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Strong women.
May we know them.
May we be them.
May we raise them.

Michelle Obama

Dedicated to all women and mothers,
whose strength too often goes unseen.

UNIVERSITY OF TURKU
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ABSTRACT

Perinatal period is a critical window for supporting women's long-term health and well-being. Despite clear benefits and established guidelines, physical activity often declines during this time, increasing the risk of preventable issues such as urinary incontinence and reduced quality of life. This study assessed the effectiveness of exercise and physical activity interventions for urinary incontinence, physical activity and quality of life among pregnant and postpartum women to support maternal health.

This research consisted of three sub-studies. Sub-study I was a review of reviews (n=9) conducted to summarize existing evidence about the effectiveness of exercise interventions for urinary incontinence and pelvic organ prolapse in pregnant and postpartum women, and to formulate recommendations for health care professionals. Sub-studies II (n=297) and III (n=48) were quasi-experimental studies aiming to assess the effectiveness of two different technology-supported exercise and physical activity interventions for urinary incontinence (sub-study II), physical activity and quality of life (sub-studies II and III) during the perinatal period.

The highest level of evidence supported the effectiveness of prenatal exercise in preventing postpartum urinary incontinence, while moderate-level evidence indicated that these interventions likely reduce the symptoms and severity of urinary incontinence. Based on the findings, the participants' urinary incontinence symptoms decreased, and physical activity increased after the interventions. Minor improvements were observed in the physical health domain of quality of life, with no changes in psychological, social, or environmental domains. The findings suggest that physical activity interventions, including those supported by digital health technologies, may be effective in managing urinary incontinence and supporting physical activity. However, improving overall quality of life in the perinatal period likely requires broader, multidimensional strategies. The findings emphasize the need for developing comprehensive, accessible, and multidisciplinary approaches to women's health and call for holistic perspectives in future perinatal research.

KEYWORDS: exercise; perinatal period; physical activity; quality of life; quasi-experimental study; urinary incontinence

TURUN YLIOPISTO
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TIIVISTELMÄ

Perinataaliaika, raskauden, synnytyksen ja synnytyksen jälkeinen aika, on tunnistettu ajanjaksona, jolloin naisten terveyteen ja hyvinvointiin voidaan vaikuttaa myönteisesti ja pitkäkestoisesti. Vaikka fyysisen aktiivisuuden hyödyt ja suositukset ovat hyvin tunnettuja, aktiivisuus vähenee usein perinataaliaikana, mikä voi lisätä vältettävissä olevien terveysongelmien, kuten lantionpohjan toimintahäiriöiden ja heikentyneen elämänlaadun riskiä. Tämän tutkimuksen tarkoituksena oli arvioida liikuntainterventioiden vaikuttavuutta virtsankarkailuun, fyysiseen aktiivisuuteen ja elämänlaatuun perinataaliaikana.

Tutkimus koostui kolmesta osatutkimuksesta. Osatutkimus I oli katsaus aiempiin kirjallisuuskatsauksiin (n=9), jonka tarkoituksena oli tiivistää olemassa oleva näyttö liikuntainterventioiden vaikuttavuudesta virtsankarkailuun ja lantionpohjan laskeumaan perinataaliaikana, sekä laatia suositukset terveydenhuollon ammattilaisille. Osatutkimukset II (n=297) ja III (n=48) olivat kvasikokeellisia tutkimuksia, joissa arvioitiin kahden eri teknologiaa hyödyntävän liikuntaintervention vaikuttavuutta virtsankarkailuun (osatutkimus II), fyysiseen aktiivisuuteen ja elämänlaatuun (osatutkimukset II ja III) perinataaliaikana.

Osatutkimus I osoitti, että vahvin näyttö tukee raskaudenaikaisen liikunnan vaikuttavuutta synnytyksen jälkeisen virtsankarkailun ehkäisyssä, kun kohtalainen näyttö viittaa oireiden lieventymiseen. Osatutkimusten II ja III empiiriset tulokset osoittivat, että osallistujien virtsankarkailuoireet vähenivät ja fyysinen aktiivisuus lisääntyi interventioiden jälkeen. Elämänlaadun fyysisen terveyden ulottuvuudessa havaittiin vähäisiä parannuksia, ilman muutoksia psykologisissa, sosiaalisissa tai ympäristöllisissä elämänlaadun ulottuvuuksissa. Kaikkien osatutkimusten tulokset viittaavat siihen, että liikuntainterventiot, mukaan lukien teknologiaa hyödyntävät interventiot, voivat olla vaikuttavia virtsankarkailun hallinnassa ja fyysisen aktiivisuuden tukemisessa. Yleisen elämänlaadun parantaminen perinataaliaikana vaatii kuitenkin laajempia ja moniulotteisempia strategioita. Havainnot korostavat tarvetta kehittää kokonaisvaltaisia, saavutettavia ja monialaisia lähestymistapoja naisten terveyden ja hyvinvoinnin edistämiseksi.

AVAINSANAT: elämänlaatu; fyysinen aktiivisuus; kvasikokeellinen tutkimus; liikunta; perinataaliaika; virtsankarkailu

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Abbreviations

ACOG	American College of Obstetricians and Gynecologists
BMI	Body mass index
CI	Confidence interval
DHI	Digital health intervention
EPDS	Edinburgh Postnatal Depression Scale
FITT	Frequency, Intensity, Time, Type
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HRQOL	Health-related quality of life
ICF	International Classification of Functioning, Disability and Health framework
IIQ	Incontinence Impact Questionnaire
IPAQ	International Physical Activity Questionnaire
JBI	Joanna Briggs Institute
MET	Metabolic equivalent of task
NRF	Nursing Research Foundation
PA	Physical activity
PASE	Self-Efficacy for Physical Activity Scale
PFD	Pelvic floor disorder
PFDI	Pelvic Floor Distress Inventory
PFM	Pelvic floor muscles
PFMT	Pelvic floor muscle training
PICO	Population, Intervention, Comparison, Outcome
POP	Pelvic organ prolapse
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOL	Quality of life
SD	Standard deviation
SF-	Short Form Health Survey
SLIM	Supporting Lifestyle Change in Obese Pregnant Women through Wearable Internet-of-Things

TENK	Tutkimuseettinen neuvottelukunta (Finnish National Board on Research Integrity)
THL	Terveyden ja hyvinvoinnin laitos (National Institute of Health and Welfare)
TREND	Transparent Reporting of Evaluations with Nonrandomized Designs
TIDieR	Template for Intervention Description and Replication
UDI	Urogenital Distress Inventory
UI	Urinary incontinence
UKK	Urho Kaleva Kekkonen Institute for Health Promotion Research
US	United States
WEL	Weight Efficacy Life-Style Questionnaire
WHO	World Health Organization
WHOQOL	World Health Organization Quality of Life Questionnaire

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Ryhtä I, Axelin A, Parisod H, Holopainen A, Hamari L. Effectiveness of exercise interventions on urinary incontinence and pelvic organ prolapse in pregnant and postpartum women: umbrella review and clinical guideline development. *JBI Evid Implement*, 2023; Oct 18;21(4):394–408. doi: 10.1097/XEB.0000000000000391

II Ryhtä I, Likitalo S, Hamari L, Niela-Vilen H, Axelin A. The effectiveness of an online exercise program on urinary incontinence of postpartum women: Quasi-experimental study. *Sexual & Reproductive Healthcare,* 2026; 48: 101210. https://doi.org/10.1016/j.srhc.2026.101210

III Ryhtä I, Likitalo S, Hamari L, Axelin A. The effectiveness of an online exercise program on physical activity and quality of life of postpartum women: Quasi-experimental study. *International Journal of Childbirth*, 2025; 15(3): 103–119. https://doi.org/10.1891/IJC-2024-0052

IV Ryhtä I, Niela-Vilén H, Kazemi K, Rahmani A, Liljeberg P, Kolari T, Axelin A. Effectiveness of the SLIM Intervention ("Supporting Lifestyle Change in Pregnant Mothers with Obesity Through the Wearable Internet-of-Things") on Quality of Life: A Quasi-experimental Trial. Manuscript.

1 Introduction

Maternal health is a key determinant of population health and essential for the well-being of future generations. With over 43,000 births annually in Finland (Statistics Finland, 2025) and more than 132 million globally (UN, n.d.), the scale of its impact is significant. Supporting women's health and providing timely support and care during the perinatal period not only benefits the individual but also promotes the well-being of children, families, and communities (McLeish & Redshaw, 2017; THL, n.d.; Vuorenmaa et al., 2023).

The perinatal period is widely acknowledged as a unique and vulnerable phase in women's lives, marked by profound physical, emotional, and psychosocial transformations that reshape a woman's identity and life priorities (Koukopoulos et al., 2020; Lagadec et al., 2018; Wadephul et al., 2020). These changes may significantly impact on a woman's health and overall quality of life, including challenges such as urinary incontinence and reduced physical activity. Physical activity has been widely recognized as a factor that supports and promotes maternal health (Díaz-Burrueco et al., 2021; Dipietro et al., 2019), yet its role in addressing specific conditions, such as pelvic floor dysfunctions and overall quality of life, remains insufficiently utilised. As digital health technologies become more integrated into everyday life, there is growing interest in how technology-supported interventions can be used to promote physical activity and improve outcomes of maternal health (Adusei-Mensah et al., 2025; Mohamed et al., 2025).

With a background in physiotherapy, my professional focus has been on supporting individuals' functional ability as a foundation for health and well-being. Physiotherapists aim to promote movement and participation across diverse life situations, and I believe that physical activity should be accessible and meaningful for everyone. This perspective has strongly influenced the focus of this study. My interest in maternal health stems from both clinical experience and a recognition that mothers often deprioritize their own well-being (Makama et al., 2021; Ryan et al., 2022), which led to the decision to explore physical activity during the perinatal period and examine its impact on quality of life. The International Classification of Functioning, Disability and Health (ICF) framework, which guides this research, aligns closely with physiotherapy practice by providing a biopsychosocial lens for understanding health, functioning, and participation (WHO, 2002, 2013). It provides a comprehensive structure for examining how physical activity interventions can support and promote maternal health in a holistic and meaningful way.

Physical activity is recognized to offer various benefits both for maternal and fetal health (Díaz-Burrueco et al., 2021; Nagpal & Mottola, 2020). Regular physical activity, when aligned with established recommendations (Bull et al., 2020; UKK Institute, 2022, 2023), can, for example, help manage weight gain (Díaz-Burrueco et al., 2021; Ribeiro et al., 2022), reduce the risk of gestational diabetes (Davenport, Ruchat, et al., 2018; Díaz-Burrueco et al., 2021) and depression (Davenport, McCurdy, et al., 2018; Ribeiro et al., 2022), and contribute to overall well-being (Liu et al., 2019). Importantly, physical activity may also play a role in preventing or alleviating pelvic floor dysfunctions, such as urinary incontinence and pelvic organ prolapse, conditions that can significantly affect quality of life during the perinatal period. Despite these known benefits, the level of physical activity in pregnant women is low (Bacchi et al., 2016; Daly et al., 2016; Dipietro et al., 2019; Evenson & Wen, 2011; Nascimento et al., 2012; Okafor & Goon, 2020), and after childbirth, activity levels may not reach the desired level or return to pre-pregnancy levels (Pereira et al., 2007). This highlights the need for accessible, evidence-based interventions that promote safe and effective physical activity throughout the perinatal period.

This study investigates the role of physical activity in supporting and promoting maternal health during the perinatal period, with a particular focus on urinary incontinence, physical activity and quality of life. Guided by the ICF framework, maternal health is conceptualized as a multidimensional, biopsychosocial phenomenon. The study comprises three sub-studies that assess the effectiveness of exercise and physical activity interventions, particularly those supported by digital health technologies, among pregnant and postpartum women. Sub-study I, a review of reviews, summarized existing evidence about the effectiveness of exercise interventions for urinary incontinence and pelvic organ prolapse in pregnant and postpartum women, and formulated recommendations for health care professionals. Sub-studies II and III, both quasi-experimental in design, assessed the effectiveness of two different technology-supported exercise and physical activity interventions for urinary incontinence (sub-study II), physical activity and quality of life (sub-studies II and III) during the perinatal period. By addressing gaps in current knowledge and exploring digital solutions, the goal of this dissertation is to generate knowledge that supports the development and implementation of accessible, cost-effective, and sustainable physical activity interventions tailored to the needs of women in the perinatal period in Finland.

2 Review of the literature

This chapter provides a comprehensive overview of the literature on maternal health and physical activity during the perinatal period. The chapter is divided into three main sections. The first section introduces the conceptual framework for maternal health based on the International Classification of Functioning, Disability and Health (ICF), and discusses key topics such as changes in body functions and structures, physical activity, and quality of life during pregnancy and postpartum. The second section focuses on exercise and physical activity interventions, summarizing recent evidence from systematic reviews and meta-analyses regarding their effects on urinary incontinence and quality of life. The final section highlights gaps in the existing literature and outlines areas for future research.

2.1 The International Classification Functioning, Disability and Health (ICF) framework conceptualizing maternal health

As pregnancy and childbirth are transformative life events causing physical, emotional, and social changes for women's lives (Lagadec et al., 2018; Romano et al., 2010; Stowe et al., 2005; Wadephul et al., 2020), it is essential to focus on the maternal health during the perinatal period holistically. In this dissertation, the maternal health is studied by utilizing the International Classification of Functioning, Disability and Health (ICF) framework (WHO, 2002, 2013).

The ICF framework offers a comprehensive biopsychosocial approach to understanding and doing research on health, functioning, and their determining factors. It views functioning and limitations as multidimensional, dynamic, and interactive phenomena. Functional limitations arise when there is a discrepancy between an individual's health condition and the demands of their daily activities. Addressing this discrepancy requires considering not only health status but also the influence of environmental and personal factors. (WHO, 2002, 2013.)

The ICF framework consists of two main parts: 1) functioning and disability which includes body functions and structures, activities, and participation; and 2) contextual factors encompassing environmental and personal factors. Body functions and structures refer to physiological and anatomical aspects of the body, including the presence or absence of impairment, while activities and participation refer to the ability to perform various activities and engage in life situations. Environmental factors refer to the external factors that influence an individual's functioning, such as physical environment, social support, and societal attitudes, whereas personal factors include the internal characteristics such as age, sex, education level, and coping styles. (WHO, 2002, 2013.)

