathered quality of life data, which involved asking questions about general, physical, and mental health. The first study found that those who participated in yoga had a significantly steeper linear increase in quality-of-life scores (*p*<0.001) during the intervention, compared to wait list controls (Buttner et al., 2015). The second study used the same assessment to measure quality of life (short form-36 item health related quality of life scale) but looked in more detail at the subscales to find that issues with physical functioning, bodily pain, general health, social functioning, and

vitality were all significantly lower in the yoga group compared to the control group (all *p* values <0.001) (Unver & Timur Tashan, 2021).

5.4.3. Satisfaction with the interventions

One study (Timlin & Simpson, 2017) conducted focus groups to assess the subjective experience of taking part in the intervention. Content analysis was used to determine the main themes. Overall, the intervention was positively received. Facilitators to attend the classes were identified and included convenience (classes being at a convenient time and location), having someone to look after the baby, and an awareness of the health benefits of yoga. Barriers to attending were identified as tiredness, not being comfortable with their postnatal body shape, and an instructor that they felt did not understand their needs.

Another study (Miklowitz et al., 2015) measured satisfaction with the course using the Client Satisfaction Questionnaire. All participants who completed the programme rated high levels of satisfaction.

5.4.4. Quality assessment

According to the JBI Critical Appraisal Checklist for Quasi-Experimental Studies, two studies received a score of 5/7 (Ko et al., 2013; Miklowitz et al., 2015) and the final study received a score of 7/9 (Cameron & Shepherd, 2018). The two former studies did not include a control group, meaning that there was no comparison between the intervention group and a group receiving no intervention, so any causal plausibility is weaker. See the full quality assessment in Appendix D.3.

According to the JBI Critical Appraisal Checklist for RCT's, studies received a score of 7/11 (Unver & Timur Tashan, 2021), 8/11 (Timlin & Simpson, 2017) and 10/11 (Buttner et al., 2015). As all 3 RCT studies included no treatment or wait list controls, there was no blinding for participants and instructors. There was also no information as to whether the individuals conducting the analysis were blinded, suggesting potential bias related to administration of the intervention. For the study with the lowest quality score, the method of participant allocation was suboptimal, as this was based on which family health centre they were from (3 family health centres were randomly allocated to each group) (Unver & Timur Tashan, 2021). See the full quality assessment in Appendix D.3.

None of the 6 studies had a complete follow up, and differences between groups in terms of their follow up were not adequately described and analysed which could represent a threat to internal validity.

Table 5.1. Summary of studies.

Author & date	Title	Sample size and population	Design	Intervention	Outcome measures	Results/ conclusions
Timlin & Simpson, 2017	A preliminary randomised control trial of the effects of Dru yoga on psychological well-being in Northern Irish first-time mothers.	n = 32 (16 = yoga, 16 = WLC[a]). Postnatal participants between 6 weeks and 1 year following birth. All participants were first-time mothers. Range 8 - 50 weeks postpartum.	RCT[b]	4 weeks of Dru yoga (Hatha).	Perceived Stress scale; Positive and Negative Affect Scale (PANAS); Brief COPE inventory.	- Significant time by group interactions were found. - Compared to the control group, the yoga group shows reduced stress (p=0.001), negative affect (p=0.001) & dysfunctional coping (p=0.042) and an increase in problem focused coping (p=0.001).
Buttner et al. 2015	Efficacy of yoga for depressed postpartum women: A randomised controlled trial.	n = 57 (28 = yoga, 29 = WLC). Postnatal participants between 6 weeks and 1 year following birth and scoring over 12 on HDRS (depression).	RCT	8 weeks (16 sessions) of vinyasa (Ashtanga) yoga. Same sequence in each session.	The Hamilton Depression Rating Scale (HDRS); The Inventory of Depression and Anxiety Symptoms (IDAS); The Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36).	- Both groups showed improvements (p<0.001). - The yoga group demonstrated significantly greater improvement on all measures (HDRS: p=0.005, IDAS Depression: p=0.002, IDAS Anxiety: p=0.006, IDAS Trauma: p=0.021, SF-36: p<0.001).
Ko et al., 2012	Community-based postpartum exercise program.	n = 23 (28 without attrition). Postnatal participants between 2- and 6-months following birth.	Quasi-experiment Within-subjects	Once a week for three months. Yoga & Pilates exercise, stretching, breathing, muscle contractions and low-intensity aerobics.	Centre for Epidemiological Studies Depression Scale (CES-D); Fatigue Symptoms Checklist (FSC); Body composition analyser	- Participants with high depression scores at baseline demonstrated a significant reduction in depression symptoms following the intervention (p=0.021). Low scorers did not. - No significant effects on fatigue, or BMI. Weight (p<0.001) and body fat (p<0.001) significantly reduced, and fat loss significantly increased (p<0.001).

Miklowitz et al. 2015	Mindfulness-Based Cognitive Therapy for Perinatal Women with Depression or Bipolar Spectrum Disorder.	n = 39 (attended at least one session). Pregnant, up to one year postnatal (up to 1 year after birth), non-pregnant but trying to conceive. Diagnosis of major depression or bipolar disorder, current subthreshold depressive symptoms.	Quasi-experiment Within-subjects	8 weekly sessions of mindfulness training (including yoga).	Beck Depression Inventory (BDI-II), The Hamilton Depression Rating Scale (HDRS); Young Mania Rating Scale (YMRS); State-Trait Anxiety Inventory-Current Status Scale (STAI-C); Longitudinal Interval Follow-up Evaluation (LIFE); Psychiatric Status Ratings (PSR); Five Facet Mindfulness Questionnaire (FFMQ).	- Depression decreased across the entire sample (p=0.008) - No difference was found between perinatal stage (p=0.43). Authors did not single out results for postpartum participants. - Those who had increases in mindful tendencies showed decreases in depression (p=0.048). - There were no significant differences in anxiety scores between groups.
Cameron & Shepherd 2018*	Evaluation of outcomes from an evidence-based programme for mothers and babies.	n = 66 (33 = intervention, 33 = control) postnatal participants 0 - 3 months following birth.	Quasi-experiment Between-subjects	8 weekly sessions of baby yoga (4 weeks) or baby massage (4 weeks) songs rhyme and discussion topic.	Dyadic synchrony (Infant CARE-Index (ICI) - video interaction) questionnaires - My Baby scale; Mother to Infant Bonding scale; Warwick-Edinburgh Mental Well-being Scale, qualitative responses.	- No significant differences between intervention and control group. - Positive qualitative experiences of participants led to continuation of the sessions.
Unver & Timur Tashan 2021	Effect of yoga on posttraumatic growth and quality of life in first-time mothers: A randomised controlled trial.	N = 160 (80 = intervention, 80 = control) postnatal participants 2-6 months following birth.	RCT	10 weekly sessions of yoga. Same sequence in each session.	Posttraumatic Growth Inventory (PTGI); Short Form 36 Item quality of life questionnaire (SF-36).	- Significant differences between intervention and control group for both post traumatic growth (p<0.001) and quality of life (p<0.001).

[a]WLC = Wait list control, [b]RCT = Randomised controlled trial, *No p values provided

5.5. Discussion

The review has collated studies investigating the effect of yoga-based interventions on postnatal maternal outcomes and has uncovered three key findings. Firstly, studies examining the potential benefits of postnatal yoga are scarce. Only six studies were found following a systematic search of the literature and these varied in terms of type of intervention, study design, analysis, and target sample. All but one study only delivered the intervention to the mother/birthing parent, with the remaining study requiring the parent to deliver the intervention to the baby (Cameron & Shepherd, 2018). No studies to date examine the potential benefits of mother/parent *and* baby yoga and there is little consistency between studies as to what is considered the 'postnatal period', with participants ranging from 0-12 months post birth.

The second key finding is that yoga-based interventions may have a positive impact on symptoms of depression postnatally. All studies measuring depressive symptoms or low mood found a significant decrease in symptoms following the intervention, especially in those with higher-levels of depression at baseline. Further to this, quality of life, psychological growth and physical benefits were found to be improved following yoga, suggesting that interventions such as this may have wider psychological and physical benefits. These results support the positive outcomes associated with yoga-based interventions that have been found in antenatal literature (Jiang et al., 2015; Ng et al., 2019; Rong et al., 2020), suggesting some consistency between perinatal periods.

The final key finding is that yoga-based interventions seem to be acceptable to the participants. All studies received positive feedback from those attending, and/or demonstrated low attrition rates. In addition, no adverse effects were reported, although most studies did not include additional follow ups to assess more longer-term consequences of taking part. This suggests that such interventions may be well received by the target audience and thus may offer a logistically feasible method to be implemented in the community.

From these main findings, the potential benefits and feasibility of postnatal yoga-based interventions are made clear. These findings and future research in this area has the potential to impact clinical health practices, health care policy and public awareness of effective and accessible postnatal nonpharmacological interventions. This is particularly important, given the potential for yoga-based interventions to be virtually accessible, and an opportunity for community building during a period of potential isolation for mothers (Adlington et al., 2023).

It is hoped that this review, by providing a foundation of evidence for nonpharmacological yoga-based postnatal interventions, will facilitate future research and intervention development to improve maternal well-being in the first 12 months following birth without side effects associated with pharmacological treatments (Chow et al., 2021).