In this dissertation, the ICF framework is used to structure the background and results by defining the key concepts and illustrating how their interactions affect maternal health during the perinatal period (Figure 1). The physiological and anatomical changes during the perinatal period and symptoms related to these changes, such as, **urinary incontinence**, represent ICF's body functions and structures, **physical activity** represents activities, and **quality of life** represents the level of participation. All of these are influenced by environmental and personal factors, emphasizing the dynamic and multidimensional nature of functioning and maternal health within the ICF framework.

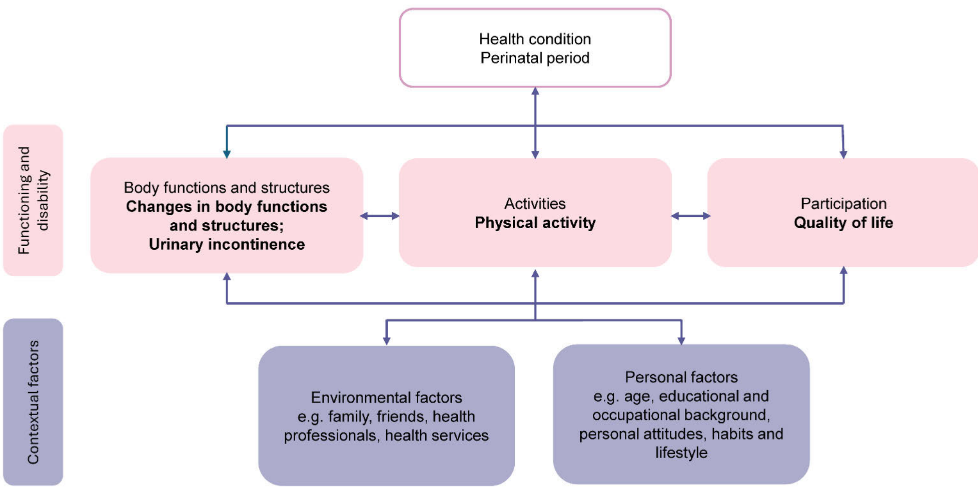

Figure 1. The key concepts described according the ICF framework (adapted from WHO, 2002).

By conducting literature review, the theoretical background of this study was formulated and reported following the structure of the ICF framework. The aims of this literature review were 1) to summarize literature on changes in body functions and structures and symptoms related to changes, physical activity and quality of life among pregnant and postpartum women, and 2) to identify previous exercise and physical activity interventions aiming to prevent and treat urinary incontinence and pelvic organ prolapse (to update the search following the results published in Paper I) and to enhance quality of life during the perinatal period. The overall aims were to establish the theoretical background for this study and to highlight current gaps in the research.

The literature search was done using PubMed / Medline, CINAHL, and the Web of Science databases. The topics of the searches were: 1) changes and symptoms in body functions and structures during the perinatal period, 2) physical activity during the perinatal period, 3) quality of life during the perinatal period, 4) exercise and physical activity interventions for urinary incontinence and pelvic organ prolapse during the perinatal period, and 5) exercise and physical activity interventions for quality of life during the perinatal period. The literature searches were supplemented with manual searches. Publications related to the selected articles, as well as the reference lists of articles, were reviewed. In addition, relevant articles and materials were used to define the key concepts of the study. The limitation of the literature search was that the publication language was set only to Finnish or English.

2.1.1 Perinatal period

The perinatal period is widely acknowledged as a unique and vulnerable phase in women's lives, characterized by profound physical, emotional, and psychosocial transformations, during which pregnancy and childbirth significantly reshape a woman's identity, relationships, and life priorities (Koukopoulos et al., 2020; Lagadec et al., 2018; Leach et al., 2016; Romano et al., 2010; Stowe et al., 2005; Wadephul et al., 2020). The perinatal period is defined in various ways within the literature, typically beginning at gestational week 22, covering the intrapartum period, and extending from seven days to up to one year postpartum (Pearlman & Martin, 2011; Wadephul et al., 2020; WHO, 2022). In this study, the perinatal period is understood to cover the entire pregnancy and the first two years postpartum, reflecting the dynamic nature of perinatal well-being (Allan et al., 2013; Wadephul et al., 2020). This extended timeframe is intentional, acknowledging that postpartum recovery goes beyond early physiological changes and includes prolonged functional, emotional, psychological, and social adjustments, making a two-year period more appropriate for capturing maternal recovery.

Pregnancy lasts an average of 280 days, or 40 weeks and it can be divided into three trimesters. The first trimester begins at the start of the last menstrual period and continues until the beginning of the 14th week of pregnancy. The second trimester begins in the 14th week of pregnancy and continues until the 28th week of pregnancy. The third trimester lasts from the 29th week of pregnancy until delivery. (Tiitinen, 2023a.) Normal pregnancy involves many physical and anatomical changes and symptoms starting from the first weeks of pregnancy (Lockitch & Gamer, 1997; Soma-Pillay et al., 2016), as well as emotional and psychological changes (Lagadec et al., 2018; Wadephul et al., 2020). These changes are intended to enable the fetus to grow, ensure the woman's health and well-being during pregnancy, prepare the woman for childbirth (Soma-Pillay et al., 2016) and for the new life situation (Wadephul et al., 2020).

During the first six months after childbirth, women undergo a significant transformation and recovery process (Mercer, 2004; Romano et al., 2010), where they experience most of the physiological and anatomical changes toward the pre-pregnancy conditions. However, recovery is not limited to this initial period. For many women, physical and functional changes may persist well beyond six months, and many experience, that the body may never fully return to its pre-pregnancy state. In addition, the changes in a woman's life encompass not only physiological and anatomical adjustments but also emotional, psychological, and social transformations that continue to evolve over time (Cheng & Li, 2008; Jones, 2023; Wadephul et al., 2020). Providing both formal and informal support during the perinatal period, holds considerable potential to enhance not only maternal health and quality of life (McLeish & Redshaw, 2017; THL, n.d.) but also the health and well-being of the whole family and the baby (Vuorenmaa et al., 2023).

2.1.2 Maternity care in Finland

In Finland, during the perinatal period women receive free care at maternity clinics located in primary health care centres run by registered public health nurses or registered midwives (Government Decree on Maternity and Child Health Clinic Services, School and Student Health Services and Preventive Oral Health Services for Children and Youth 338/2011, 2011; Health Care Act 1326/2010, 2010; Hakulinen, Uotila-Laine, et al., 2023). The aim of the maternity care services is to ensure and promote the health, safety and well-being of the woman and fetus, as well as the whole family, and to promote public health and to prevent pregnancy complications. At maternity care, parents get information related to pregnancy, childbirth, and childcare, and they have possibility to discuss and actively participate and affect their care during pregnancy. Parents have possibility to review their own and their family's lifestyle and health habits and potentially change their health behaviour with the support of maternity care. (Hakulinen, Uotila-Laine, et al., 2023; THL, n.d..) During the last decades, a private service sector has emerged around maternal care as well, offering parents the option to purchase various substitute and additional services (Jones & Lahtinen, 2025). Still, the utilization of public maternity care services in Finland is on a high level (Jones & Lahtinen, 2025; Tiitinen, 2023c), with birth registry data indicating that only 0.2–0.3% of pregnant women do not access public services (Jones & Lahtinen, 2025; Vuorenmaa et al., 2023).

For primipara mothers there are at least nine health checks organised during prenatal period, and multipara women at least eight times (THL, n.d.). The first health check during pregnancy is organised between gestational weeks 8-10 (Hakulinen, Korpilahti, et al., 2023a) and the last one before childbirth between gestational weeks 37-41 (Hakulinen, Korpilahti, et al., 2023b). During postpartum period, there is one health check right after childbirth during the first postpartum week either at home or at the maternity care clinic (Hakulinen, Korpilahti, et al., 2023c). The second health check, the postnatal check-up, is carried out between 5-12 weeks after childbirth (Wedenoja et al., 2023). In addition of these 8-9 health checks, there can be additional health checks organised based on the individual needs (THL, n.d.). The health checks are primarily carried out by registered public health nurses or registered midwives, with physicians involved at selected visits. As needed, mothers may also be referred to other professionals, including physiotherapists, psychologists, social workers, oral health care providers, mental health and substance use services, or other multidisciplinary family-centered services. (Hakulinen, Uotila-Laine, et al., 2023.)

Most parents have experienced pregnancy monitoring at public maternity clinics in Finland as high-quality and consistent. However, parents have felt that health checks were least likely to include an assessment of the well-being of the whole family and adequate support for parenting. (Vuorenmaa et al., 2023.) In addition, 20% of the pregnant women have experienced that the support in the areas of preparing for childbirth and well-being were not adequate (Klemetti et al., 2024). Women often feel they do not receive sufficient guidance and support to adopt and maintain healthy lifestyle behaviour during the perinatal period (Saarikko et al., 2021). Although nationally standardised, evidence-based guidance for maternity counselling is available through the NEUKO database (Hakulinen, Uotila-Laine, et al., 2023), including recommendations on topics such as physical activity (Luoto & Kinnunen, 2021), there appears to be variability in how these guidelines are applied in routine practice.

International evidence also indicates similar challenges, with many women reporting a lack of adequate support specifically for initiating or resuming physical activity during and after pregnancy (Edie et al., 2021). At the same time, some countries have developed structured services to support postpartum recovery (Critchley, 2022). For instance, in France, publicly funded maternity care includes a routine prescription for postpartum pelvic floor rehabilitation, making all women automatically eligible for approximately 10 physiotherapy sessions conducted by midwives or physiotherapists to support pelvic floor recovery and prevent pelvic floor dysfunction (Critchley, 2022; Day & Goad, 2010).

2.1.3 Changes in body functions and structures during the perinatal period

The perinatal period involves various physiological, anatomical, and psychological changes that can influence woman's health, functioning and quality of life. The purpose of the changes is to support fetal development and prepare the body for childbirth and facilitate postpartum recovery. These changes affect nearly every organ system and are driven primarily by hormonal shifts. (Tiitinen, 2024.) Within the ICF framework, these changes are understood as alterations in body functions and structures (WHO, 2002, 2013). Although body functions also include mental and emotional functions, this section focuses primarily on describing the physiological and anatomical changes characteristic of pregnancy and the postpartum period, as these are most relevant to the present study. Psychological aspects are acknowledged, and key elements are briefly noted where appropriate. The following subsections first outline changes occurring during pregnancy and then describe changes typical of the postpartum period.

Changes during pregnancy

The cardiovascular system undergoes significant changes during pregnancy to meet the increased metabolic demands of both the mother and the fetus. Blood volume increases by approximately 40–50%, supporting fetal metabolism and preparing for blood loss during childbirth (Kepley et al., 2025; Tiitinen, 2024). Consequently, cardiac output increases by about 30–40%, and the maternal heart rate rises by an average of 15 beats per minute, with even greater increases during physical activity (Selman et al., 2022; Tiitinen, 2024). Pregnancy also increases oxygen consumption by 20–30%, requiring more efficient breathing. As the uterus grows, it elevates the diaphragm and reduces lung capacity, but both tidal volume and respiratory rate increase, enhancing oxygen intake. Many pregnant individuals experience a sensation of breathlessness, especially in the third trimester. (Tiitinen, 2024.) Hormonal changes slow gastrointestinal motility, often leading to constipation and heartburn, while nausea is also common. The kidneys work harder to filter the increased blood volume, and the expanding uterus puts pressure on the bladder, resulting in frequent urination. (Kepley et al., 2025.) Additionally, the body retains extra salt and water, which accumulates in the blood and tissues and causes swelling (Tiitinen, 2024).

As the uterus expands during pregnancy, body's centre of gravity shifts downward and forward, placing increased strain on the core muscles (Berber & Satılmış, 2020; Casagrande et al., 2015), stretching the abdominal muscles up to 115% of its resting length by gestational week 38 (Gilleard & Brown, 1996). This shift often leads to changes in posture: the lumbar lordosis typically deepens, and the kyphosis become more pronounced (Yoo et al., 2015). Simultaneously, the chest muscles and hip flexors tend to tighten, the superficial back muscles may shorten, and the straight abdominal muscles stretch to accommodate the growing uterus. The core muscles: the deep back and abdominal muscles, diaphragm, and pelvic floor, play a vital role in supporting the lumbar spine, sacroiliac joints, and pubic symphysis. Hormonal changes loosen the connective tissues in the pelvic region, softening the cervix and ligaments. (Selman et al., 2022.) This process begins in the first half of pregnancy and intensifies during the final trimester, allowing the pelvic ring to flex and adapt to the size of the fetus in preparation for childbirth. However, these structural and hormonal changes can also lead to discomfort. (Casagrande et al., 2015; Selman et al., 2022.)

The loosening of ligaments and altered posture may cause low back pain, pelvic pain or both at the same time referred as lumbopelvic pain that can radiate into the buttock, leg and foot (Casagrande et al., 2015; Liddle & Pennick, 2015; Tiitinen, 2023a). For many women, the pain can become so intense that it disrupts everyday activities (Berber & Satılmış, 2020; Citko et al., 2018; Elden et al., 2013), interferes with sleep (Aydin et al., 2015), reduce the quality of life (Aydin et al., 2015; Berber & Satılmış, 2020; Gutke et al., 2011) and leads to increased rates of sick leave (Backhausen et al., 2018). The reported prevalence of low back pain and pelvic pain is varying from 24% to 90% (Berber & Satılmış, 2020; Liddle & Pennick, 2015; Vermani et al., 2010; Vleeming et al., 2008), whereas a recent meta-analysis reported the prevalence of back pain being at 41% during pregnancy (Salari et al., 2023).

The progressive increase in volume of the uterus causes a major overload in perineal structures, which can result as in muscle trauma, nerve injuries, and connective tissue damage (Abramowitch et al., 2009; Fonti et al., 2009). Pelvic floor muscles (PFM) support the bladder, vagina, rectum, and lower back (Raizada & Mittal, 2008). Reduced strength and functionality of PFM can cause dysfunction of the PFM, resulting in different common and bothersome symptoms (Fonti et al., 2009; Kahyaoglu Sut & Balkanli Kaplan, 2016) called pelvic floor disorders (PFD) (Hage-Fransen et al., 2021), such as urinary incontinence (UI) (Sangsawang & Sangsawang, 2013) or pelvic organ prolapse (POP) (Patel et al., 2006). PFD limit daily functioning, reduce quality of life, and generate significant healthcare and societal costs (Mendes et al., 2017).

Urinary incontinence refers to the unintentional passing of urine (Abrams et al., 2002; Woodley et al., 2020). There are different types of urinary leakage recognized, including stress urinary incontinence, defined as involuntary leakage during effort, exertion, sneezing, or coughing; urge urinary incontinence, characterized by leakage accompanied by or immediately preceded by urgency; and mixed urinary incontinence, which involves symptoms of both stress and urge incontinence (Abrams et al., 2003). The prevalence during pregnancy varies from 30% to 70%

(Abramowitch et al., 2009; Moossdorff-Steinhauser et al., 2021b; Sangsawang & Sangsawang, 2013; Thom & Rortveit, 2010). Typically, urinary incontinence increases during pregnancy and gradually decreases during the first postpartum year, with prevalence varying from 26% to 33% (Dai et al., 2023; Thom & Rortveit, 2010; Wesnes et al., 2017). However, women with incontinence three months after a first delivery has found to have a particularly high risk of long-lasting symptoms, up to five years postpartum (Viktrup & Lose, 2001). The variance between the estimates of prevalence might be due to differences in definitions of urinary incontinence, recognition of urinary incontinence symptoms, timing of the assessments, as well as cultural differences and attitudes. Despite the severity of the urinary incontinence symptoms, women are bothered by them (Møller et al., 2000). Urinary incontinence affects women's physical, psychological and social well-being, and reduces overall quality of life (Contreras Ortiz, 2004; Mendes et al., 2017; Moossdorff-Steinhauser et al., 2021a; Norton & Brubaker, 2006). Urinary incontinence affects many aspects in women's life, such as physical activity (Temml et al., 2000), social life (Mendes et al., 2017), working, and sex (Mendes et al., 2017). Women can feel isolated and depressed, since they might restrict their social involvement (Contreras Ortiz, 2004). Experiences of fear and shame are also common, which can cause emotional difficulties and problems with self-esteem (Mendes et al., 2017).

Pelvic organ prolapse refers to the bulging of the uterus, bladder, and/or bowel as a result of impairment of the supporting tissues surrounding the vagina (Rahkola-Soisalo et al., 2021). The estimates of prevalence of pelvic organ prolapse in women generally varies greatly from 3% to 50% (Barber & Maher, 2013; Wu et al., 2014), but it is known that pregnancy and vaginal childbirth are risk factors for developing pelvic organ prolapse (Cattani et al., 2021). The symptoms of pelvic organ prolapse can severely decrease the quality of life of women (Mendes et al., 2017). In addition to urinary incontinence and pelvic organ prolapse, PFDs can cause symptoms of overactive bladder and faecal or anal incontinence (Hallock & Handa, 2016).

Sleep and biological rhythms are commonly disrupted during pregnancy (Facco et al., 2010), and almost half of pregnant women experience poor sleep quality (Sedov et al., 2018). Generally, disturbed sleep is associated with many adverse health outcomes such as depression, metabolic syndrome, and coronary heart disease, as well as changes in cognition (Li et al., 2022). During pregnancy, sleep disturbances are associated with variety of maternal complications and adverse fetal outcomes, e.g. pre-eclampsia, gestational diabetes mellitus, preterm birth, and caesarean section (Lu et al., 2021).

During pregnancy, weight increases due to the weight of the uterus, fetus, placenta, and amniotic fluid, as well as increased blood circulation and fluid volume in the body. Most of the weight gain occurs after the 20th gestational week during the second trimester. (Tiitinen, 2023a.) Normal weight gain during pregnancy is approximately 8-15 kg (Tiitinen, 2023a), while the recommendation for gestational weight gain based on pre-pregnancy body mass index (BMI) is 5-18 kg (ACOG, 2013). In Finland, 47.8% of pregnant women were overweight or obese (BMI ≥25 kg/m^2), with 20.3% classified as obese (BMI ≥30 kg/m^2) in 2024 (THL, 2025). Maternal overweight and obesity are linked to many adverse health outcomes, such as gestational diabetes, pre-eclampsia (Driscoll & Gregory, 2020; Langley-Evans et al., 2022), caesarean delivery, preterm delivery, and fetal macrosomia (Driscoll & Gregory, 2020), and therefore weight management and consequently physical activity, are important.

Changes during postpartum period

The postpartum period is a critical phase of recovery and adjustment of physical, psychological, functional, and social changes for women following childbirth (Aber et al., 2013; ACOG, 2018). Physically, the body undergoes significant changes. The uterus begins contracting back to its pre-pregnancy size, vaginal tone and external genitalia are starting to recover from childbirth, and the tone of abdominal wall is returning within the first week and typically returns to normal by six weeks (Ospina Romero et al., 2012). However, the recovering of PFM after vaginal delivery towards mid-pregnancy values can take over one year (Bø et al., 2022). In addition, women may experience a range of physical symptoms, including fatigue, perineal or caesarean section pain or discomfort, breast problems such as breast engorgement or soreness (ACOG, 2018; Cheng & Li, 2008; Ospina Romero et al., 2012), urinary or faecal incontinence (Cheng & Li, 2008; Moossdorff-Steinhauser et al., 2021a; Romano et al., 2010), back pain, and PFD (Cheng & Li, 2008). Musculoskeletal issues such as abdominal separation (diastasis recti) (Sperstad et al., 2016) and pelvic organ prolapse (H. W. Brown et al., 2022) are also common and can affect mobility and physical performance. Functionally, many women face challenges in resuming daily activities, including physical activity, work, and sexual function (ACOG, 2018). Recovery is influenced by factors such as the mode of childbirth, the presence of perineal tears, other complications, and access to postpartum care (ACOG, 2018).

Psychologically and hormonal fluctuations can lead to mood swings, feelings of overwhelm, and in some cases, postpartum depression or anxiety (ACOG, 2018; Ospina Romero et al., 2012). While mental health often stabilizes by six months postpartum, some women may continue to experience emotional challenges, especially if they are experiencing sleep deprivation (Cheng & Li, 2008; Gallaher et al., 2018), breastfeeding difficulties, or lack of social support (Ospina Romero et al., 2012).

Socially and emotionally, the transition to motherhood involves adapting to new roles and responsibilities (Ospina Romero et al., 2012). Factors such as relationship satisfaction, infant sleep patterns, and the joy of motherhood can significantly influence a woman's perceived quality of life. Conversely, stress, lack of support, and maternal psychopathology can negatively impact recovery. (ACOG, 2018.)

Recognizing these changes is essential for supporting maternal health and guiding perinatal care. As women navigate the physical and emotional transitions of pregnancy and postpartum recovery, targeted strategies and actions are needed to promote well-being and enhance recovery. One such strategy is physical activity, which plays a vital role not only in maintaining general health but also in addressing specific perinatal challenges such as urinary incontinence and reduced quality of life. The following section describes the role of physical activity during the perinatal period, highlighting its recommendations, safety, benefits, and potential to support both maternal and fetal health.

2.1.4 Physical activity

Physical activity is associated with significant maternal health benefits and has been consistently demonstrated to be safe and advantageous for both the pregnant woman and the developing fetus (Díaz-Burrueco et al., 2021; Nagpal & Mottola, 2020). Physical activity is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985). Physical activity refers to all movement throughout the daily life including transport, occupational, domestic, conditioning, sports or other leisure time activities (Caspersen et al., 1985; WHO, 2020). Exercise is a type of physical activity that is intentionally designed, organised, and repeated, with the goal of enhancing or preserving physical fitness, physical ability, or general health (Bull et al., 2020; WHO, 2020). Both concepts are used in this dissertation; physical activity while referring all bodily movement throughout the day, and exercise when referring specifically to intentionally designed physical activity.

Physical activity can be determined by its frequency, intensity, time, and type (FITT). Frequency refers to how often one is physically active or exercise, for example, during a day, week, or month. Intensity refers to rate of energy expenditure, time to duration of being physically active, and type refers to the type of physical activity. (Barisic et al., 2011.)

Physical activity intensity can be expressed as either absolute or relative intensity. Absolute intensity describes the energy required to perform an activity, whereas relative intensity reflects the effort relative to an individual's maximal capacity. (Siddique et al., 2020.) These two perspectives complement each other, as the same absolute workload may feel easier or harder depending on a person's fitness level, age, or health status.

One way to measure the absolute intensity of physical activity is by using the metabolic equivalent of task (MET). MET expresses the energy cost of physical activities relative to the energy used while resting. One MET corresponds to the amount of oxygen consumed at rest while sitting, which is approximately 3.5 mL of oxygen per kilogram of body weight per minute (3.5 mL O_2/kg/min). For example, brisk walking has a MET value of 4, meaning that a person walking briskly is expending four times more energy than when sitting still. (Franklin et al., 2018; Jetté et al., 1990.)

The intensity of physical activity is commonly divided into three categories: light, moderate, and vigorous (or high) intensity. Light-intensity physical activity is defined as activity between 1.5 and 2.9 METs, e.g. slow walking or light household tasks (Herrmann et al., 2024; Jetté et al., 1990; WHO, 2020). Light-intensity physical activity is moving without sweating or breathing hard (Davenport et al., 2022). Moderate-intensity physical activity refers to activity performed at 3 to less than 6 METs (Bull et al., 2020; Herrmann et al., 2024; WHO, 2020), e.g. brisk walking, dancing, and swimming (Jetté et al., 1990). During moderate-intensity physical activity, heart rate goes up, and people might be sweating or breathing hard (Davenport et al., 2022). A practical way to recognize moderate intensity is that it is possible to talk, even if one is slightly out of breath (UKK Institute, 2023; US Department of Health and Human Services, 2018). Vigorous-intensity physical activity is performed at 6.0 METs or more (Bull et al., 2020; Herrmann et al., 2024; WHO, 2020), such as hiking, jogging, and ball games like soccer (Jetté et al., 1990). During vigorous-intensity physical activity, heart rate goes up substantially, one is feeling hot and sweaty, and it is impossible to say more than a few words without pausing to breathe (Davenport et al., 2022).

2.1.4.1 Physical activity recommendations during the perinatal period

In 2020 WHO published guidelines on physical activity and sedentary behaviour, that include own recommendations for pregnant and postpartum women (Bull et al., 2020; Piercy et al., 2018; WHO, 2020). In addition, many countries, e.g. Australia, Canada and the US have published their own national recommendations for pregnant and postpartum women (W. J. Brown et al., 2022; Davenport et al., 2025; Mottola et al., 2018; US Department of Health and Human Services, 2018). Also, American College of Obstetricians and Gynecologists (ACOG) has published their own statement (ACOG, 2020). In Finland, the recommendations and guidelines for physical activity during pregnancy and postpartum have been published by UKK Institute (UKK Institute, 2022, 2023), The Finnish Medical Society Duodecim (Tiitinen, 2023b), and Nursing Research Foundation (NRF) (Hamari et al., 2022). The contents of the different guidelines and recommendations are mainly similar, emphasizing the importance of any physical activity throughout the perinatal period (Figure 2.). During recent decades, the influence of perinatal physical activity and exercise has been acknowledged for optimizing the health of two generations; the mother and child. However, there are some situations where engaging physical activity may not be recommended. In case of any complications associated with pregnancy or childbirth or concerns, including warning signs and contraindications (Davenport et al., 2022), it is essential to consult a healthcare professional. (W. J. Brown et al., 2022; Bull et al., 2020; Davenport et al., 2025; WHO, 2020.)

Women without medical contraindications are encouraged to stay physically active throughout pregnancy (Yang, Li, et al., 2022). It is recommended that pregnant women aim to achieve at least 150 minutes of moderate physical activity per week (ACOG, 2020; W. J. Brown et al., 2022; Bull et al., 2020; Hamari et al., 2022; Mottola et al., 2018; UKK Institute, 2023; US Department of Health and Human Services, 2018; WHO, 2020) and muscle strengthening and balance activities, such as gym training, gymnastics exercise, dancing or yoga (Bull et al., 2020; Mottola et al., 2018; UKK Institute, 2023; WHO, 2020), twice a week (W. J. Brown et al., 2022; Hamari et al., 2022; UKK Institute, 2023). Pelvic floor muscle training (PFMT) is recommended (W. J. Brown et al., 2022; Bull et al., 2020; Hamari et al., 2022; Mottola et al., 2018; WHO, 2020). Physical activity should be accumulated over a minimum of three days per week; however, being active every day is encouraged (W. J. Brown et al., 2022; Mottola et al., 2018; UKK Institute, 2023; US Department of Health and Human Services, 2018). The role of light-intensity activities in pursuing health benefits has been highlighted recently, and pregnant women are encouraged to utilise everyday opportunities, such as, housework, grocery shopping, and outdoor activities, to be physically active – every step counts (Hamari et al., 2022; UKK Institute, 2023; Yang, Li, et al., 2022). Some recommendations also encourage pregnant women to break sedentary behaviour whenever possible to improve blood circulation, activate muscles and reduce physical strain (W. J. Brown et al., 2022; Bull et al., 2020; Hamari et al., 2022; UKK Institute, 2023; WHO, 2020).

If pregnant woman has not been physically active before pregnancy, it is recommended to start with short and light sessions focusing on regularity. The duration, intensity and number of sessions can be increased gradually. (W. J. Brown et al., 2022; UKK Institute, 2023; WHO, 2020.) A growing amount of evidence is suggesting that especially inactive populations should be encouraged to engage in physical activity of any intensity (Füzéki et al., 2017; Hupin et al., 2015; Warburton & Bredin, 2017). If pregnant woman has been physically active before pregnancy, continuing with light and moderate physical activity as before is encouraged, but with consideration with one's body and easing the training accordingly (Mottola et al., 2018; UKK Institute, 2023; US Department of Health and Human Services, 2018; WHO, 2020). If pregnant woman is engaged with competitive sports or another goal-oriented vigorous physical activity, it is advisable to consult physician (UKK Institute, 2023).