However, research in this area is scarce, with inconsistencies in measures taken, study design, target population, types of intervention and data analysis. All studies were found to have significant shortcomings, and this means that conclusions drawn based on the current literature need to be taken with caution. For example, one of the RCT studies had a suboptimal method of participant randomisation (Unver & Timur Tashan, 2021), and only one study considered weeks postpartum as a contributing factor to maternal outcomes in their analysis (Timlin & Simpson, 2017). Most studies also did not require participants to refrain from other forms of yoga practice/postnatal groups or exercise. Sample sizes for most of the studies were small (ranging from 23-160). Despite some reporting a power analysis to justify the sample size, it is unclear what the estimated effect size was based on and whether such calculations were appropriate for all analyses that were conducted, including subgroup analysis (Buttner et al., 2015; Miklowitz et al., 2015; Unver & Timur Tashan, 2021). Additionally, samples in all studies were self-selecting and most participants were middle class, which limits the generalisability of the research findings, especially when considering the diverse range of postnatal experiences influenced by factors such as ethnicity (Henderson et al., 2013).

Outcomes measured were also inconsistent between studies, with only one study examining possible effects on the mother/parent-infant relationship (Cameron & Shepherd, 2018) and one examining psychological growth (Unver & Timur Tashan, 2021). The studies were also limited when thinking about longer-term outcomes. Only one study (Miklowitz et al., 2015) included longer-term follow-ups but this study sample was not exclusively postnatal, consisted of participants with prior mental health diagnoses, and did not include a control group for comparison. Therefore, although short-term effects might seem promising, longer-term outcomes of taking part in a postnatal yoga-based intervention are unclear. Further to this, only one study measured physiological outcomes pre- and post-intervention, which allows us to identify whether the yoga intervention is associated with significant physical change, however this study did not have a control group (Ko et al., 2013). The impact of yoga on a mother's physicality and physiology is an important area for future research, given the fact that yoga is primarily a physical activity, postnatal physical and psychological health are intrinsically

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linked (Slomian et al., 2019), and the postnatal period involves profound physiological transformations (Chauhan & Tadi, 2022). Therefore, the known benefits yoga can bring in regard to muscle strength (Corrigan et al., 2022) and reducing stress via the HPA (Chen et al., 2017) could have important physiological implications.

Finally, considering specific limitations of this review, only studies that had been though full peer review were considered in order to ensure quality of study design. Including grey literature within this review may have broadened the scope and depth of this review by allowing for the identification of further studies and therefore, the potential for more consistency between study designs and outcomes measured as well as avoiding potential publication bias. Furthermore, limiting the review to only publications available in the English language may have also limited our access to appropriate studies. Due to the diversity in the studies examined, a meta-analysis was not possible. Expanding our search to grey literature and non-English texts may have provided us with sufficient data to do this and thus add further weight to the current findings.

It is clear from this review that more high-quality research is required, with larger and empirically justified sample sizes and effectively randomised control samples. Future research should aim to include a wider demographic of participants to determine efficacy and acceptability of yoga-based interventions across samples of different backgrounds. Additionally, further post-intervention follow-up assessments are required to examine the longer-term effects of the intervention on a wider range of outcome measures, particularly relating to the infant given the links between maternal mental-health and infant well-being (Sanger et al., 2015; Sui et al., 2016). A better understanding of physiological outcomes, such as weight loss, could further assess the potential physical benefits of yoga and its links to psychological factors.

Developing interventions that involve both mother/birthing parent and baby is another avenue to explore. A key reason identified in the studies as attributing to attrition for the mother/birthing parent only interventions, was difficulty obtaining childcare (Buttner et al., 2015; Ko et al., 2013; Timlin & Simpson, 2017). A yoga intervention that incorporates both the parent and infant means that any childcare issues would be limited (with the exception of potential older siblings), thus making the intervention more accessible and lowering attrition rates further.

5.6. Conclusions

Although current research is both scarce and limited, there is evidence for potential benefits of postnatal yoga, particularly on postnatal mood (depressive symptoms). Overall, it seems that such interventions are well received by those who take part and may therefore offer a prospective method for prevention and treatment of low mood following birth. However, more high-quality research in this area is imperative in order to establish these effects by addressing significant limitations in the current research, assessing longer-term effects of yoga practice and exploring interventions aimed at both mother and baby.

6. Chapter 6: General Discussion

6.1. Key results

The journey of pregnancy, often celebrated for its miraculous nature, places significant physical burdens on the expectant mother that warrant in-depth exploration and understanding. Evidently from the investigations conducted within this thesis, how women feel about these physical changes is central to wider mother and infant health and well-being. Specifically, Chapter 2 introduces links between external and internal bodily experiences during pregnancy and implicates these in a range of outcomes including maternal anxiety and depression, antenatal attachment, and breastfeeding intentions. Chapter 3 expands on this by adapting a new measure to assess pregnancy body dissatisfaction from a postnatal time point. Here, connections were identified between retrospective body dissatisfaction and elevated levels of postnatal anxiety and depression, and lower levels of postnatal bonding. Thus, implicating pregnancy body dissatisfaction in postnatal experiences and paving the way for a longitudinal analysis. This longitudinal approach was addressed in Chapter 4, where both body dissatisfaction and interoceptive sensibility, measured during pregnancy, were identified as key components in a postnatal network consisting of maternal mental health, bonding, breastfeeding outcomes, infant development and infant birth weight.

Critically, Chapters 2 and 4 consistently highlight interoceptive body trust and body dissatisfaction as central components within antenatal and postnatal networks, potentially indicating these may be viable targets for interventions. The postnatal network within Chapter 4 allows for a temporal analysis of these constructs and identifies body dissatisfaction as more central at 3 months, where interoceptive trust becomes more central at 6 months. This longitudinal approach indicates that interventions could be timed strategically to maximise their impact on postnatal outcomes. Chapter 5 investigates a potential postnatal intervention, yoga, and its impact on maternal psychological well-being. Despite the scarcity of research around postnatal yoga, this systematic review found it to be associated with a decrease in mother's depressive symptoms, and an increase in mother's psychological well-being and quality of life. New mothers were willing to engage in postnatal yoga as an intervention, demonstrating its feasibility and opening the door for further research to explore its benefits.

6.1.1. Mental health

The role of bodily experiences in mental health is well established. There is a synonymous relationship between the psychological and the physical, meaning it is unsurprising that physical challenges and changes have been associated with poorer psychological health (Doherty & Gaughran, 2014). Indeed, periods of intense and rapid physical changes such as puberty (Dehestani et al., 2023), menopause (Riecher-Rössler, 2020) and pregnancy (Kirk & Preston, 2019) are often accompanied by vulnerabilities in mental health. During the perinatal period, this thesis has demonstrated that the bodily experience plays a significant role in mental health outcomes, providing support for, and going beyond, previous work (Kirk & Preston, 2019; Singh Solorzano et al., 2022).

Within the antenatal network, women dissatisfied with their body's physical abilities had higher levels of both anxiety and depression. The significant changes during pregnancy can affect the body's capabilities, often limiting what women can do in later stages of pregnancy compared to pre-pregnancy. This reduction in activity, often due to fatigue (Chien & Ko, 2004) and pain (Vermani et al., 2010), can lead to less endorphin release and fewer stress relief activities (Marín-Jiménez et al., 2022) contributing to feelings of depression and anxiety. Given that the relationship between mental health and bodily experiences is likely bi-directional, negative and intrusive thoughts characteristic of anxiety and depression may contribute to the lack of satisfaction with the body. The relationship between mental health and body dissatisfaction maintains throughout the 6-month network and retrospective analysis, emphasising the stability of this connection and supporting previous literature (Chan et al., 2020; Kirk & Preston, 2019; Singh Solorzano et al., 2022).

Similarly, interoception is consistently linked with anxiety and depression. Women's interoceptive body trust seems more closely linked to anxiety, with connections across three networks, compared to depression with connections across only two networks. Anxious individuals tend to be more aware of internal bodily signals, often as a self-protection mechanism against perceived threats, however, they struggle with regulating these signals and have difficulty trusting their own bodies (Garfinkel et al., 2015; Hsueh et al., 2023). The antenatal network confirms this during pregnancy, with low levels of trusting and self-regulatory interoception, and high emotional awareness being associated with increased anxiety during pregnancy. One potential mechanism behind this relationship is the discrepancy between observed and expected bodily states that anxious individuals often hold (Paulus &

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Stein, 2010). For example, during pregnancy women might anticipate feeling similarly to their pre-pregnancy state, but instead notice an increase in heart and respiratory rate. This incongruence can amplify anxiety, as these bodily sensations may be misinterpreted as concerning. These experiences can further heighten attention towards bodily states resulting in a feedback loop and creating a cycle of anxiety and mistrust in the body.

The relationships between mental health and the bodily experience, in particular, serves to illuminate the importance of considering body dissatisfaction and interoception from a multifaceted perspective. Research has particularly highlighted the need to assess interoception in a more comprehensive way by investigating multiple interoceptive dimensions, including attention paid to internal bodily signals and how they are interpreted (Suksasilp & Garfinkel, 2022). Unique relationships were identified between subscales of the bodily experiences and various outcomes, such as that between dissatisfaction with physical ability and depression within the antenatal network, and between interoceptive emotional awareness and anxiety within the 3-month network. These results demonstrate the importance of looking at both internal and external bodily experiences as multifaceted and complex constructs in order to gain a holistic understanding of the pregnancy bodily experience, providing a foundation for intervention development.