Even though, physical activity has been demonstrated to be safe both for the pregnant woman and the developing fetus (Díaz-Burrueco et al., 2021; Nagpal & Mottola, 2020), there are some safety precautions to consider. Gradual warm-ups and cool-downs are recommended (UKK Institute, 2023). It is also essential to maintain hydration and remember to drink water before, during and after physical activity (Mottola et al., 2018; UKK Institute, 2023). Physical activity in hot and humid, and at high altitudes is recommended to be avoided (Mottola et al., 2018; UKK Institute, 2023; WHO, 2020), as well as, activities which involve physical contact or risk of falling or abdominal trauma, such as, many ball games, downhill skiing or horseback riding (Mottola et al., 2018; UKK Institute, 2023; US Department of Health and Human Services, 2018; WHO, 2020). In addition, a prolonged supine position is recommended to be avoided (Mottola et al., 2018; UKK Institute, 2023; US Department of Health and Human Services, 2018; WHO, 2020). As pregnancy progresses, physical activity may need to be adjusted to account for the body's changing needs and physical changes (ACOG, 2020; W. J. Brown et al., 2022). If there are any concerns, including warning signs, such as vaginal bleeding, dizziness or swelling, or contraindications, women are advised to seek advice from a qualified health professional (ACOG, 2020, 2020; W. J. Brown et al., 2022).

For women experiencing a healthy pregnancy and an uncomplicated childbirth, it is recommended to start or continue PFMT immediately after childbirth (ACOG, 2020; W. J. Brown et al., 2022; Davenport et al., 2025; UKK Institute, 2022) and light physical activity as soon as one feels ready to do so (ACOG, 2020; Davenport et al., 2025; UKK Institute, 2022). It is recommended to increase the amount and intensity of physical activity gradually so that a week should contain either 120 minutes of moderate-to-vigorous intensity physical activity (Davenport et al., 2025), 150 minutes of moderate physical activity (2018 Physical Activity Guidelines Advisory Committee, 2018; ACOG, 2020; W. J. Brown et al., 2022; UKK Institute, 2022; WHO, 2020) or 75 minutes of vigorous physical activity (UKK Institute, 2022). In addition, week should contain muscle strengthening and balance activities (WHO, 2020) at least twice a week (W. J. Brown et al., 2022; UKK Institute, 2022). However, right after childbirth it is recommended to avoid physical activities that include jumps or rapid changes of direction (UKK Institute, 2022). Returning to running or other high-impact sports involving jumping is generally not recommended until at least three months postpartum, provided that the body has been gradually conditioned for such impact, as this timeframe allows for essential musculoskeletal recovery and reduces the risk of injury (Hamari et al., 2022; UKK Institute, 2022). For lactating women, it is recommended to feed their infants or expressing milk before exercising to avoid discomfort (ACOG, 2020; UKK Institute, 2022).

The recommendations emphasize the importance of adaptation of the physical activity according to the one's resources (Davenport et al., 2025; UKK Institute, 2022). The postpartum period is a unique time of life, and the recommendations may not always be achievable, since infant feeding and care impact significantly on daily life, e.g. amount of sleep. It is essential to remember and to be reminded that any kind of physical activity is beneficial (W. J. Brown et al., 2022; UKK Institute, 2022; WHO, 2020), including minimizing the amount of time spent in prolonged sitting and breaking of sedentary behaviour (W. J. Brown et al., 2022; UKK Institute, 2022).

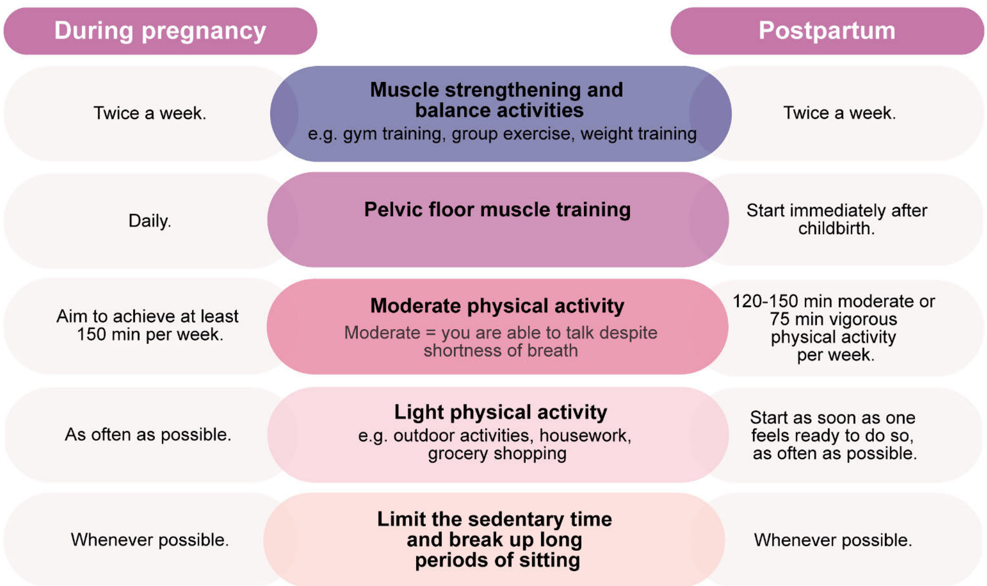

Figure 2. Physical activity recommendations during the perinatal period.

2.1.4.2 Benefits of physical activity during the perinatal period

Physical activity and exercise are known to have various benefits during the perinatal period both for maternal and fetal health (Díaz-Burrueco et al., 2021; Nagpal & Mottola, 2020; Ribeiro et al., 2022; WHO, 2020). Physical activity and exercise during pregnancy can decrease the risk of gestational hypertension (Davenport, Ruchat, et al., 2018; Díaz-Burrueco et al., 2021; Mottola et al., 2018; Prevett et al., 2025; Ribeiro et al., 2022), pre-eclampsia (Davenport, Ruchat, et al., 2018; Mottola et al., 2018; Ribeiro et al., 2022), gestational diabetes (Davenport, Ruchat, et al., 2018; Díaz-Burrueco et al., 2021; Mottola et al., 2018; Prevett et al., 2025; Ribeiro et al., 2022), and excessive gestational weight gain (Díaz-Burrueco et al., 2021;

Elliott-Sale et al., 2015; Ribeiro et al., 2022; Ruchat et al., 2018). Physical activity and exercise can decrease the risk of low back pain (Liddle & Pennick, 2015; Shiri et al., 2018) and pelvic pain (Liddle & Pennick, 2015) during pregnancy, as well as the severity of the pain (Davenport, Marchand, et al., 2019; Liddle & Pennick, 2015; Peng & Chou, 2019; Ribeiro et al., 2022). Exercise during pregnancy might prevent separation of the rectus abdominis muscles and ensure their recovery (Benjamin et al., 2019; Davenport, Ruchat, et al., 2019). Prenatal physical activity has been associated with a reduced risk for perinatal mood disorders (Prevett et al., 2025), antenatal depression (Davenport, McCurdy, et al., 2018; Mottola et al., 2018; Ribeiro et al., 2022) and milder depressive symptoms during pregnancy (Corrigan et al., 2022; Davenport, McCurdy, et al., 2018). Preliminary evidence also suggests that it may alleviate the severity of postpartum depressive symptoms, although robust scientific evidence on this is lacking (Davenport, McCurdy, et al., 2018; Nakamura et al., 2019). In addition, exercise is likely to increase pregnant women's satisfaction with their body image (Sun et al., 2018), and exercise during pregnancy may be associated with a better quality of life (Liu et al., 2019). In addition of the benefits for maternal health, exercise during pregnancy is also associated with positive fetal outcomes including reduced odds of macrosomia (Davenport, Meah, et al., 2018; Mottola et al., 2018; Prevett et al., 2025), and instrumental delivery (Corrigan et al., 2022; Davenport, Ruchat, et al., 2019).

Physical activity is known to have various benefits during the postpartum period. Physical activity can, for example, decrease depressive symptoms (Daley et al., 2009; Dipietro et al., 2019; Kołomańska-Bogucka & Mazur-Bialy, 2019), speed up physical recovery after childbirth (UKK Institute, 2022), and support weight management (Ruchat et al., 2018). PFMT performed according to instructions after childbirth is likely to reduce symptoms of urinary incontinence (Mørkved & Bø, 2014; Woodley et al., 2020; Wu et al., 2018) and may improve sexual function, as well as reduce dissatisfaction with sexual activity (Hadizadeh-Talasaz et al., 2019; Wu et al., 2018). Physical activity and exercise can also improve the quality of life (Bulguroglu et al., 2023; Kołomańska-Bogucka & Mazur-Bialy, 2019; Okyay & Ucar, 2018).

Despite the known benefits of physical activity (Dipietro et al., 2019) and physical activity recommendations, the level of physical activity in pregnant women is low (Bacchi et al., 2016; Daly et al., 2016; Dipietro et al., 2019; Evenson & Wen, 2011; Nascimento et al., 2012; Okafor & Goon, 2020). The amount of exercise usually decreases as the pregnancy progresses and only a few pregnant women move as much as recommended (Nascimento et al., 2012; Santo et al., 2017). It is also common that after birth, the amount of exercise may not reach the desired level or return to pre-pregnancy levels (Pereira et al., 2007). To address low physical activity levels during the perinatal period, it is essential to explore the factors that support or hinder women's engagement in physical activity and exercise.

2.1.4.3 Facilitators and barriers to physical activity during the perinatal period

There are many identified facilitators and barriers related to physical activity during the perinatal period. In the next chapters, the facilitators and barriers to physical activity during pregnancy and postpartum period have been synthesized using the ICF framework (Figure 3).

Body functions and structures. Perceived health benefits, such as relief from pregnancy-related symptoms like pain and fatigue (Angrish et al., 2023; Thompson et al., 2017) and weight loss postpartum (Makama et al., 2021) can facilitate continuing physical activity. Experiences of improved appearance (Harrison et al., 2018; Makama et al., 2021; Skjold et al., 2022) along with feelings of relaxation, well-being, happiness, and excitement resulting from physical activity, are likely to promote engagement in physical activity (Makama et al., 2021; Skjold et al., 2022; Thompson et al., 2017) during pregnancy and postpartum. On the contrary, pregnancy-related symptoms and physical limitations are well-documented barriers to physical activity. Common issues such as fatigue, dizziness, muscle pain, breathlessness, and swollen feet have been reported as barriers to being active during pregnancy (Angrish et al., 2023; Coll et al., 2017; Harrison et al., 2018; May et al., 2024; Sparks et al., 2023; Thompson et al., 2017), especially in the third semester (Angrish et al., 2023). In addition, discomfort related to weight gain and increasing body size can reduce physical activity levels during pregnancy (Coll et al., 2017; Harrison et al., 2018; May et al., 2024; Sparks et al., 2023) and postpartum (Edie et al., 2021; Makama et al., 2021; Ryan et al., 2022). After childbirth, known barriers for physical activity are reported to be physical or health limitations such as illness, fatigue, stress, lack of sleep, and low energy levels (Edie et al., 2021; Makama et al., 2021; Ryan et al., 2022), as well as, pregnancy complications (Edie et al., 2021; Makama et al., 2021) and recovering from childbirth (Ryan et al., 2022).

Activities and participation. Previous studies have identified insufficient time (Coll et al., 2017; Edie et al., 2021; Makama et al., 2021; Ryan et al., 2022; Skjold et al., 2022; Thompson et al., 2017), work commitments (Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; Skjold et al., 2022; Thompson et al., 2017), and childcare responsibilities (Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; Ryan et al., 2022; Sparks et al., 2023; Thompson et al., 2017) as significant barriers to achieving recommended levels of physical activity during pregnancy and postpartum. Especially during postpartum period, the baby's dependency on the mother (Makama et al., 2021; Ryan et al., 2022) and breastfeeding (Edie et al., 2021; Makama et al., 2021) were reported as barriers to physical activity. Previous studies have found that women tend to prioritize other responsibilities, e.g. caring for their baby and other children, work and housekeeping, over their own health promoting (Makama et al., 2021; Ryan et al., 2022).

Environmental factors. Clear and reassuring guidance from healthcare professionals has been shown to encourage physical activity during pregnancy (Angrish et al., 2023; Coll et al., 2017; Harrison et al., 2018; May et al., 2024; Thompson et al., 2017). Knowing that physical activity is safe and beneficial for both mother and baby (Angrish et al., 2023; Harrison et al., 2018; Makama et al., 2021), helping to relieve pregnancy-related discomfort, support weight management, and ease childbirth, can further promote engagement in physical activity (Harrison et al., 2018). On the contrary, lack of advice and support from professionals appears to decrease physical activity levels during pregnancy (Coll et al., 2017; Harrison et al., 2018) and postpartum (Edie et al., 2021; Makama et al., 2021). Pregnant women often express concern for their own and their baby's health, and insufficient information about the safety of physical activity and appropriate exercises can act as a barrier (Angrish et al., 2023; Coll et al., 2017; Harrison et al., 2018; Skjold et al., 2022; Thompson et al., 2017). Especially during postpartum period, lack of knowledge and advice when to safely resume exercise after childbirth has identified as a barrier (Makama et al., 2021). Exercise programs and opportunities specially designed for pregnant women, particularly group-based activities (Thompson et al., 2017) and personalized exercise prescriptions (Sparks et al., 2023), have been shown to support and encourage physical activity during pregnancy (Harrison et al., 2018; Thompson et al., 2017). Similarly, during postpartum period exercise partners and access to exercise classes and facilities were experienced as facilitators (Ryan et al., 2022). During postpartum period, the possibilities to exercise together with baby and available childcare at facilities were promoting physical activity (Makama et al., 2021; Ryan et al., 2022). However, a lack of awareness about these opportunities (Coll et al., 2017; Harrison et al., 2018; May et al., 2024), or distance and access to facilities (Coll et al., 2017; Edie et al., 2021; Makama et al., 2021; Thompson et al., 2017) have been reported to reduce the physical activity during pregnancy and postpartum. Support from a spouse, friends and family plays a crucial role in initiating and maintaining physical activity during pregnancy (Angrish et al., 2023; Coll et al., 2017; Harrison et al., 2018; May et al., 2024; Thompson et al., 2017) and postpartum (Makama et al., 2021; Ryan et al., 2022). In contrast, the absence of such support has been associated with reduced physical activity during pregnancy and postpartum (Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; Makama et al., 2021). Related to environmental factors, cultural norms that discourage active pregnancies have been identified as barriers to participation in physical activity (Angrish et al., 2023). Additionally, adverse weather such as extreme heat or cold, are commonly reported barriers to physical activity (Coll et al., 2017; Makama et al., 2021; Thompson et al., 2017).

Personal factors. Self-confidence and self-efficacy have been shown to promote physical activity both during pregnancy (Harrison et al., 2018; Thompson et al., 2017) and postpartum (Makama et al., 2021). Intention to engage in physical activity is a significant predictor of actual participation across all trimesters (Thompson et al., 2017) and postpartum as well (Makama et al., 2021). Women, who perceived their own health as important, reported making effort to exercise during postpartum period. In addition, setting realistic goals and scheduling exercise promote physical activity postpartum. (Makama et al., 2021.) On the contrary, psychosocial attitudes, including low motivation (Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; May et al., 2024; Thompson et al., 2017), reduced self-confidence (Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; Thompson et al., 2017), lack of interest (Skjold et al., 2022) or enjoyment (Edie et al., 2021; Makama et al., 2021), and low self-efficacy (Makama et al., 2021; May et al., 2024), may act as barriers to physical activity during pregnancy and postpartum. In addition, the perception that daily activities already provide sufficient physical activity can discourage further engagement in structured exercise during pregnancy (Coll et al., 2017). Also, low wealth and income levels (Edie et al., 2021; Makama et al., 2021), and low educational level (Edie et al., 2021) have acknowledged to be barriers to adopt healthy lifestyle.

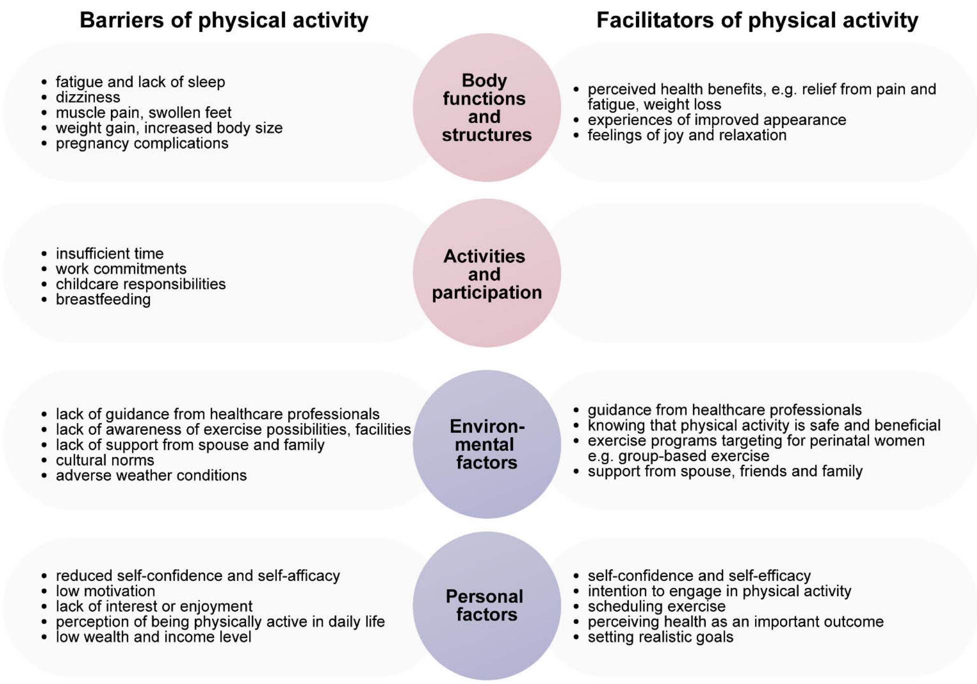

Figure 3. Facilitators and barriers to physical activity in the perinatal period.

Understanding the factors that influence physical activity during the perinatal period is essential, as they not only affect maternal health but also intersect with broader aspects of well-being. One such aspect is quality of life, which is increasingly recognized as a key outcome in perinatal health and is shaped by both physical and psychosocial experiences during pregnancy and postpartum.

2.1.5 Quality of life

Quality of life (QoL) is a complex and broad concept that can be interpreted and defined differently (Ferrans, 1990; Haraldstad et al., 2019; Karimi & Brazier, 2016). According to the WHO, quality of life refers to "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns". Quality of life is affected by the person's physical and psychological health and state, personal beliefs, social relationships and their environment. (WHO, 2012b.) Also, term health-related quality of life (HRQOL) is used, and sometimes terms quality of life and health-related quality of life are used interchangeably, even though, the definition is slightly different. HRQOL refers to the health-related aspects of quality of life, typically reflecting how disease and treatment affect disability and daily functioning. It also encompasses how an individual's perception of their health influences their ability to lead a fulfilling life. In this study, the term quality of life (WHO, 2012b) was selected for use, recognizing that although the perinatal period represents a unique and specific condition, it does not constitute a disease. (Karimi & Brazier, 2016.)

Quality of life is understood through four different domains: physical health, psychological health, social relationships and environment (Figure 4). Physical health domain encompasses facets related to pain and discomfort, energy and fatigue, and sleep and rest. It evaluates the extent to which physical sensations, such as pain or fatigue, interfere with daily functioning and overall well-being. This domain also considers the individual's perceived control over these symptoms and the impact of sleep quality on life satisfaction. Variability in personal tolerance and response to physical challenges is acknowledged as influencing quality of life. (WHO, 2012b, 2012a.)

Psychological domain addresses facets related to emotional well-being, cognitive functioning, self-perception, body image, and spirituality. It includes the experience of positive emotions such as happiness, hope, and contentment, as well as the negative emotions such as anxiety, sadness, and despair. Cognitive functioning refers to the ability to think clearly, learn, concentrate, and make decisions. Self-esteem is explored through perceptions of self-worth, efficacy, and personal satisfaction, while body image reflects the individual's view of their physical appearance. Spirituality reflects an individual's sense of meaning, purpose, and connection to something greater, which may significantly influence overall quality of life. (WHO, 2012b, 2012a.)

Social relationships domain encompasses facets related to personal relationships, social support, and sexual activity. It evaluates the quality and depth of emotional and physical intimacy, the availability and reliability of support from family and friends, and the individual's satisfaction with their sexual life. This domain reflects how interpersonal connections and the ability to give and receive care contribute to overall well-being. (WHO, 2012b, 2012a.)

The environment domain encompasses external factors that influence an individual's quality of life, including physical safety, living conditions, financial resources, access to health and social services, and opportunities for learning and leisure. It also considers the broader physical environment, such as pollution, noise, and climate, and the availability of transportation. This domain reflects how supportive, secure, and resourceful the surrounding environment is in enabling individuals to live comfortably, participate in society, and pursue personal development. (WHO, 2012b, 2012a.)

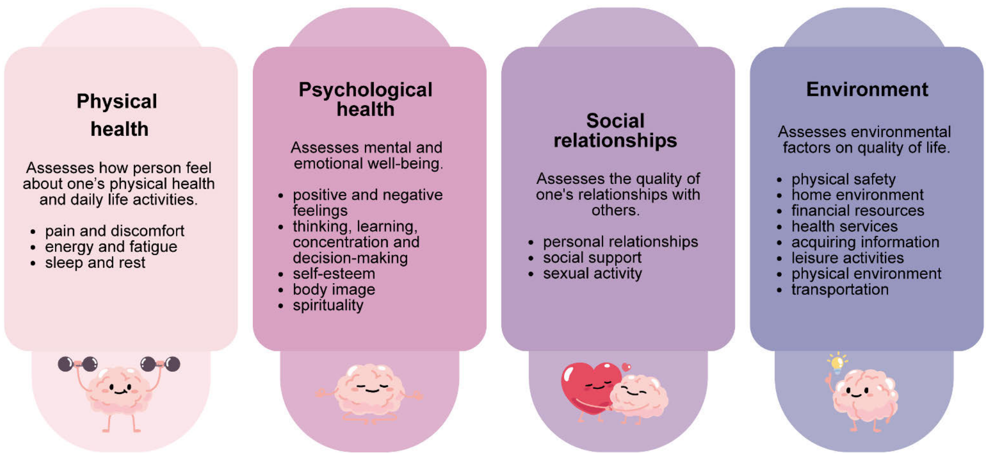

Figure 4. Four domains of quality of life (based on the WHOQOL-BREF instrument).

2.1.5.1 Quality of life in the perinatal period

During the pregnancy, many previous studies have found that quality of life and health status of pregnant women declines as the pregnancy progresses (Haas et al., 2005; Ishaq et al., 2021; Kazemi et al., 2022; Kolu et al., 2014; Morin et al., 2019). Some studies have found that the quality of life of pregnant women rises from the first trimester to the early second trimester but then decreases to the lowest at the late third trimester (Boutib et al., 2022; Wu et al., 2021) following the same trend noticed in the previous studies (Haas et al., 2005; Ishaq et al., 2021; Kazemi et al., 2022; Kolu et al., 2014; Morin et al., 2019). Overall, although previous studies show broadly similar patterns in how quality of life changes across pregnancy, with many reporting a decline as gestation progresses, the findings regarding the absolute level of quality of life at different stages of pregnancy are inconsistent.

While some studies have found the quality of life very good during pregnancy (Ishaq et al., 2021; Mazúchová et al., 2018), several other studies have found the levels of quality of life to be generally lower compared with non-pregnant populations (Boutib et al., 2022; Lagadec et al., 2018). Pregnant women have been found to report lower physical health–related quality of life compared to non-pregnant women (O. K. Chan et al., 2010; Da Costa et al., 2006; Elsenbruch et al., 2007; Nakamura et al., 2019). It is also acknowledged that quality of life is lower during pregnancy than before pregnancy (Chang et al., 2014).

The studies related to the level of quality of life postpartum are scarce. Existing studies regarding quality of life in pregnant and postpartum populations tend to focus on factors associated with quality of life, instead of focusing on the level of quality of life. However, there are some studies indicating that physical health of postpartum women is on a lower level compared to general population (McGovern, 2006; Otchet, 1999).

2.1.5.2 Determinants of quality of life in the perinatal period

There are several factors identified that may impact on quality of life either positively or negatively. In the next chapters, the factors associated with quality of life during the perinatal period have been synthesized using the ICF framework.

Body functions and structures. BMI below 25 (Boutib et al., 2022), early gestational age (Lagadec et al., 2018) or longer time since childbirth (Bai et al., 2019), and high sleep quality during pregnancy (Boutib et al., 2022) are associated with a better quality of life. In contrast, several factors are linked to a lower quality of life, including pregnancy complications (Lagadec et al., 2018), such as hyperemesis gravidarum and gestational diabetes mellitus (Boutib et al., 2022), higher gestational age (Morin et al., 2017), mode of delivery (having caesarean delivery vs. vaginal delivery) (Bai et al., 2019; Evans et al., 2022; Martínez-Galiano et al., 2019; Van Der Woude et al., 2015), excessive gestational weight gain (Boutib et al., 2022), and obesity (Lagadec et al., 2018). Additionally, mental health issues such as stress, anxiety (Bai et al., 2019; Boutib et al., 2022; Lagadec et al., 2018), and postnatal depression (Valla et al., 2022), as well as sleep problems (Boutib et al., 2022; Lagadec et al., 2018; Peters et al., 2023), fatigue (Bai et al., 2019; Bulguroglu et al., 2023; Okyay & Ucar, 2018), urinary incontinence (Boutib et al., 2022; Van Der Woude et al., 2015), and low back (Boutib et al., 2022; Lagadec et al., 2018) and pelvic girdle pain (Boutib et al., 2022), are also associated with reduced quality of life.

Activities and participation. Exercise has generally been found to have a positive impact on quality of life during the perinatal period (Boutib et al., 2022; Bulguroglu et al., 2023; Lagadec et al., 2018; Liu et al., 2019; Okyay & Ucar, 2018). More specifically, high exercise adherence, resistance training (Boutib et al., 2022; Liu et al., 2019), Pilates (Boutib et al., 2022), general physical activity (Okyay & Ucar, 2018) and PFMT (Hadizadeh-Talasaz et al., 2019) have been shown to improve the quality of life during the perinatal period. On the contrary, low levels of physical activity are associated with a decrease in quality of life (Bulguroglu et al., 2023; Okyay & Ucar, 2018).

Environmental factors. Social support, particularly from family (Boutib et al., 2022; Lagadec et al., 2018) and friends (Lagadec et al., 2018) is associated with a higher quality of life. Receiving appropriate support, information and lifestyle advice from healthcare professionals also contributes to improved quality of life (Boutib et al., 2022). On the contrary, inadequate care consultations during pregnancy (Boutib et al., 2022), and hospitalization after childbirth (Bai et al., 2019; Martínez-Galiano et al., 2019) are linked to a lower quality of life.

Personal factors. Lower maternal age has been associated with higher quality of life (Lagadec et al., 2018; Valla et al., 2022), whereas older maternal age is linked with lower quality of life (Bai et al., 2019; Boutib et al., 2022). However, adolescent motherhood is associated with reduced quality of life (Boutib et al., 2022). Factors such as primiparity (Lagadec et al., 2018), higher level of education (Lagadec et al., 2018; Valla et al., 2022), absence of economic problems (Boutib et al., 2022; Lagadec et al., 2018), and being employed (Lagadec et al., 2018) are positively associated with quality of life. In contrast, low educational level (Boutib et al., 2022) and low household income (Bai et al., 2019) are associated with lower quality of life. Being married (Lagadec et al., 2018), satisfaction with one's relationship (Valla et al., 2022) and sexual satisfaction (Boutib et al., 2022) are linked to higher quality of life. Overall, positive emotions, such as joy in motherhood contribute to improved quality of life (Lagadec et al., 2018; Valla et al., 2022).

Enhancing the quality of life of women during the perinatal period is significant, since improved quality of life has the potential to affect the well-being of the mother and the rest of the family, which has positive consequences for both individual and populational health (Oyetunji & Chandra, 2020). Assessment of quality of life facilitates a deeper understanding of women's experiences during the perinatal period, enabling more effective symptom relief, personalized care, and targeted rehabilitation strategies, which might promote health interventions in the future (Haraldstad et al., 2019; Lagadec et al., 2018; Mogos et al., 2013). In this context, studying the effectiveness of physical activity is particularly relevant, as it supports maternal health (Díaz-Burrueco et al., 2021; Nagpal & Mottola, 2020; WHO, 2020) by improving physical functioning, reducing pregnancy-related discomforts, and aiding postpartum recovery. Moreover, physical activity contributes to emotional well-being by alleviating symptoms of anxiety and depression (Corrigan et al., 2022; Davenport, McCurdy, et al., 2018), enhancing self-esteem and body image (Sun et al., 2018), and fostering a sense of autonomy during a time of significant life transition. It may also promote spiritual well-being by reinforcing inner balance and purpose.