6.1.2. Attachment

Results from this thesis also encourage the consideration of bodily experiences within the context of mother-infant relationships. Poorer antenatal attachment intensity was associated with higher body appearance dissatisfaction, and poorer postnatal bond quality was associated with antenatal body weight dissatisfaction and postnatal body trust. The retrospective investigation in Chapter 3 supported this, with associations between body dissatisfaction during pregnancy and poorer postnatal bond quality. Therefore, women who feel more positively towards their bodies have stronger bonds with their babies. In fact, dissatisfaction with the body has previously been identified as one of the biggest predictors of antenatal attachment, beyond other known predictors such as anxiety and depression (Kirk & Preston, 2019), highlighting the importance of the bodily experience in the development of mother-infant relationships.

One underlying mechanism that explains the relationship between body dissatisfaction and attachment is interoception. Stafford et al (2024) assessed multiple dimensions of interoception during pregnancy and identified that worry related to interoceptive signals

moderated the relationship between pregnancy body dissatisfaction and antenatal attachment. Further investigation identified body trust as the interoceptive dimension most strongly associated with antenatal attachment. Perceptions of internal experiences, such as foetal movements, have also been shown to enhance levels of antenatal attachment (Heidrich & Cranley, 1989), potentially due to encouragement from healthcare professionals for mothers to assess foetal movements and bodily signals. This intensified interoceptive awareness can foster a stronger connection with the developing foetus, as the mother feels more attuned to the physical changes and movements of her baby. In particular, trusting bodily sensations and the body's ability to support the foetus enables mothers to address their baby's needs more effectively, enhancing maternal responsiveness and the mother-infant bond (Crossland et al., 2022; Stafford et al., 2024). It is therefore understandable that concerns about bodily experiences are heightened during pregnancy compared to the postpartum period (Singh Solorzano et al., 2022).

6.1.3. Breastfeeding

However, concerns around the postpartum bodily experience can be heightened by breastfeeding difficulties. Chapter 4 emphasised the relationship between breastfeeding and bodily experiences at both 3- and 6-month postnatal timepoints. According to these networks, women experiencing more dissatisfaction with their body at antenatal and postnatal time points, and less trust in the body postpartum, were more likely to be breastfeeding. This result was not identified in the antenatal network, which investigated feeding intentions, likely due to the fact intentions don't account for the challenges women may face once they attempt breastfeeding. The difficulties associated with breastfeeding are acknowledged within the literature (Brown et al., 2015), despite the popular narrative that breastfeeding is natural and easy. Brown et al (2015) identified several reasons why women with high body dissatisfaction chose to stop breastfeeding, including finding it difficult e.g. baby wouldn't latch, or finding it painful e.g. mastitis. Additionally, women who were more concerned about their prospective postpartum body shape were more likely to stop due to embarrassment when publicly feeding, and the impact it had on the appearance of their breasts. This link between body dissatisfaction and breastfeeding outcomes is bolstered by the implication of body trust within this relationship, according to the postnatal network analyses. Difficulties with breastfeeding can lead to feelings of body failure, negatively impacting body trust, and by association postnatal bonding

(Ondrušová, 2023). For women that choose to or are able to breastfeed, similar negative feelings towards the body may arise by feeling 'trapped' in their bodies, now recognising their bodies as not exclusively their own, and the impact exercise and dieting have on breast milk production (Bravi et al., 2016; Brown et al., 2015). This also cycles back to mental health, with women who are highly anxious often being more concerned about their bodies ability to provide their baby with enough milk, and lacking confidence in addressing difficulties if they arise (Brown, 2014; Li et al., 2008). This emphasises the holistic nature of the bodily experience, and the interconnectivity of factors involved in the perinatal period.

6.1.4. Infant outcomes

Infant outcomes were investigated within the 3-month network. Infant development was associated with an increase in bond quality, which is in line with previous literature implicating the mother-infant relationship in a child's developmental progress (Branjerdporn et al., 2017). This research identified that mothers experiencing a more positive bond with their baby are more likely to address their needs and spend time with their child, encouraging development. Lower infant birth weight was associated with poorer breastfeeding experiences and a shorter gestation period. Although the link between birth weight and gestation are established (Vinther et al., 2023), the link between breastfeeding experiences and infant birth weight can be further considered. Mothers of infants with lower birth weights may experience more difficulties with breastfeeding and feelings such as self-blame, resulting in more negative breastfeeding experiences (Lee et al., 2009). Mothers may also experience internalised pressure to breastfeed for longer periods to encourage infant weight gain, potentially impacting the feelings a mother has towards the breastfeeding experience.

Postnatal body dissatisfaction was directly associated with breastfeeding rate and experience at 3-month, and postnatal and antenatal bodily experiences were associated with postnatal bonding at 6-months. As both breastfeeding and bonding go on to link with infant outcomes, this suggests they may act as 'bridge' variables that connect the bodily experience to infant birth weight and development. Future research could explore whether these bridge variables mediate or moderate the relationship between the bodily experience and infant outcomes. Overall, these results emphasise the need for holistic care practices during the perinatal period, considering both physical and psychological support for mothers to encourage infant development.

6.2. Theoretical and practical implications

6.2.1. Competition of cues

When considering which factors are most significant within the context of mother and infant outcomes, the network analyses identified interoceptive and exteroceptive bodily experiences as the most central constructs. During pregnancy, antenatal body trust and body weight dissatisfaction were the most central. At 3 months postpartum, antenatal body weight dissatisfaction and postnatal body dissatisfaction were identified as two of the most central nodes, while at 6 months postpartum, pivotal nodes included antenatal and postnatal body trust. These results go beyond emphasising the importance of bodily experiences during the perinatal period, and provide a novel temporal aspect. This suggests that the influence of body dissatisfaction is particularly central in the early postnatal period, with body trust becoming increasingly central over time. The Competition of Cues Hypothesis can shed some light on this, suggesting that perception of internal (e.g. interoception) and external (e.g. body dissatisfaction) cues should be balanced (Pennebaker & Lightner, 1980). According to this hypothesis, overemphasis on either internal or external signals can disturb this balance, potentially leading to negative outcomes. For example, someone who focuses heavily on their external body may neglect interoceptive signals such as hunger, which can contribute to body concerns and poor well-being. This is supported by Badoud & Tsakiris (2017), who suggest a combination of both exteroception and interoception is required for a coherent bodily experience. This hypothesis can be extended to suggest that this balance is not maintained during the perinatal period, with emphasis on external cues early in the postpartum period, and internal cues later. The significant bodily changes that occur immediately postpartum may make internal signals less reliable due to physiological changes, causing them to be downregulated. This may make physical changes in appearance become more prominent. Interoceptive signals may therefore become more stable as the maternal body recovers from the changes during pregnancy, and more salient over time due to its crucial role in regulating a mother's physical abilities, which gain increased importance as the baby grows.

6.2.2. Neural mechanisms

The concept of interoceptive inference can expand our understanding of how bodily experiences change during the perinatal period. This is a form of predictive coding, where interoceptive signals and sensory information are continuously updating predictions about

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internal bodily states, helping to maintain physiological balance. This is in line with the predictive coding theory which suggests that the brain generates predictions based on both internal and external sensory information in order to accurately perceive the world around us (Kilner et al., 2007). Interoceptive inference suggests that the brain's predictive processing of internal bodily signals such as heart rate and temperature gives rise to emotions (Seth, 2013). This predictive coding, alongside interpretations of interoceptive signals, is integrated with external experiences such as sensory information which contributes to the experience of body ownership. Therefore, if this interoceptive inference is disrupted by altering bodily states, this can negatively impact emotional states and bodily experiences (Seth, 2013). During pregnancy, significant bodily changes occur due to the regulation of internal signals such as the upregulation in sensitivity to cardiovascular and respiratory systems, meeting the demand to sustain the foetus (Ishida et al., 2011). Conversely, downregulation of signals such as nausea or pain can provide relief to the mother in order to manage discomfort. Given the significant bodily changes that occur during pregnancy, the brain must adapt and update its predictive models of internal signals, having the potential to influence emotional states and well-being, including mental health and bonding experiences. Unexpected or novel bodily signals can therefore lead to uncertainty or misinterpretation that contributes to feelings of anxiety and depression (Paulus & Stein, 2010), particularly if the brain doesn't learn from new bodily experiences resulting in maladaptive prediction patterns.

Investigations into the cognitive mechanisms behind anxiety have identified associations between anxiety and difficulties adjusting predictions to accommodate changing bodily signals (Browning et al., 2015). This theory can be applied to pregnancy, as the brain must adjust its predictions to accommodate rapidly changing internal signals, such as an increase in heart and breathing rate (Longo, 1983), which differ to baseline bodily experiences pre-pregnancy. If the brain doesn't update its learning rate to reflect the normality of these signals, women could be more likely to relate these experiences to feelings of anxiety. This implicates predictive error as a potential factor involved in the development and maintenance of emotional disorders during pregnancy and postpartum, with the body transitioning into its post-pregnancy state. This can impact the mother infant relationship through maternal emotion dysregulation (Brake et al., 2020), and also explain the predisposition to poor mental health during other periods of rapid bodily change e.g. menopause and puberty (Dehestani et al., 2023; Riecher-Rössler, 2020). Further investigation is needed to uncover whether women who are

less able to adapt their learning rates to internal and external bodily signals during pregnancy are more likely to have poor mental health outcomes, and whether pre-pregnancy learning rates influence this relationship or predict this vulnerability.