2.2 Physical activity and exercise interventions during the perinatal period

In recent years, there has been a growing amount of research and increasing interest in the effects of physical activity and exercise interventions for urinary incontinence and quality of life of pregnant and postpartum women. To better understand and summarize the current state of evidence, searches of previously published systematic reviews and meta-analyses on these topics were conducted.

2.2.1 Physical activity and exercise interventions for urinary incontinence and pelvic organ prolapse

Sub-study I aimed to summarize the existing evidence about the effectiveness of exercise interventions for urinary incontinence and pelvic organ prolapse in pregnant and postpartum women and to formulate recommendations for health care professionals (Paper I), and these results are described in the Chapter 5.1.

However, after conducting the review of reviews (Paper I), multiple systematic reviews and meta-analysis on this topic have been published. Altogether nine systematic reviews were recognized after search update (Beamish et al., 2025; Cabrera-Martos et al., 2025; Chen et al., 2024; Gallego-Gómez et al., 2025; Höder et al., 2023; Mantilla Toloza et al., 2024; Santos et al., 2024; Yu et al., 2023; Zhang et al., 2024). These nine reviews have been published between 2023 and 2025. The main purpose of the reviews was to assess the effectiveness of physical activity and exercise interventions in pregnant (n=2), postpartum (n=3), or both pregnant and postpartum women (n=4). Primary outcomes assessed were urinary incontinence (n=8) and both urinary incontinence and pelvic organ prolapse (n=1). Most of the interventions included in the reviews relied on face-to-face guidance. A few reviews also included interventions that utilized mobile applications (Beamish et al., 2025; Gallego-Gómez et al., 2025), but their effectiveness compared to face-to-face guidance was not specifically addressed in the reviews. The interventions, as well as the extent to which they were described in the reviews, were heterogeneous, similarly to the previous results. However, PFMT remained the most studied intervention, often delivered alone or in combination with modalities such as biofeedback, electrical stimulation, core stabilization, and general physical activity. The characteristics of the included reviews are described in Appendix 1.

The evidence supports PFMT during the postpartum period in reducing urinary incontinence symptoms and improving quality of life (Beamish et al., 2025; Chen et al., 2024; Gallego-Gómez et al., 2025), with supervised interventions showing greater effectiveness than unsupervised ones (Chen et al., 2024; Mantilla Toloza et al., 2024). PFMT during pregnancy was also found to be moderately effective in preventing urinary incontinence (Santos et al., 2024; Zhang et al., 2024). Combination therapies, particularly those integrating PFMT with biofeedback or electrical stimulation, demonstrated superior outcomes compared to PFMT alone (Chen et al., 2024; Gallego-Gómez et al., 2025). Despite promising results, the reviews highlighted considerable heterogeneity in study designs, intervention protocols, and outcome measures, limiting the overall certainty of evidence (Cabrera-Martos et al., 2025; Gallego-Gómez et al., 2025; Höder et al., 2023). Only one review addressed pelvic organ prolapse as primary outcome beside urinary incontinence, suggesting a potential benefit of PFMT postpartum, but the topic remains underexplored (Beamish et al., 2025). Overall, the findings reinforce the role of PFMT as a key conservative strategy for managing urinary incontinence, while emphasizing the need for individualized instruction, supervision, and further high-quality research.

2.2.2 Physical activity and exercise interventions for quality of life

A review of previous physical activity and exercise interventions targeting quality of life in pregnant women reveals considerable variation in study design, sample size, and intervention characteristics (Bernardo et al., 2024; Cai et al., 2022; Chan et al., 2019; De Castro et al., 2022; Ferraz et al., 2023; Liu et al., 2019; Mérida-Téllez et al., 2025; Redondo-Delgado et al., 2025; Sánchez-Polán et al., 2023; Zhao et al., 2024). The included reviews (n=10) comprised between two and 44 studies, with a subset of two to 14 studies in each review specifically addressing quality of life outcomes. The study populations consisted exclusively of pregnant women, with sample sizes ranging from 33 participants to over 132,000 individuals. The interventions employed diverse exercise modalities, including aerobic training, strength training, Pilates, aquatic exercise, and relaxation techniques. Frequency of exercise ranged from one to seven sessions per week, with session durations spanning 15 to 70 minutes. Intervention periods varied from four to 21 weeks. Intensity levels were reported as light to vigorous in some studies, while others did not specify intensity. Most interventions were delivered in supervised settings, either individually or in groups, although some included home-based components or did not clearly report the delivery context. While face-to-face guidance was the predominant mode of delivery, a few reviews highlighted the use of digital platforms to support communication and engagement. For example, social networking tools like Facebook and WhatsApp, were used to enhance motivation and adherence (De Castro et al., 2022). Additionally, two studies employed smartphone applications to interact with participants and monitor progress, offering both informational and motivational support (Bernardo et al., 2024). Quality of life was assessed using a range of validated instruments, such as the Short Form Health Surveys (SF-36, SF-12, SF-8), and the World Health Organization Quality of Life Questionnaire (WHOQOL-BREF). The characteristics of the reviews are described as supplement in Appendix 2.

The findings across reviews were generally positive, with several studies reporting significant improvements in both physical and mental aspects of quality of life following structured physical activity and exercise interventions. High levels of physical activity during pregnancy were associated with improved prenatal quality of life compared to lower levels of activity (Cai et al., 2022). In addition to overall physical activity, Pilates, strength training, and aquatic exercises were found beneficial. Pilates showed significant benefits for pregnant women's quality of life (Ferraz et al., 2023; Mérida-Téllez et al., 2025). Similarly, strength training was found to enhance various dimensions of HRQOL, including physical activity levels, muscular strength, flexibility, sleep quality, energy expenditure, and psychological well-being (Redondo-Delgado et al., 2025). In addition, aquatic exercise interventions demonstrated significant improvements in maternal quality of life when compared to standard prenatal care or no exercise (Zhao et al., 2024). The effectiveness of combined exercise modalities was also highlighted. While aerobic and resistance training alone had mixed effects, their combination, especially when paired with yoga or group-based formats, resulted in significant improvements of quality of life (Liu et al., 2019).

Two reviews reported promising results, but because of the low number of studies included in the analysis and the variability in outcome measures, the conclusions were interpreted with caution. One review found that control groups not engaging in exercise interventions were more likely to report decreased quality of life (De Castro et al., 2022). Another review found that physically active pregnant women reported better mental and physical self-perceptions of quality of life than their inactive counterparts, suggesting that physical activity may enhance both psychological and physical quality of life during pregnancy (Sánchez-Polán et al., 2023).

However, not all findings were consistently positive. One review reported contrasting effects, indicating that the overall effectiveness of physical activity interventions for quality of life may still be inconclusive in some contexts (Chan et al., 2019). Additionally, physical activity interventions targeting pregnant women with overweight or obesity did not find statistically significant improvements in quality of life (Bernardo et al., 2024).

Even though the results remain mixed or inconclusive related to quality of life, the reviews concluded that physical activity and exercise interventions were positively linked to several other outcomes, such as, better physical health (Bernardo et al., 2024), improved weight control (Bernardo et al., 2024; De Castro et al., 2022; Ferraz et al., 2023; Redondo-Delgado et al., 2025; Zhao et al., 2024), and increased aerobic fitness (Bernardo et al., 2024) or physical activity levels overall (Chan et al., 2019; De Castro et al., 2022). Interventions contributed to greater confidence about women's own health and their baby (Bernardo et al., 2024) and enhanced their mood (Redondo-Delgado et al., 2025). High levels of physical activity decreased the odds of developing prenatal depression and anxiety (Cai et al., 2022), as well as decreased the levels and severity of depression during pregnancy (Cai et al., 2022; De Castro et al., 2022). Overall, the evidence supports the potential of physical activity and exercise to enhance quality of life during pregnancy, though further research with more standardized protocols and rigorous methodological approaches is needed to determine optimal exercise parameters and long-term effects, also during postpartum.

2.3 Summary and knowledge gaps in current literature

The perinatal period involves profound physiological, psychological, and social changes that holistically affect maternal health. While maternity care services are designed to support women through these transitions, many still reports feeling inadequate guidance, particularly when it comes to adopting and maintaining healthy lifestyle behaviours. The perinatal period brings notable changes in body structures and functions, including physical, psychological, and functional shifts, all of which can influence a woman's health, daily functioning, and overall quality of life. As women navigate the physical and emotional transitions of pregnancy and postpartum recovery, targeted interventions, such as physical activity and exercise interventions, are needed to promote well-being and enhance recovery.

Physical activity during the perinatal period has been associated with multiple health benefits both for maternal and fetal health. Despite the known benefits and official recommendations, level of physical activity in pregnant and postpartum women remain low. Commonly identified barriers for physical activity during the perinatal period include lack of time, insufficient guidance and knowledge, and limited access to supervised exercise programs. In contrast, clear information about the benefits and safety of physical activity, along with accessible services, are recognized as key facilitators. Emerging evidence suggests that targeted physical activity interventions may help alleviate bothersome symptoms, such as urinary incontinence, and improve overall well-being and quality of life. However, findings from recent reviews of reviews, while promising, highlight the need for further research due to variability in study designs, intervention types, and outcome measures. The following knowledge gaps were identified:

- **Fragmented evidence on PFMT and physical activity and exercise interventions.** Research on physical activity and exercise interventions for urinary incontinence and pelvic organ prolapse remains heterogeneous in study designs, intervention protocols and outcome measures, reducing the certainty and comparability of the evidence. This fragmentation limits the applicability of existing findings for clinical guideline development and creates challenges for providing consistent, evidence-based counselling in maternity care.
- **Limited research on physical activity and quality of life.** Research on physical activity and quality of life during the perinatal period, particularly postpartum, is limited. Existing studies often focus on associated factors rather than directly assessing physical activity or quality of life. In addition, quality of life is frequently treated as a secondary outcome, which may restrict the depth of understanding.
- **Intervention delivery formats and adherence.** Most prior interventions rely on supervised, in-person formats. The effectiveness of independently performed, digitally delivered physical activity and exercise programs on urinary incontinence, physical activity, and quality of life among perinatal women remains underexplored. Additionally, there is a need for trials that systematically monitor and report adherence and intensity. Electronic devices, such as smart rings and other wearable trackers, are underutilised despite their potential to support adherence and provide real-time feedback.
- **Methodological limitations.** Many studies had small sample sizes and short follow-up periods, limiting statistical power and the ability to assess long-term changes in quality of life.

To advance the field, future research should focus on postpartum period, both in terms of physical activity and quality of life. Studies should aim to directly assess quality of life as a primary outcome and adopt standardized protocols to reduce heterogeneity and improve comparability. Integrating both supervised and independently performed physical activity into interventions may better reflect real-world conditions and enhance sustainability. Moreover, health technology, such as mobile apps, digital platforms, and wearable devices, could be effectively utilised to deliver and support physical activity interventions, offering personalized and accessible solutions for postpartum women. These tools also enable accurate monitoring of adherence and intensity, while providing real-time feedback to participants. Finally, larger sample sizes and longer follow-up periods are essential to strengthen statistical power and capture meaningful changes over time.

3 Aims of the study

The aim of this study was to assess the effectiveness of exercise and physical activity interventions for urinary incontinence, physical activity and quality of life among pregnant and postpartum women to support maternal health. Maternal health is conceptualized through ICF framework which offers a comprehensive biopsychosocial approach to understand and research maternal health as a dynamic and multidimensional phenomenon. This study includes three sub-studies (Papers I-IV). Sub-study I is a review of reviews that synthesizes existing evidence, whereas sub-studies II and III are quasi-experimental studies that generate new empirical data on the effectiveness of exercise and physical activity interventions during the perinatal period.

The research questions were:

1. What is the effectiveness of exercise interventions on urinary incontinence and pelvic organ prolapse in pregnant and postpartum women? (Sub-study I; Paper I)
2. What is the effectiveness of an online exercise program focusing on core and pelvic floor muscle strengthening in reducing self-assessed urinary incontinence symptoms and its impact on the lives of postpartum women? (Sub-study II; Paper II)
3. What is the effectiveness of an online exercise program focusing on core and pelvic floor muscle strengthening in increasing physical activity and improving quality of life among postpartum women? (Sub-study II; Paper III)
4. What is the effectiveness of the Supporting Lifestyle Change in Obese Pregnant Women through Wearable Internet-of-Things (SLIM) intervention in improving quality of life during pregnancy and postpartum and how do physical activity patterns evolve during pregnancy and postpartum, based on data collected via the Oura smart ring? (Sub-study III; Paper IV)

It is acknowledged that many pregnant and postpartum women do not engage in sufficient physical activity, despite its known benefits. At the same time, digital and remote solutions are becoming increasingly common in health promotion, yet their effectiveness in the perinatal context remains underexplored. Given the various challenges described in chapter 2, such as barriers to participation in physical activity and gaps in support, it is essential to investigate which types of interventions are effective within the Finnish context. Exploring the potential of digitally delivered and supported interventions is important to determine whether they can address commonly reported issues during the perinatal period and be effectively implemented to support maternal health. This study evaluates the effectiveness of two different interventions which both utilise health technology in different ways.

Ultimately, the goal of this dissertation is to generate knowledge that supports the development, targeting, and implementation of health-technology–assisted physical activity interventions that enhance maternal health. There is a clear need for efficient, cost-effective, and sustainable solutions within the context of maternal care. By providing evidence on the effectiveness of exercise and physical activity interventions, as well as new knowledge on women’s physical activity and quality of life during pregnancy and postpartum, this dissertation offers valuable insights that can guide the development of future services and interventions.

4 Materials and Methods

This study is comprised of three sub-studies which are reported in four original publications (Papers I-IV, Table 1). Sub-study I (Paper I) was conducted as part of the preparation of the NRF Finnish National Clinical Practice Guideline “Pregnant and postpartum women in health care: justification and guidance for physical activity”. Sub-study II (Papers II and III) was conducted in collaboration with the Nordic Wellness Group, whose online exercise program was used as intervention. Sub-study III (Paper IV) was conducted as part of the Academy project of the Department of Nursing Science at the University of Turku "Supporting Lifestyle Change in Obese Pregnant Mothers through the Wearable Internet-of-Things (SLIM)".

Table 1. Summary of the sub-studies included in this study.