The prefrontal cortex (PFC) and anterior cingulate cortex (ACC) are some of the brain regions implicated in predictive error and learning rates. A study by Behrens et al (2007) tracked changes in the brain between periods of stability and volatility. This paper identified the ACC and PFC as central to adjusting decision making processes and adapting to environmental changes. In volatile environments with unpredictable experiences, the brain revises predictions and requires faster learning rates to update beliefs and strategies (Behrens et al., 2007). Further evidence comes from studies that show lesions to the ACC impair the ability to adjust learning based on reinforcement history, a process fundamental to decision making (Kennerley et al., 2006). Given the rapid changes characteristic of pregnancy, this research could be extended to consider these regions as key in the adaptation to body changes when pregnant. Being able to accurately respond to changes in interoceptive signals is important for decisions such as when to rest or seek medical advice. The insula has also been identified as a crucial region for integrating bodily experiences with well-being, where the processing of interoceptive signals and emotional experiences converge (Zaki et al., 2012). The insula, alongside the ACC, has been further implicated in perception of the external body. Preston & Ehrsson (2016) used multisensory illusions to create the sensation of owning an obese or slim body to assess how perception and emotion interact within the brain. They identified the insula and ACC as key interconnected regions in developing negative feelings towards the body, highlighting the neurological basis of body dissatisfaction.

The implication of brain regions such as the ACC in processing interoception and body dissatisfaction, suggests a degree of neural overlap between the regions that track external and internal stimuli. Given the shift in centrality of interoceptive and exteroceptive experiences across the postpartum period, identified in Chapter 4, further investigation could identify whether these are domain-general or domain-specific regions, within the context of the perinatal period. Domain-general regions would handle both internal and external signals equally, whereas domain-specific regions, such as subregions or specific neural populations, would specialise in either internal or external learning. A deeper understanding of the neural mechanisms responsible for processing interoception and body dissatisfaction could provide

valuable insights into the shift in influence of internal and external bodily experiences over time.

6.2.3. *Interventions*

Identifying the brain regions involved in interoception and body dissatisfaction can expand our understanding of how physiological changes can influence mental health and well-being outcomes. This could inform targets for interventions and have public health implications, with the potential to optimise perinatal mental health care and bodily experiences during pregnancy. For example, modulating activity and connectivity of relevant brain regions through appropriate interventions, such as mindfulness and yoga, could have significant benefits and provide further evidence for the implementation of such interventions in wider public healthcare settings. The insula, ACC and PFC are increasingly activated during yoga based practices, and have been implicated in the integration of sensory and cognitive processes during yoga (Schmalzl et al., 2015; van Aalst et al., 2020). This could therefore be an effective strategy to target bodily experiences and regulate interoception and emotions. Techniques such as yoga and mindfulness could also target prediction errors and act as a complementary approach to social and psychological interventions by helping individuals recognise and address maladaptive patterns. These benefits could go beyond improving present outcomes, by offering potential to prevent future negative bodily experiences and providing long term advantages throughout the postpartum period. Future research should investigate predictive coding and neural mechanisms behind bodily experiences within pregnant samples, to identify central brain regions to target and enhance the potential of intervention implementation and development. Assessing the effectiveness of yoga and mindfulness-based interventions has been considered within this thesis and should be extended to address potential neural correlates. Through understanding computations that are predictive of postnatal outcomes, these can then be targeted at a behavioural level.

In addition to the neural mechanisms behind bodily experiences, understanding the temporal significance of interoception and body dissatisfaction throughout the perinatal period can inform interventions. The varied temporal influence of internal and external bodily experiences identified in the postnatal network analyses suggests targeting different bodily experiences at different time points may be an effective way to improve outcomes downstream. Future research should aim to develop and assess potential interventions for both interoception

and body dissatisfaction, implementing them at different postnatal time points to measure their effectiveness. Postnatal yoga, which Chapter 5 of this thesis identified as an acceptable intervention that improves maternal psychological well-being and quality of life, addresses the bodily experience through mindfulness and body appreciation techniques (Mehling et al., 2012; Neukirch et al., 2019). This allows women time to tune into, appreciate and trust their bodies, whilst encouraging awareness of bodily signals. Research could go further and see whether effectiveness of such interventions change depending on temporal implementation, e.g. asking different groups of women to complete yoga courses at different postnatal periods. As yoga can be identified as primarily influencing internal bodily signals over external body dissatisfaction, it could be predicted that yoga practice later in the postpartum period (around 6 months) may have a more significant impact on postnatal outcomes, given the heightened influence of interoception at 6 months according to the network analysis. Alternatively, interventions mainly targeting body dissatisfaction may be more effective at improving outcomes earlier on in the postpartum period, such as self-compassion training and media literacy programmes to educate women and their support networks on the unrealistic standards surrounding pregnancy and postpartum.

Interventions implemented during the antenatal period are also likely to have a positive influence on the whole perinatal period, with the power to mitigate potential concerns down the line and prevent the development of poor maternal mental health and bonding. Yoga has been identified as an effective way of improving interoception (van Aalst et al., 2020), therefore bolstering its potential to improve antenatal interoception and by association, attachment and maternal mental health.

Considering these interventions, wider healthcare implications can be drawn from this research. There is a strong consensus on the need to incorporate conversations around the bodily experience during antenatal and postnatal care practices. Simple acts such as conversation or information sharing could give rise to positive outcomes by raising awareness and encouraging acceptance of bodily changes. This is similar to how enhanced knowledge on maternal mental health through training of healthcare professionals and public awareness campaigns benefited mother and infant outcomes (Maternal Mental Health Alliance, 2018). Knowledge could be spread through leaflets provided by healthcare providers or charities, conversations with healthcare professionals (informed through training courses) and digital platforms. This could help women prepare for the changes their body will undergo, and enhance

support provided by their partners, family and friends. Partner support has been identified as particularly important in lowering levels of body dissatisfaction during pregnancy (Kirk & Preston, 2019; Morozumi et al., 2020). A more accurate understanding of bodily experiences during pregnancy could also alter how women are perceived by society. Women have reported feeling judged on their pregnancy body changes, with pressures to conform to a socially acceptable pregnant body shape (Hodgkinson et al., 2014; Incollingo Rodriguez et al., 2020), often fuelled by media representations of pregnant bodies generating unrealistic standards of pregnancy (Heslehurst et al., 2022). It is possible that women also feel judged for having bodily concerns during pregnancy, worried to be labelled as vain or shallow, similar to the stigma experienced by individuals with anorexia (Dimitropoulos et al., 2016). Spreading awareness and acceptance of pregnant body changes could combat the stigma associated with body concerns.

6.3. Limitations and Future Directions

As is the nature of research, this thesis was presented with some challenges. Firstly, causality cannot be inferred across the results, thus limiting the ability to determine whether specific pregnancy bodily experience drive postnatal mother-infant well-being outcomes. This results in challenges for future research and intervention development, making it difficult to identify which factors might be significantly contributing to negative perinatal experiences. Although inferring causality within psychological research is a global challenge, the longitudinal design within this thesis means that temporal precedence of negative bodily experiences can be observed. As body dissatisfaction and poor interoceptive trust were identified as preceding poorer mental health and bonding scores, this can help to establish a potential causal link. Further research could implement causal mediation analysis techniques to establish pathways between variables, with the potential to identify whether a mediator significantly influences the relationship between bodily experiences and postnatal bonding and mental health. Interoception has previously been identified as a mediator of the relationship between body dissatisfaction and antenatal attachment (Stafford et al., 2024), providing insight into potential pathways between bodily experiences and outcomes, however this research should be extended across longitudinal projects considering postnatal well-being. Similarly, randomised controlled trials can be used by implementing interventions that target specific

body experiences e.g. body trust or body weight dissatisfaction, and assessing their impact on outcomes to establish causality.

Given the subjectivity of self-reported pregnancy bodily experiences, results may lack reliability, potentially resulting in findings that do not accurately reflect the true nature of these experiences. Responses are likely to be influenced by a participant's current mental state and overall pregnancy experience e.g. social support and trimester. Future research could address this by using ecological momentary assessments, collecting multiple samples across the day via text messages to gather more reliable data. Given the inherent subjectivity of body dissatisfaction, interoception is the only bodily experience that could be measured objectively. Measures, such as the heartbeat detection task for interoceptive accuracy (the ability to accurately perceive internal bodily signals), may gather a more reliable and accurate interoceptive experience and provide a more holistic view of pregnancy bodily experiences. However, this method has been fraught with criticism due to the lack of standardisation and limited sensitivity (Brener & Ring, 2016).

In addition, this research faces difficulties in generalising results. A lack of ethnic and socio-economic diversity within research has detrimental impacts on the ability to improve health outcomes for these populations (Redwood & Gill, 2013). This highlights a need to focus on investigating bodily experiences during pregnancy within marginalised or minority groups, and in groups where research is less accessible. Given the differences in perinatal experiences identified among various ethnic and social groups, with mothers from non-white and low socioeconomic backgrounds experiencing poorer outcomes (Henderson et al., 2013; Nicholls-Dempsey et al., 2023), investigations into these populations could identify targets for interventions that are more widely impactful. Cultural differences in how pregnancy is viewed can also influence mother and infant outcomes. For example, research by Hassan et al (2020) highlights how in many Muslim communities, babies are seen as a blessing from god, which can sometimes lead to the mother's needs being secondary to the baby's. Future research should concentrate on creating culturally sensitive interventions and address the lack of research into minority groups throughout the perinatal period. This extends to theoretical implications, with the development of generalisable theories being crucial as a foundation for more accessible and inclusive research. Future investigations should attempt to address this gap in the literature through thoughtful recruitment strategies, incorporating public patient involvement to address barriers to accessing research and healthcare for those underrepresented populations. Some

barriers may include a lack of time due to working patterns and multiple children, cultural and religious inequalities, and health vulnerabilities (Pilav et al., 2022; Propper, 2024). For perinatal recruitment, this may mean reaching out to local mother and baby groups across diverse locations, engaging relevant community and religious leaders, and working alongside national health services to recruit participants representative of the general population.

Thoughtful recruitment will enable the development of more effective support. Interventions based on data from middle-class, white populations is likely to be less effective for minority groups and targets a group who are already at lower risk of negative bodily experiences during pregnancy. Therefore, this may not be the most impactful route to intervention development. In general, there is a lack of research around body-based interventions during the perinatal period. Perinatal yoga has become increasingly popular, with Chapter 5 emphasising benefits linked to postnatal yoga despite the limited literature. High-quality, diverse studies with longer-term follow-ups are needed to validate findings and understand the lasting effects of yoga on a wider range of outcomes, such as bonding and breastfeeding experiences. Intervention accessibility is also paramount, to account for women being the primary caregiver for other children or working. Exploring online, non-pharmacological or combined mother and baby interventions may mitigate childcare as a potential barrier to accessing support and enabling engagement of more diverse populations. The previous chapters highlighted the importance of considering the bodily experience during the perinatal period, and so overall, this thesis emphasises the necessity for further research to consider interventions.

Research should also be extended to consider neurodiverse populations, with interoceptive experiences in autistic populations being highlighted as an area for future body-related research (Seth, 2013). There is a particular lack of investigation into sensory sensitivities and interoception among pregnant women, which has led to an urgent need for research to address this gap and for perinatal health care services to better accommodate the needs of autistic mothers (Grant et al., 2022). The transition of pregnancy can be particularly challenging for autistic women, who may experience unique sensory and interoceptive differences (Proff et al., 2022). Given the unique and enhanced experiences within autistic populations (DuBois et al., 2016; Matsushima & Kato, 2013), it is unsurprising that new sensory experiences are reported among autistic populations during pregnancy (Samuel et al., 2022), which could impact the mother-infant relationship and well-being. Similarly, sensory

challenges, pain, and interoceptive difference can impact autistic women's views and experiences of infant feeding (Grant et al., 2022). For autistic individuals, given observed differences in interoception at other points in the lifespan, it could be possible that altered interoception during pregnancy could affect the experience of pregnancy, potentially intensifying or altering the perception of internal changes and foetal movements. This thesis has identified the importance of bodily experiences in bonding, maternal mental health and breastfeeding; therefore, these altered interoceptive experiences could have a knock-on effect on perinatal outcomes. The need for such investigations is paramount given that autistic women often experience late or incorrect diagnosis (Harmens et al., 2022).

6.4.   Conclusions

Overall, this thesis has contributed to the understanding of bodily experiences during pregnancy and postpartum, and how these integrate with perinatal outcomes such as bonding, mental health and breastfeeding experiences. The longitudinal design has identified body weight dissatisfaction and interoceptive trust as most integral in the pregnancy bodily experience, with the temporal aspect being something that few other studies can offer. Retrospective analyses confirm that pregnancy bodily experiences contribute to postnatal outcomes and opens the door for future research to investigate causality between interventions and downstream impacts. Yoga has been identified as a promising potential intervention to address postnatal maternal well-being, with additional investigation needed to identify the effectiveness of this across broader postnatal outcomes and diverse populations.

This research has implications for other periods of rapid bodily change where there are vulnerabilities to mental health, such as puberty and menopause, emphasising the importance of considering bodily experiences within the context of well-being outcomes. Healthcare and policy can be informed by these findings, taking bodily experiences into account to develop more comprehensive perinatal care strategies, enhance mental health support, and create policies that better address the physical and emotional needs of pregnant women, ultimately improving both maternal and infant outcomes.

Appendices

A. Supplementary Material: Chapter 2

A.1. Regression results without covariates

Table A.1 shows regression results without covariates, with body dissatisfaction and body trusting as regressors. Distinct regression models were employed for each variable. Beta coefficients pertain specifically to the relationship between the body dissatisfaction or interoceptive body trusting and the mentioned variable.

Appendix Table A.1. Regression results without covariates

	df	Beta	t value	*p* value	F	F *p* value	Adjusted R^2
Body dissatisfaction							
Antenatal attachment	199	-0.121	-3.25	0.001	10.56	0.001	0.046
Anxiety	199	0.057	2.92	0.004	8.51	0.004	0.036
Depression	199	0.098	6.56	<0.001	42.98	<0.001	0.173
Body trusting							
Antenatal attachment	142	1.553	3.30	0.001	10.90	0.001	0.065
Anxiety	145	-1.297	-5.47	<0.001	29.88	<0.001	0.165
Depression	145	-0.873	-4.42	<0.001	19.51	<0.001	0.112

A.2. Antenatal network analysis bootstrapping

Bootstrapping with 1000 resamples was employed to enhance the robustness of our network analysis. Table A.2 shows the results, including edge weights and corresponding confidence intervals (CIs) for the bootstrapped network.

The stability of the relationships between variables was further assessed using case-drop bootstrapping. To maintain a correlation of 0.7 or higher in at least 95% of the samples, a maximum of 51.8% of cases could be dropped without significantly affecting the network edges, and up to 28.5% of cases could be dropped while retaining the strength of associations. These results show the robustness of our network and provide valuable guidance for data inclusion and analysis.

Appendix Table A.2. Bootstrapping results showing edge weights and confidence intervals.

Nodes	Edge Weight	Lower CI	Upper CI
AA Intensity — Gestation	0.18	-0.01	0.36
AA Quality — AA Intensity	0.54	0.41	0.65
Breastfeeding — BMI	-0.22	-0.36	-0.04
BUMPs Physical — BUMPs Weight	0.34	0.21	0.47
BUMPs Physical — HADS Anxiety	0.18	0.00	0.32
BUMPs Physical — HADS Depression	0.26	0.08	0.39
BUMPs Physical — Gestation	0.20	0.07	0.33
BUMPs Appearance — AA Intensity	-0.17	-0.35	0.02
BUMPs Appearance — MAIAP Trusting	-0.24	-0.39	-0.07
BUMPs Weight — AA Intensity	0.19	0.02	0.35
BUMPs Weight — BMI	0.19	0.02	0.35
BUMPs Weight — BUMPs Appearance	0.32	0.18	0.46
BUMPs Weight — MAIA-Preg Trusting	-0.25	-0.40	-0.10
BUMPs Weight — Gestation	-0.17	-0.30	-0.03
HADS Anxiety — HADS Depression	0.32	0.16	0.50
HADS Anxiety — MAIA-Preg Awareness	0.23	0.02	0.46
HADS Anxiety — MAIA-Preg Regulation	-0.23	-0.42	-0.04
HADS Anxiety — MAIA-Preg Trusting	-0.33	-0.52	-0.15
HADS Depression — MAIA-Preg Distracting	-0.20	-0.42	-0.03
MAIA-Preg Attention — MAIA-Preg Trusting	0.29	0.13	0.44
MAIA-Preg Awareness — MAIA-Preg Attention	0.34	0.19	0.50
MAIA-Preg Awareness — MAIA-Preg Regulation	0.34	0.20	0.49
MAIA-Preg Trusting — BMI	-0.25	-0.45	-0.08

CI = Confidence Interval, MAIA-Preg = Multidimensional Assessment of Interoceptive Awareness for Pregnancy, BUMPs = Body Understanding Measure for Pregnancy, HADS = Hospital Anxiety and Depression Scale

A.3.   Antenatal network centrality and clustering coefficients

Appendix Table A.3. Antenatal network centrality and clustering coefficients.

Node	Strength Centrality	Betweenness Centrality	Clustering
BUMPs Physical	0.976	13	0.333
BUMPs Weight	1.461	32	0.333
BUMPs Appearance	0.728	0	0.666
Anxiety	1.285	23	0.200
Depression	0.781	13	0.333
Attachment Quality	0.535	0	0.000
Attachment Intensity	1.078	13	0.333
Emotional Awareness	0.909	1	0.333
Not-Distracting	0.201	0	0.000
Attention Regulation	0.625	7	0.000
Self-Regulation	0.572	0	1.000
Body Trusting	1.349	35	0.200
Breastfeeding Intention	0.221	0	0.000
Age	0.000	0	0.000
Gestation	0.548	0	0.666
BMI	0.668	13	0.333

B. Supplementary Material: Chapter 3

B.1. Exclusion criteria

Age Under 18: Women below the age of 18 were excluded from the study.

Current or past mental health or eating disorders: Participants with a clinical diagnosis of mental health disorders or eating disorders, as self-disclosed through an online consent form, were excluded. This aligns with ethical approval requirements.

Incomplete data: Participants who did not complete any key measures were excluded. Specifically, 66 participants were excluded due to incomplete data.