SUB-STUDY	DESIGN	SAMPLE	INTERVENTION	DURATION OF INTERVENTION	OUTCOME
I PAPER I	Review of the reviews	Scientific research articles (n=9)	Various PA interventions including e.g. PFMT, strength training, stretching, and/or aerobic exercise	From 4 weeks to 17 months	UI, POP
II PAPERS II AND III	Quasi-experimental study	Postpartum women (n=297)	Online exercise program “Rehabilitate your core” focusing on strengthening the core and PFM	6 weeks	UI, QOL, PA
III PAPER IV	Quasi-experimental study	Pregnant women in maternity care (n=48)	Intervention focusing on to improve self-efficacy in weight management of pregnant women with overweight or obesity utilising health technology, motivational interviewing, feedback, and goal setting	From 37 weeks to 45 weeks	QOL, PA

Abbreviations: PA: physical activity; PFMT: pelvic floor muscle training; POP: pelvic organ prolapse; QOL: quality of life; UI: urinary incontinence

4.1 Sub-study I: Review of the reviews

4.1.1 Study design

Sub-study I was a systematic review (Paper I) conducted as part of the preparation of the NRF's Finnish National Clinical Practice Guideline "Pregnant and postpartum women in health care: justification and guidance for physical activity" (Hamari et al., 2022). The review of the reviews was conducted following the Joanna Briggs Institute methodological guidance (Aromataris et al., 2024) to summarize the existing evidence about the effectiveness of exercise interventions for urinary incontinence and pelvic organ prolapse in pregnant and postpartum women, and to formulate recommendations for health care professionals according to the NRF guideline (Siltanen et al., 2023). The protocol was registered in PROSPERO (CRD42020191591).

4.1.2 Sample and data collection

Sample consisted of international scientific articles. To find the relevant publications, systematic literature searches were conducted across nine databases, including MEDLINE (PubMed), CINAHL (EBSCOhost), PsycINFO (EBSCOhost), Web of Science, Medic, Cochrane Library, ERIC (EBSCOhost), Embase, and Academic Search Premier (EBSCOhost), on 3 January 2022, with an update on 11 January 2023. The used search queries are available as Appendix of the Paper I. The search strategy was based on the PICO model (Stern et al., 2014) and developed with the assistance of an information specialist (Appendix 3). Publications were included if they met the following criteria: 1) types of study: systematic review and/or meta-analysis of effectiveness; 2) population: pregnant and/or postpartum women up to 24 months from birth; 3) interventions: any type of physical activity (e.g. exercise, physiotherapy) or guidance to address the symptoms of urinary incontinence and/or pelvic organ prolapse, delivered individually, in a group, face-to-face, or online; 4) comparison: usual care, no exercise, or being on a waiting list; 5) outcomes: symptoms of urinary incontinence and/or pelvic organ prolapse; and 6) language: English or Finnish, as there was no funding for translations.

Two reviewers independently screened titles, abstracts, and full texts using Covidence software, resolving conflicts through discussion. After removing 342 duplicates, 391 titles and abstracts were screened. Of these, 359 were excluded as irrelevant. Then, 32 full-text articles were assessed for eligibility, and 19 more were excluded, leaving thirteen articles for methodological quality assessment.

Methodological quality of the reviews was assessed using Joanna Briggs Institute's (JBI) Critical Appraisal Checklist for Systematic Reviews and Research

Syntheses (Joanna Briggs Institute, 2017), with reviews scoring at least 6/11 and a "Yes" on Item 5 (critical appraisal of included studies) being eligible (Siltanen et al., 2023). Two reviewers independently assessed the reviews, resolving conflicts through discussion. Finally, nine articles were included in the review of the reviews. The scores of the included studies varied between 6/11 points to the maximum of 11/11 points (Appendix 4). Four studies scored the maximum 11/11 points (Davenport, Nagpal, et al., 2018; Woodley et al., 2020; Wu et al., 2018; Yang, Zhang, et al., 2022). Item 9, "Was the likelihood of publication bias assessed?", was the most frequently unreported criterion, with five studies failing to address it (Harvey, 2003; Lemos et al., 2008; Mørkved & Bø, 2014; Von Aarburg et al., 2021; Wagg & Bunn, 2007). The study selection process is described in a PRISMA flow diagram (Figure 5).

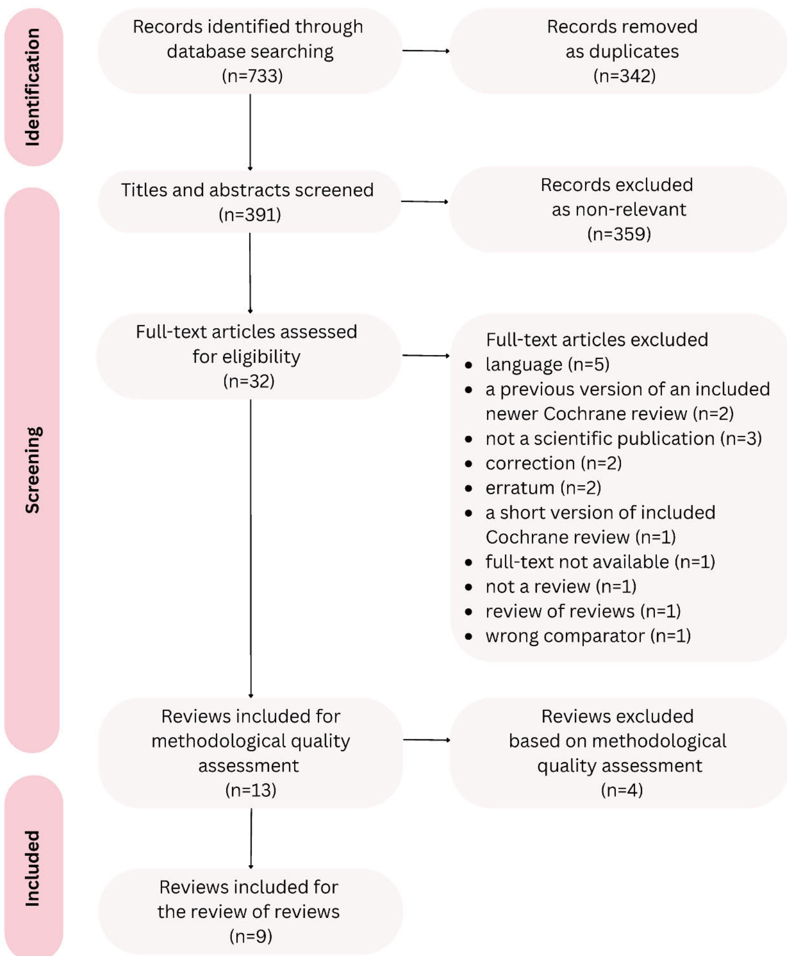

Figure 5. PRISMA 2020 flow diagram for review of the reviews (Paper I).

4.1.3 Data analysis

Data extraction was performed independently by two reviewers following JBI guidelines (Aromataris et al., 2024) using Covidence. The data extraction table was piloted before use. A narrative synthesis was conducted, and findings were summarized in tabular format. Lastly, grading the level of evidence (GRADE) and forming the recommendations were conducted following the NRF guideline handbook (Siltanen et al., 2023).

4.2 Sub-study II: Quasi-experimental study

4.2.1 Study design

Sub-study II was a quasi-experimental trial (Papers II and III) conducted in collaboration with the Nordic Wellness Group, whose online exercise program was used as intervention. Pre- and posttest design without a control group was used (Capili & Anastasi, 2024; Shadish et al., 2001). A quasi-experimental study was conducted to assess the effectiveness of a six-week online exercise program focusing on strengthening the core and pelvic floor muscles on self-assessed urinary incontinence symptoms, physical activity and quality of life among postpartum women. Ethical approval for sub-study II was obtained from the Ethics Committee for Human Sciences at the University of Turku in June 2021 (18/2021) and the trial registration was done retrospectively to Clinicaltrials.gov (NCT06268782) in February 2024.

4.2.2 Intervention

The intervention used was a pre-existing, commercially available six-week online exercise program titled "Rehabilitate Your Core", which aims to support postpartum recovery by strengthening core and pelvic floor muscles. The program, developed by a multidisciplinary group with expertise in perinatal exercise coaching, gynaecology, midwifery, and physiotherapy, was entirely independent of this study and available for purchase for 89€. Once enrolled, participants received access to an online platform where the training was divided into six modules corresponding to the program's weekly progression. Each module had a defined thematic focus, and the exercises advanced systematically from foundational activation and relaxation techniques to more demanding and comprehensive training. (Figure 6.)

Participants conducted all exercises on their own, completing approximately 10-minute sessions five days per week. Alongside the weekly training structure, the program provided additional informational resources on topics relevant to postpartum recovery, including pelvic floor function, breathing strategies, relaxation techniques, and guidance on scar care following cesarean delivery or episiotomy. Participants were also invited to join a closed online discussion group that served as a forum for peer interaction, sharing experiences, and asking questions.

The program was designed to be easily incorporated into the daily routines of postpartum women and to accommodate familiar challenges that may limit opportunities for structured exercise, such as breastfeeding or fatigue. Although the program was intended to be completed within six weeks, participants retained full access to all materials for six months after purchase, allowing them to follow the weekly structure as recommended or repeat and progress through the content at their own pace. To this study, participants were instructed to follow the program according to its intended six-week schedule. The intervention included written instructional material supported by photographs and videos, and participants received automated daily email reminders highlighting the exercises scheduled for each day.

Figure 6. The weekly themes of the online exercise program (Papers II and III).

4.2.3 Sample and data collection

Participants were recruited using a self-selection sampling method ('Self-Selected Sample', 2008) through an advertisement placed on the online exercise program's website. Women who expressed interest were contacted and provided with a detailed information letter and a link to an electronic questionnaire, which included an informed consent form. Participants were eligible if they 1) were aged ≥18 years, 2) were within two years of their most recent childbirth, 3) had completed a routine postnatal examination (typically 5–12 weeks postpartum), 4) were fluent in Finnish, and 5) were able to pay for access to the online exercise program.

The required sample size was based on the WHOQOL-BREF instrument. Power analysis indicated that 127 participants were needed to detect differences between pre-test, posttest and 6-month follow-up at a 5% significance level (two-sided) with 80% power. Allowing for 30% dropout from pre-test to posttest and 40% dropout by 6-month follow-up, the target sample was increased to 303 at baseline.

Data were collected using REDCap e-questionnaires between September 2021 and September 2023. The baseline questionnaire (pre-test) gathered sociodemographic information and responses to four validated instruments (described in the next section). Participants completed the baseline questionnaire before beginning the intervention, posttest right after the six-week intervention, and the follow-up questionnaire at six months after baseline. The flow diagram of participants is presented in Figure 7.

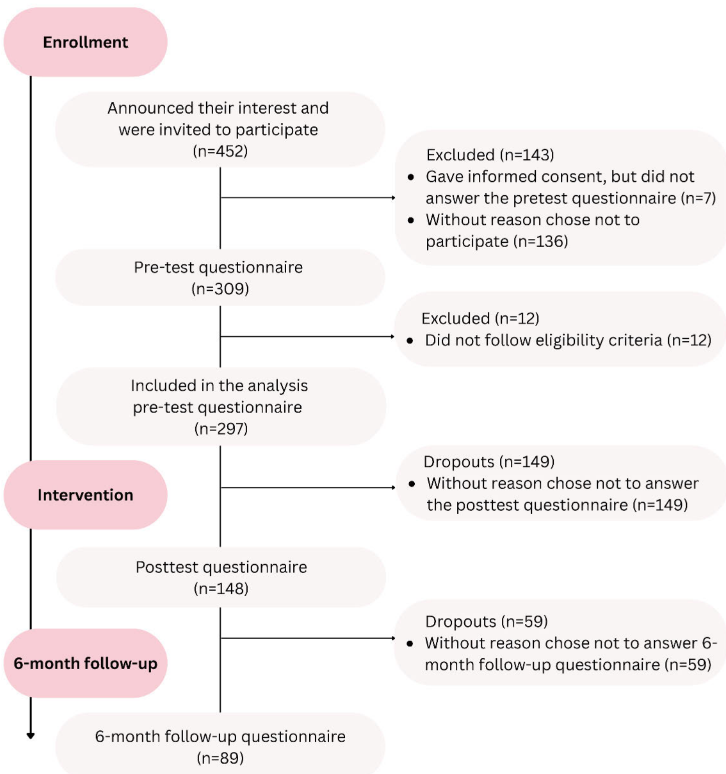

Figure 7. Flow diagram of the participants of sub-study II (Papers II and III).

Measurements

A background questionnaire was developed based on previous literature identifying factors relevant to urinary incontinence, physical activity and quality-of-life outcomes. It included sociodemographic characteristics (age, number of adults and children in the family, education, employment situation, weight, height, and chronic health conditions), childbirth-related factors (date of the most recent childbirth, mode of birth, birth complications), dysfunctions and symptoms related to the pelvic floor and core, and reasons for participating in the online exercise program. In addition, study-specific questions on physical activity and exercise were included. The posttest questionnaire asked about the frequency of exercise during the intervention and any additional physical activity performed. At the 6-month follow-up, participants were asked whether they had continued the intervention exercises and whether they engaged in other physical activity. Because objective usage data from the commercial online platform were not available, adherence to the intervention was assessed using participants' self-reported training frequency collected in the posttest questionnaire.

The Urogenital Distress Inventory, short form (UDI-6) instrument was used to assess urinary incontinence symptoms and their severity. The instrument consists of six items addressing urinary frequency, urgency-related leakage, activity-related leakage, small amounts of leakage, difficulty emptying the bladder and discomfort or pain in the lower abdomen/genital area. Items are rated on a 4-point Likert scale (0 = not at all, 1 = slightly, 2 = moderately, and 3 = greatly), and a higher score indicates more severe symptoms. (Uebersax et al., 1995.) The UDI-6 correlates strongly with the original long version of the instrument and has demonstrated good internal consistency and test–retest reliability across multiple populations (Cam et al., 2007; S. S. C. Chan et al., 2010; Mikuš et al., 2020; Shumaker et al., 1994; Uebersax et al., 1995; Utomo et al., 2015).