Lack of engagement with the survey: Participants who took less than 4 minutes to complete the survey were excluded, as this indicated a lack of engagement. This decision was based on pilot testing which determined that less than 4 minutes was insufficient for thorough completion of the questionnaire. Among the participants for whom survey completion time was recorded, the average time taken was 15 minutes (SD = 14.5). This helped in determining the engagement and adequacy of responses. This led to the exclusion of 12 participants.

After applying the exclusion criteria, the final sample size was 404 participants.

B.2. Ethics and open research

Participants were asked to complete questionnaires that included potentially distressing questions about their feelings towards their babies, their bodies, and their mental health (see section 3.3.3 in Chapter 3 for further information on measures). To minimise distress, participants were provided with support resource information and informed they could withdraw from the study at any time without consequence.

This study's design and analytic plan were preregistered; see https://osf.io/5jez7. All data and materials used in this analysis are publicly available on the OSF Repository and can be accessed at https://doi.org/10.17605/OSF.IO/5JEZ7.

B.3. CFA descriptives statistics for the CFA 2 factor rBUMPs and original 3 factor BUMPs

Appendix Table B.1. Descriptives for the CFA 2 factor rBUMPs and original 3 factor BUMPs.

Measure	Mean (SD)
rBUMPs[1]	40.2 (11.9)
BUMPs Appearance	18.2 (6.4)
BUMPs Weight	22.0 (8.2)
BUMPs[1]	52.4 (14.5)
BUMPs Appearance	23.3 (7.8)
BUMPs Weight	19.3 (7.3)
BUMPs Physical	9.8 (3.2)

[1]N=202

B.4. The Retrospective Body Understanding Measure for Pregnancy (rBUMPs)

Please read each statement and indicate on the 5-point scale the extent to which you agree. Please answer based on your feelings **during the last two weeks.**

		Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1.	I felt good about my changing body	1	2	3	4	5
2.	I got embarrassed that I can't do as much physically as I could before I was pregnant	1	2	3	4	5
3.	When I compared the shape of my body to other women, I was dissatisfied with my own	1	2	3	4	5
4.	I enjoyed taking photos of my changing body	1	2	3	4	5
5.	I was concerned about the amount that I am eating and the effect this has on my physical appearance	1	2	3	4	5
6.	I liked it when people comment on the size of my bump	1	2	3	4	5

7. I worried about getting my figure back after pregnancy	1	2	3	4	5
8. I wore clothes to accentuate my bump	1	2	3	4	5
9. I liked it when people noticed I'm pregnant	1	2	3	4	5
10. I looked overweight	1	2	3	4	5
11. felt like my bump was too big	1	2	3	4	5
12. I enjoyed changing my wardrobe during pregnancy	1	2	3	4	5
13. I was worried about the amount of weight I was putting on	1	2	3	4	5
14. When I compared the shape of my body to other non-pregnant women, I was dissatisfied with my own	1	2	3	4	5
15. I enjoyed my new curves in pregnancy	1	2	3	4	5

Scoring Instructions

Dissatisfaction with appearing pregnant: 1 (reverse) + 4 (reverse) + 6 (reverse) + 8 (reverse) + 9 (reverse) + 12 (reverse) + 15 (reverse)

Weight gain concerns: 2 + 3 + 5 + 7 + 10 + 11 + 13 + 14

Total rBUMPs Score: Sum the total score on all 15 items

C. Supplementary Material: Chapter 4

C.1. Descriptive statistics

Appendix Table C.1. Descriptive statistics of key variables.

Measure	3 months		6 months	
	Mean (SD)	**Range**	**Mean (SD)**	**Range**
BUMPs (SD)[1]				
BUMPs Appearance	26.39 (6.44)[a]	9-45	25.50 (6.45)[i]	12-45
BUMPs Physical	11.34 (3.31)[a]	3-15	11.34 (3.21)[i]	3-15
BUMPs Weight	21.67 (6.71)[a]	7-35	20.72 (7.16)[i]	7-35
Postpartum Mind and Body (SD)[2]	122.23 (26.78)[a]	64-174	119.58 (25.09)[i]	59-179
Antenatal MAIA_Preg (SD)[1]				
MAIA_Preg Trusting	2.93 (1.11)[b]	0.33-5	3.06 (1.18)[j]	0.3-5
Postnatal MAIA_Preg (SD)[2]				
MAIA_Preg Emotional Awareness	3.17 (0.99)[c]	0.75-5	3.23 (1.05)[k]	0-5
MAIA_Preg Not Distracting	1.83 (0.97)[d]	0-5	1.72 (1.01)[l]	0-5
MAIA_Preg Attention Regulation	2.33 (0.97)[e]	0-5	2.33 (0.95)[m]	0-4.5
MAIA_Preg Self-Regulation	2.60 (1.05)[e]	0-5	2.71 (1.11)[n]	0-5
MAIA_Preg Trusting	2.69 (1.13)[e]	0-5	2.93 (1.20)[o]	0-5
HADS (SD)[2]				
Anxiety	9.12 (4.54)[f]	1-20	8.69 (4.01)[o]	0-18
Depression	6.33 (3.46)[g]	1-21	6.27 (3.39)[k]	1-21
MPAS (SD)[2]				
Bond Quality	39.63 (3.75)[g]	27.8-45	39.97 (4.01)[k]	24.8-45
Absence of Hostility	17.64 (3.19)[g]	11.9-25	16.98 (3.37)[k]	9.6-25
Pleasure in Interaction	21.54 (3.30)[g]	10-25	21.15 (3.53)[k]	10-25
Breastfeeding (%)[2]	45.8%[d]	0-1	41%[o]	0-1
Breastfeeding Experience[2]	2.13 (1.07)[h]	1-5	1.90 (1.02)[p]	1-5
Infant Birth Weight (kg) [2]	3.48 (0.50)[e]	1.84-4.82	3.53 (0.45)[i]	1.84-4.82
Infant Development[2]	6.80 (1.31)[a]	0-8	7.44 (0.99)[i]	0-8
Maternal Age[2]	33.03 (4.39)[a]	22.5-43.7	32.66 (4.52)[i]	21.1-46.3
Gestation[2]	39.15 (1.67)[a]	32-42	39.29 (1.48)[i]	32-42
BMI[2]	28.66 (6.77)[e]	16.6-55.9	27.10 (5.68)[q]	18.2-44.2

N^a=137, N^b=108, N^c=133, N^d=131, N^e=132, N^f=130, N^g=134, N^h=115, N^i=107, N^j=81, N^k=101, N^l=103, N^m=102, N^n=98, N^o=100, N^p=90, N^q=95.

[1]Data gathered at antenatal time point, [2]Data gathered at respective postnatal time point.

C.2. Bootstrapping

Bootstrapping was applied with 1000 resamples to identify the robustness of both the 3- and 6-month network analyses. See Table C.2 and C.3 for the results showing edge weights and their corresponding bootstrapped confidence intervals, and Table C.4 and C.5 for edge correlation matrices for both networks. Figure C.1 and C.2 show edge stability graphs. Case-drop bootstrapping was employed to assess the stability of the relationships. Bootstrapping analyses found the networks to be relatively stable.

Appendix Table C.2. Bootstrapping results showing edge weights and confidence intervals for the 3-month network.

Node 1	Node 2	Edge Weight Mean	Lower CI	Upper CI
BUMPs Physical*	BUMPs Weight*	0.17	0.04	0.31
BUMPs Physical*	PBD	0.03	-0.07	0.10
BUMPs Appearance*	Depression	0.05	-0.08	0.14
BUMPs Appearance*	Postnatal Body Trusting	-0.04	-0.11	0.06
BUMPs Appearance*	Antenatal Body Trusting*	-0.05	-0.13	0.10
BUMPs Weight*	BUMPs Appearance*	0.25	0.11	0.39
BUMPs Weight*	Postnatal Body Trusting	-0.05	-0.14	0.05
BUMPs Weight*	Antenatal Body Trusting*	-0.14	-0.29	-0.01
BUMPs Weight*	PBD	0.12	-0.25	-0.02
Anxiety	Depression	0.23	0.13	0.35
Anxiety	Bond Quality	-0.06	-0.16	0.03
Depression	Bond Quality	-0.13	-0.28	0.01
Attention Regulation	Self-Regulation	0.13	-0.02	0.26
Emotional Awareness	Anxiety	0.16	0.02	0.29
Emotional Awareness	Attention Regulation	0.26	0.14	0.37
Emotional Awareness	Self-Regulation	0.17	0.00	0.30
Not-Distracting	PBD	-0.07	-0.19	0.05
Self-Regulation	Postnatal Body Trusting	0.17	0.03	0.30
Self-Regulation	Breastfeeding Experience	-0.05	-0.12	0.10
Postnatal Body Trusting	Anxiety	-0.07	-0.18	0.06
Postnatal Body Trusting	Depression	-0.11	-0.23	0.00
Postnatal Body Trusting	PBD	-0.24	-0.36	-0.12
Antenatal Body Trusting	Anxiety	-0.05	-0.15	0.08
Antenatal Body Trusting	Postnatal Body Trusting	0.05	-0.10	0.15
Absence of Hostility	Pleasure in Interaction	0.06	-0.09	0.17
Pleasure in Interaction	Maternal Age	-0.09	-0.20	0.10
Bond Quality	Absence of Hostility	0.22	0.03	0.40
Bond Quality	Pleasure in Interaction	0.15	-0.02	0.29

Bond Quality	Child Development	0.05	-0.09	0.14
PBD	BMI^2	0.05	-0.12	0.13
PBD	Anxiety	0.16	0.04	0.28
PBD	Depression	0.22	0.11	0.34
PBD	Breastfeeding Experience	0.06	-0.07	0.15
PBD	Breastfeeding Rate	0.08	-0.04	0.18
Breastfeeding Experience	Birth Weight	-0.06	-0.14	0.10
Breastfeeding Experience	Breastfeeding Rate	0.25	0.06	0.41
Gestation	Birth Weight	0.35	0.14	0.53

Data gathered at antenatal time point; CI = Confidence Interval; PBD = Postnatal Body Dissatisfaction; BMI = Body Mass Index

Appendix Table C.3. Bootstrapping results showing edge weights and confidence intervals for the 6-month network.

Node 1	Node 2	Edge Weight Mean	Lower CI	Upper CI
BUMPs Weight*	Depression	0.13	-0.03	0.34
BUMPs Weight*	Postnatal Body Trusting	-0.06	-0.21	0.10
BUMPs Weight*	Antenatal Body Trusting*	-0.31	-0.54	-0.14
BUMPs Weight*	Bond Quality	-0.10	-0.29	0.07
BUMPs Weight*	Breastfeeding Rate	0.07	-0.06	0.26
Anxiety	Depression	0.37	0.22	0.61
Anxiety	Breastfeeding Rate	0.12	-0.05	0.37
Depression	Bond Quality	-0.18	-0.41	0.04
Depression	Breastfeeding Rate	-0.06	-0.27	0.10
Postnatal Body Trusting	Anxiety	-0.08	-0.23	0.05
Postnatal Body Trusting	Depression	-0.22	-0.46	-0.01
Postnatal Body Trusting	PBD	0.03	-0.08	0.16
Postnatal Body Trusting	Breastfeeding Rate	-0.14	-0.40	0.03
Antenatal Body Trusting*	Anxiety	-0.06	-0.20	0.11
Antenatal Body Trusting*	Postnatal Body Trusting	0.35	0.13	0.60
Antenatal Body Trusting*	Bond Quality	0.09	-0.13	0.32
Antenatal Body Trusting*	PBD	0.07	-0.07	0.24
Bond Quality	Breastfeeding Rate	0.07	-0.06	0.28
PBD	Anxiety	-0.06	-0.24	0.07
PBD	Breastfeeding Rate	0.15	-0.02	0.42

Data gathered at antenatal time point; CI=Confidence Interval; PBD = Postnatal Body Dissatisfaction

Appendix Table C.4. Edge weight correlation matrix for the 3-month network.

	BUMPs Physical	BUMPs Weight	BUMPs Appearance	Antenatal Body Trusting	Emotional Awareness	Not-Distracting	Attention Regulation	Self-Regulation	Postnatal Body Trusting	PBD	Anxiety	Depression	Bond Quality	Absence of Hostility	Pleasure in Interaction	Breastfeeding Experience	Breastfeeding Rate	Maternal Age	Gestation	BMI	Birth Weight	Child Development
BUMPs Physical	1																					
BUMPs Weight	0.38	1																				
BUMPs Appearance	0.27	0.5	1																			
Antenatal Body Trusting	-0.18	-0.42	-0.47	1																		
Emotional Awareness	-0.06	-0.09	-0.2	0.17	1																	
Not-Distracting	-0.11	-0.35	-0.35	0.17	-0.11	1																
Attention Regulation	-0.12	-0.2	-0.22	0.21	0.56	0.07	1															
Self-Regulation	-0.21	-0.24	-0.2	0.12	0.58	0.03	0.61	1														
Postnatal Body Trusting	-0.18	-0.41	-0.36	0.43	0.18	0.39	0.34	0.33	1													
PBD	0.36	0.38	0.27	-0.31	0.19	-0.33	-0.14	-0.21	-0.5	1												
Anxiety	0.12	0.09	0.09	-0.27	0.42	-0.15	0.02	0.01	-0.35	0.58	1											
Depression	0.22	0.19	0.08	-0.11	0.23	-0.33	-0.04	-0.14	-0.3	0.58	0.61	1										
Bond Quality	-0.34	-0.24	-0.14	0.34	-0.19	0.02	-0.03	-0.09	0.15	-0.33	-0.33	-0.29	1									
Absence of Hostility	-0.3	0	-0.12	0.16	-0.21	0.14	-0.04	-0.26	0.17	-0.28	-0.16	-0.18	0.57	1								
Pleasure in Interaction	-0.23	-0.21	-0.27	0.36	-0.1	-0.03	0.1	-0.04	0.04	-0.23	-0.04	0.07	0.53	0.43	1							
Breastfeeding Experience	0.12	-0.02	-0.12	-0.06	-0.06	0.12	-0.13	-0.25	-0.06	0.34	0.22	0.16	-0.09	-0.02	-0.04	1						
Breastfeeding Rate	0.21	0.12	-0.17	-0.12	0.13	-0.13	0.01	0	-0.07	0.35	0.19	0.36	-0.14	0	-0.11	0.32	1					
Maternal Age	-0.18	-0.02	0.04	-0.02	0.09	0.04	-0.12	0.19	0.01	0.05	-0.13	-0.17	0	0.02	-0.13	-0.2	-0.03	1				
Gestation	-0.23	-0.12	-0.2	0.13	-0.1	0.04	0	-0.09	0.13	-0.19	-0.15	-0.01	0.11	0.24	0.07	0.06	-0.03	0.01	1			
BMI	-0.08	0.16	-0.18	0.06	0	-0.17	-0.02	0.03	-0.13	0.1	-0.07	0.03	0.17	0.29	0.17	0.03	0.13	0.23	0.18	1		
Birth Weight	-0.16	-0.12	-0.03	0.11	-0.07	0.03	0.19	0.05	-0.08	-0.19	-0.09	-0.03	0.04	0.16	0.2	-0.24	-0.12	0.09	0.58	0.11	1	
Child Development	0.19	0.08	0.12	0	-0.26	-0.14	-0.13	-0.03	0.03	-0.03	-0.31	-0.16	0.23	0.19	-0.07	-0.04	0.04	-0.05	-0.03	0.1	0.09	1

PBD = Postnatal Body Dissatisfaction

Appendix Table C.5. Edge weight correlation matrix for the 6-month network.

	BUMPs Physical	BUMPs Weight	BUMPs Appearance	Antenatal Body Trusting	Postnatal Body Trusting	PBD	Anxiety	Depression	Bond Quality	Breastfeeding Rate
BUMPs Physical	1									
BUMPs Weight	0.52	1								
BUMPs Appearance	0.31	0.43	1							
Antenatal Body Trusting	-0.18	-0.51	-0.43	1						
Postnatal Body Trusting	-0.37	-0.42	-0.26	0.65	1					
PBD	-0.08	-0.02	-0.19	0.17	0.22	1				
Anxiety	0.18	0.27	0.04	-0.4	-0.41	-0.29	1			
Depression	0.26	0.32	0.31	-0.37	-0.47	-0.13	0.55	1		
Bond Quality	-0.15	-0.33	-0.22	0.2	0.17	0	-0.3	-0.43	1	
Breastfeeding Rate	0.24	0.27	-0.08	-0.24	-0.37	0.09	0.25	0.01	0	1
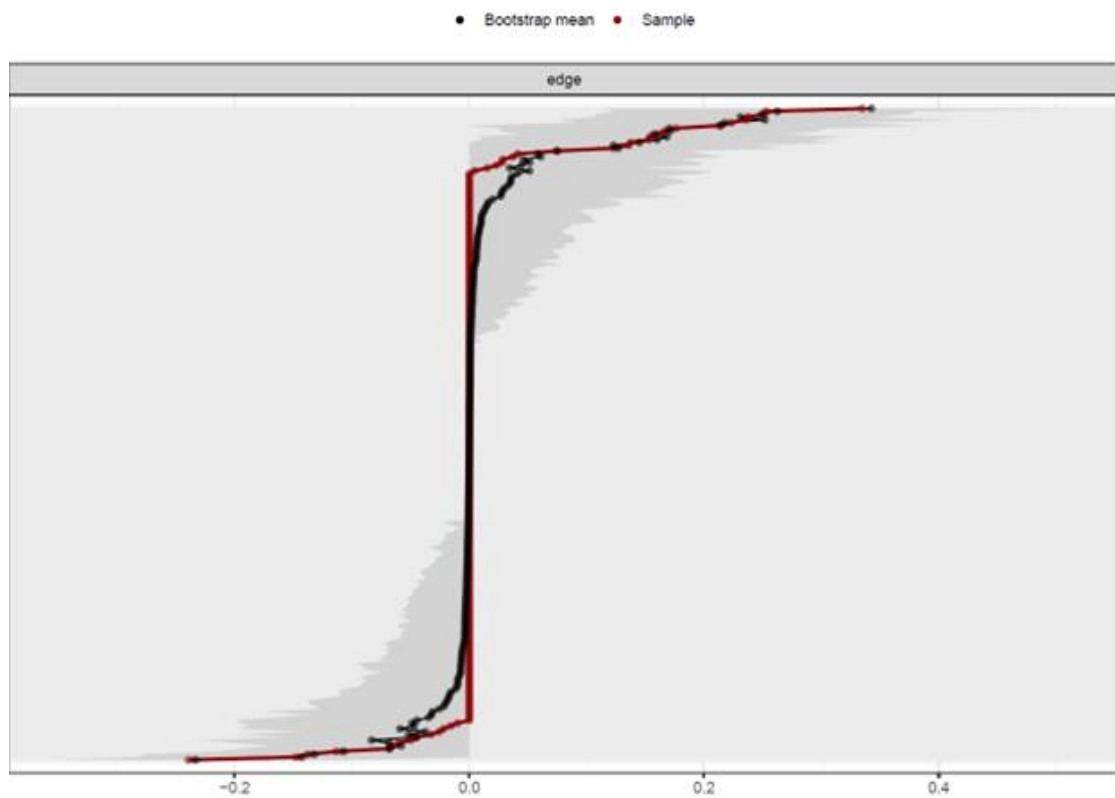
Appendix Figure C.2. Edge stability for the 3-month network.
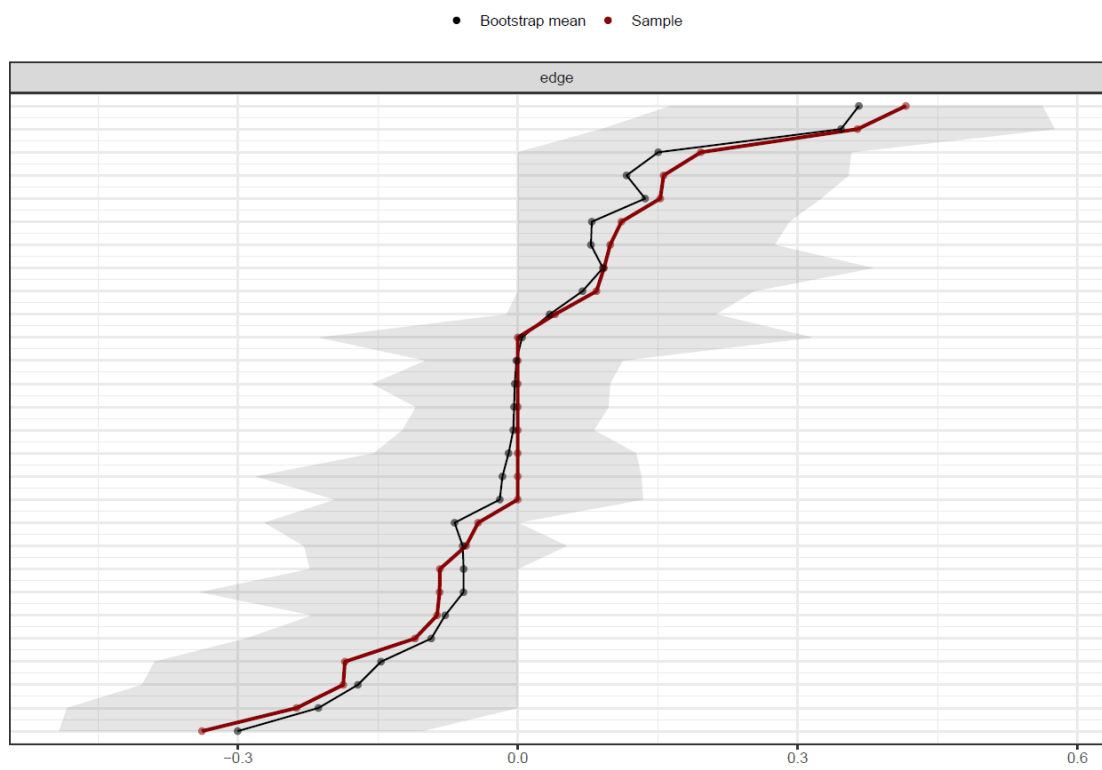
Appendix Figure C.1. Edge stability for the 6-month network.

C.3. Centrality and clustering coefficients

Appendix Table C.6. Network centrality and clustering coefficients.

Node	3-month			6-month		
	Strength Centrality	Betweenness Centrality	Clustering	Strength Centrality	Betweenness Centrality	Clustering
BUMPs Physical*	0.19	0	1.00	-	-	-
BUMPs Weight*	0.76	57	0.50	0.76	0	0.70
BUMPs Appearance*	0.32	0	0.67	-	-	-
Antenatal Body Trusting*	0.22	0	0.67	0.92	2	0.50
Anxiety	0.71	34	0.33	0.78	2	0.70
Depression	0.74	80	0.50	1.08	5	0.70
Bond Quality	0.58	73	0.20	0.50	0	0.67
Absence of Hostility	0.25	0	1.00	-	-	-
Pleasure in Interaction	0.22	20	0.33	-	-	-
Birth Weight	0.36	20	0.00	-	-	-
Child Development	0.03	0	0.00	-	-	-
PBD	0.96	156	0.17	0.40	0	0.83
Emotional Awareness	0.56	19	0.33	-	-	-
Not-Distracting	0.07	0	0.00	-	-	-
Attention Regulation	0.38	0	1.00	-	-	-
Self-Regulation	0.45	2	0.17	-	-	-
Body Trusting	0.67	17	0.43	0.97	3	0.67
Breastfeeding Rate	0.31	54	0.17	0.83	4	0.60
Breastfeeding Experience	0.31	38	1.00	-	-	-
Mother's Age	0.05	0	0.00	-	-	-
Gestation	0.33	0	0.00	-	-	-
BMI	0.00	0	0.00	-	-	-

Gathered at antenatal time point; PBD = Postnatal Body Dissatisfaction; BMI = Body Mass Index

D. Supplementary Material: Chapter 5

D.1. Search strategies according to database

Appendix Table D.1. Search strategies according to database.

	Search Strategy
Scopus	TITLE-ABS-KEY (postnatal OR postpartum OR perinatal OR maternal OR mother*) AND TITLE-ABS-KEY ('yoga' OR 'yogic') AND (LIMIT-TO (LANGUAGE, "English"))
PubMed	('yoga'[Title/Abstract] OR 'yogic'[Title/Abstract]) AND (postnatal[Title/Abstract] OR postpartum[Title/Abstract] OR perinatal[Title/Abstract] OR maternal[Title/Abstract] OR mother*[Title/Abstract])
Web of Science	(TI=(postnatal OR postpartum OR perinatal OR maternal OR mother*)) AND TI=('yoga' OR 'yogic') OR (AB=(postnatal OR postpartum OR perinatal OR maternal OR mother*)) AND AB=('yoga' OR 'yogic') OR (AK=(postnatal OR postpartum OR perinatal OR maternal OR mother*)) AND AK=('yoga' OR 'yogic')
OVID: PsycINFO Medline Embase	1. ('yoga' or 'yogic').ab,kf,ti. 2. (postnatal or postpartum or perinatal or maternal or mother*).ab,kf,ti. 3. 1 and 2 4. limit 3 to English language 5. limit 4 to human

Appendix Table D.2. Inclusion and exclusion criteria.

	Inclusion criteria	**Exclusion criteria**
Types of studies	- Experimental studies (including RCT's and quasi-experimental studies) - Full-text primary research papers - Published in English - No constraints on publication date	- Observational studies - Studies with only qualitative assessments - Cross-sectional studies - Systematic reviews - Peer reviews - Commentaries
Participants	- Over 18 years of age - Postnatal women/ birthing parents (between 0- and 12-months following birth)	- Under the age of 18
Intervention	- A postnatal 'yoga-based' intervention: A postnatal programme including yoga for mother/birthing parent and/or baby	N/A
Comparators	- Studies must compare outcomes in some way, either through comparing a control group to an intervention group, or by comparing outcome measures before and after the intervention	N/A
Outcome measures	- Measures concerning maternal postnatal mental health and well-being (e.g., depression, anxiety, stress, mother-infant interaction, quality of life)	N/A

D.3. Quality assessment

Appendix Table D.3. Quality assessment for quasi-experimental studies.

	Ko et al., 2012	Miklowitz et al. 2015	Cameron & Shepherd 2018
Clear 'cause' and 'effect'	Yes	Yes	Yes
Participants similar across comparisons	N/A	N/A	Yes
Comparison participants receiving similar treatment	N/A	N/A	No
Control group	No	No	Yes
Multiple measurements	Yes	Yes	Yes
Complete follow up	No	No	No
Outcome comparisons measured in the same way	Yes	Yes	Yes
Reliable outcome measures	Yes	Yes	Yes
Appropriate statistical analysis	Yes	Yes	Yes
Quality Assessment Score	**5/7**	**5/7**	**7/9**

Appendix Table D.4. Quality assessment for RCT's.

	Buttner et al. 2015	Timlin & Simpson, 2017	Ulver & Timur Tashan 2021
True randomisation used	Yes	Yes	No
Allocation of treatment groups concealed	Yes	Unclear	Unclear
Treatment groups similar at baseline	Yes	Yes	Yes
Participants blinded to treatment assignment	N/A	N/A	N/A
Those delivering treatment blind to treatment assignment	N/A	N/A	N/A
Treatment groups treated identically other than intervention	Yes	Yes	Yes
Outcome assessors blind to treatment assignment	Yes	No	Unclear
Outcome measured in the same way for treatment groups	Yes	Yes	Yes
Outcomes measured in a reliable way	Yes	Yes	Yes
Complete follow-up	No	No	No
Participants analysed in the groups to which they were randomised	Yes	Yes	Yes
Was appropriate statistical analysis used?	Yes	Yes	Yes
Appropriate trial design	Yes	Yes	Yes
Quality Assessment Score/11	**10**	**8**	**7**

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