The Incontinence Impact Questionnaire, short form (IIQ-7) was used to assess the impact of urinary incontinence symptoms on an individual´s life and the anxiety or harm caused by the symptoms. It includes seven items assessing effects on household chores, physical recreation such as walking, swimming, or other exercise, participation in entertainment activities such as going to movies, ability to travel by car or bus more than 30 minutes from home, participation in social activities, emotional health and frustration. Items are rated on a 4-point Likert scale (0 = not at all, 1 = slightly, 2 = moderately, and 3 = greatly), and higher scores represent greater negative impact. (Shumaker et al., 1994; Uebersax et al., 1995.) The IIQ-7 has strong correlation with the original long form and consistently demonstrates good internal consistency and test-retest reliability (Cam et al., 2007; S. S. C. Chan et al., 2010; Shumaker et al., 1994; Uebersax et al., 1995; Utomo et al., 2015).

Physical activity was assessed with **the International Physical Activity Questionnaire Short Form (IPAQ-SF) instrument**. The IPAQ-SF is a 7-item assessment instrument which purpose is to assess the types of the intensity of physical activity and sitting time that people perform as a part of their daily lives (Craig et al., 2003; Lee et al., 2011). Participants were asked to address the number of days and the time in hours and minutes that they spent on physical activity in walking, moderate, and vigorous intensity during the last 7 days. The scores are expressed in physical activity metabolic equivalent of task (MET) minutes per week. Time spent sitting is calculated as time per day and week (Craig et al., 2003). Similar to other self-assessment instruments, the correlation between the IPAQ-SF and device-based measures of activity is relatively weak (Lee et al., 2011). However, the measurement properties have been considered acceptable (Craig et al., 2003).

The primary outcome, quality of life, was assessed with **The World Health Organization Quality of Life (WHOQOL–BREF)** instrument. The WHOQOL-BREF is a 26-item assessment instrument which purpose is to assess individuals' perceptions of their position in life concerning their goals, expectations, standards, and concerns. The first two items of the WHOQOL-BREF assess the overall quality of life and general health. The rest of the items of the WHOQOL-BREF are divided into four different domains: physical health (7 items), psychological health (6 items), social relationships (3 items), and environment (8 items) (Figure 4). Each item is rated on a 5-point Likert scale (a low score of 1 to a high score of 5). The total score of each domain is calculated based on the answers and higher total score indicates higher quality of life. (WHO, 2012b.) The WHOQOL-BREF is a reliable and valid instrument for the assessment the quality of life (Webster et al., 2010; WHO, 2012b), well accepted among postpartum women, and it is encouraged to be used for assessing intervention effects (Webster et al., 2010).

The complete questionnaire, which included the background questionnaire and validated instruments (UDI-6, IIQ-7, IPAQ-SF, and WHOQOL-BREF) was pre-tested among a sample of women (n=10) to evaluate clarity, relevance and usability. Minor revisions were made to improve wording, response options, and layout based on feedback. The validated instruments were used in their published forms without modification.

4.2.4 Data analysis

Paper II: UDI-6 and IIQ-7 data

All data underwent a series of preprocessing steps prior to statistical analysis. Participant BMI values were calculated from baseline height and weight, and time since the most recent childbirth was calculated based on the date of childbirth and the date of the baseline questionnaire. UDI-6 and IIQ-7 scores were calculated according to scoring guidelines and converted to a 0 to 100 scale, with higher values indicating more severe symptoms or greater impact on daily life. (Shumaker et al., 1994; Uebersax et al., 1995.) Participants were categorised into two groups at baseline: those without urinary incontinence symptoms (UDI-6 score = 0 and IIQ-7 score = 0) and those reporting symptoms (UDI-6 score > 0 and/or IIQ-7 score > 0).

Following data preparation, statistical analyses were performed. Normality of continuous variables was evaluated using histograms, Q–Q plots and the Shapiro–Wilk test, and subsequent analyses were selected according to distributional assumptions. Demographic data and baseline outcome measures were summarised using means and standard deviations (SD) or frequencies (n) and percentages (%), depending on variable type and distribution. Baseline characteristics were summarized for the full sample and separately for participants without urinary incontinence symptoms and with symptoms, with group differences assessed using Chi-square or Fisher’s exact test as appropriate.

Two dropout analyses were conducted to assess selective attrition. First, participants who completed both pre-test and posttest assessments were compared with participants who completed only the pre-test. Second, participants who completed all three measurement points were compared with those who completed only the pre-test and posttest. Differences in demographic characteristics were examined using t-tests or Mann–Whitney U tests for continuous variables depending on distribution, and Chi-square tests for categorical variables. Group differences in UDI-6 and IIQ-7 scores were analysed using the Mann–Whitney U test.

Changes over time in urinary incontinence symptoms were examined using linear mixed models for repeated measures. Because the mixed model confidence intervals were wide due to the unbalanced data structure, descriptive raw means with 95% confidence intervals were reported, while inferential statistics (overall time effects and pairwise comparisons) were based on the mixed model estimates. Associations between baseline characteristics and baseline urinary incontinence scores were examined using Mann–Whitney U and Kruskal–Wallis tests depending on variable type.

For the subgroup of participants reporting urinary incontinence symptoms at baseline, non-parametric tests, the Friedman test with Wilcoxon signed-rank tests for pairwise comparisons, were used to analyse changes over time in UDI-6 and IIQ-7 scores. Factors associated with change in symptoms were explored using t-tests, ANOVA, Mann–Whitney U or Kruskal–Wallis tests, depending on distributional assumptions.

All statistical analyses were conducted using IBM SPSS Statistics®, versions 29.9 and 31.0. Statistical significance was set at $p \leq 0.05$.

Paper III: IPAQ-SF and WHOQOL-BREF data

All data was processed prior to statistical analysis. Participant BMI values were calculated from baseline height and weight, and time since the most recent childbirth was calculated based on the date of childbirth and the date of the baseline questionnaire. Physical activity data from the IPAQ-SF were prepared following the official scoring protocol: durations reported in hours and minutes were converted into minutes, truncation rules were applied, and walking, moderate and vigorous activity minutes were converted into MET-minutes per week (Craig et al., 2003). Total physical activity was obtained by summing the three activity domains. WHOQOL-BREF responses were processed according to instrument guidelines. Forms with more than 20% missing items within a domain were excluded; when a single item was missing, it was replaced with the mean of the other items in that domain. Raw domain scores were calculated and transformed to a 0–100 scale, where higher values reflect better quality of life. (WHO, 2012b.)

Following data preparation, statistical analyses were performed. Normality of continuous variables was evaluated using histograms, Q–Q plots and the Shapiro–Wilk test, and subsequent analyses were selected according to distributional assumptions. Demographic data and baseline outcome measures were summarised using means and standard deviations (SD) or medians and interquartile ranges (IQR) for continuous variables, and frequencies (n) and percentages (%) for categorical variables.

Two dropout analyses were conducted. First, participants who completed both pre-test and posttest questionnaires were compared with those who completed only the pre-test questionnaire. Second, participants who completed all three measurement points were compared with those who completed only the pre-test and posttest assessments. Group differences were examined using independent samples t-tests or Mann–Whitney U tests for continuous variables, and Chi-square tests for categorical variables. Differences in physical activity variables were analysed with the Mann–Whitney U test, and WHOQOL-BREF domains were compared using independent samples t-tests.

Physical activity (MET-minutes/week) and sitting time were summarised as medians, in accordance with IPAQ-SF recommendations (Craig et al., 2003). Changes between time points were evaluated using the Wilcoxon signed-rank test. WHOQOL-BREF items for overall quality of life and overall health were presented as mean scores (1–5 scale). Domain scores were reported on the 0–100 scale. (WHO, 2012b.) Changes in WHOQOL-BREF scores were analysed using either paired samples t-tests or Wilcoxon signed-rank tests depending on distributional assumptions.

Correlations between demographic characteristics and changes in physical activity and quality-of-life outcomes were examined using Pearson or Spearman correlation coefficients depending on distributional assumptions. Group comparisons for categorical demographic variables were conducted with independent samples t-tests, Mann–Whitney U tests, one-way ANOVA or Kruskal–Wallis tests as appropriate. Regression analysis was not performed because demographic variables were not significantly associated with the main outcomes.

All analyses were conducted using IBM SPSS Statistics®, version 28. Statistical significance was set at $p \leq 0.05$.

4.3 Sub-study III: Quasi-experimental study

4.3.1 Study design

Sub-study III was a quasi-experimental, non-randomized trial (Paper IV) that drew upon data collected within a separate doctoral research project (Saarikko, 2025) conducted as part of the Academy project of the Department of Nursing Science at the University of Turku "Supporting Lifestyle Change in Obese Pregnant Mothers through the Wearable Internet-of-Things (SLIM)". The SLIM project was responsible for developing the intervention and gathering the original study data. For the purposes of this study, a subset of data was analysed to assess the effectiveness of the SLIM intervention on quality of life and to describe the physical activity of the participants based on the data collected via Oura smart ring during pregnancy and postpartum. The study was conducted in three public maternity clinics located in five municipalities in the well-being services county of Southwest Finland between April 2021 and May 2023. The trial was prospectively registered in the Clinicaltrials.gov register platform (ID NCT04826861) on 17 March 2021. (Saarikko et al., 2023, 2025.)

4.3.2 Intervention

The SLIM intervention, developed within the broader SLIM research project, is a research-based health support program designed to enhance self-efficacy in weight management among pregnant women with overweight or obesity. Developed in response to the growing public health challenge posed by maternal overweight and obesity (Saarikko et al., 2023), the intervention integrated multiple components of digital health technology with personalized behavioral support.

The program combined four key elements: 1) health technology (Oura smart ring, electronic food diary, and SLIM application), 2) feedback, 3) motivational interviewing, and 4) goal setting (Figure 8). Central to the intervention was the continuous use of the Oura ring (Oura Health Oy, n.d.), which collected real-time data on heart rate, sleep quality, and activity levels. Participants were instructed to wear the ring daily from the time of recruitment (≤20 gestational weeks) through the postpartum follow-up visit 12 weeks after childbirth. To support nutritional awareness, participants used the FatSecret electronic food diary to record their dietary intake (*Reach Your Weight Loss Goals with Fatsecret*, n.d.). Food logging was required for one week at three time points: at recruitment, at 34 gestational weeks, and eight weeks postpartum. Data from both the Oura ring and the dietary records were reviewed by public health nurses during routine maternity clinic visits. Public health nurses were instructed to use these objective data sources to provide individualized feedback on physical activity, sleep patterns, and nutrition. Feedback sessions were conducted using motivational interviewing principles (Elwyn et al., 2014), helping participants explore potential challenges, strengthen their intrinsic motivation, and collaboratively establish personalized health goals. These goals were documented in patient records and revisited at subsequent visits to support continuity and adherence.

Participants completed questionnaires through the SLIM mobile application at three assessment points; recruitment, late pregnancy, and early postpartum to facilitate ongoing monitoring and engagement. The multi-component structure of the SLIM intervention was designed to offer tailored, data-driven support throughout pregnancy and the early postpartum period, enabling participants to integrate lifestyle adjustments into daily routines while receiving individualized guidance and reinforcement (Saarikko et al., 2023, 2025).

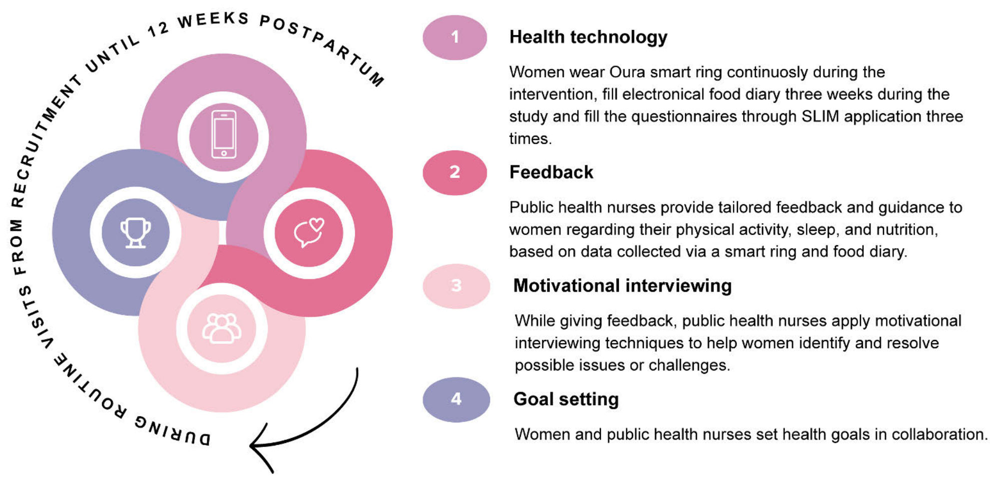

Figure 8. The SLIM intervention (adapted from (Saarikko et al., 2025).

Previous analyses based on the same dataset have examined the primary outcomes of the original intervention study. Self-efficacy in both eating and physical activity remained consistently high throughout pregnancy and postpartum, with no statistically significant changes over time ($p=0.650$ and $p=0.936$, respectively). However, most women whose gestational weight gain stayed within recommended limits, experienced postpartum weight loss ($p<0.001$). The findings suggest that although the intervention did not improve self-efficacy, adherence to recommended gestational weight gain was associated with more favourable postpartum weight development. (Saarikko et al., 2025.)

4.3.3 Sample and data collection

Participants were recruited using convenience sampling. During the first antenatal visit, public health nurses informed eligible women about the study and requested permission for researchers to contact them. Researchers subsequently called interested women to explain the study procedures. Those willing to participate attended a face-to-face meeting, during which written informed consent was obtained, and participants received an Oura smart ring and instructions for its use and the accompanying applications. Participants were eligible if they 1) were ≥18 years, 2) were ≤20 gestational weeks pregnant, 3) had pre-pregnancy overweight or obesity (BMI ≥25 kg/m^2), and 4) were fluent in Finnish. Exclusion criteria were: 1) no mobile device to install and synchronise study applications, 2) diagnosed severe mental illness, 3) pre-existing type 1 diabetes, or 4) mobility limitations. (Saarikko et al., 2023, 2025.)

The required sample size was based on the Weight Efficacy Life-Style Questionnaire (WEL) (Ames et al., 2015; Clark et al., 1991) and the Self-Efficacy for Physical Activity Scale (PASE) (Marcus et al., 1992; Mendoza-Vasconez et al., 2018). Power analysis indicated that 54 participants were needed to detect changes in eating or physical activity self-efficacy (one-sided t-test, effect size 0.50, $\alpha=0.05$, power=0.80). A 20% loss to follow-up was included in the estimate. (Saarikko et al., 2023, 2025.)

Data were collected through questionnaires via the SLIM application at three time points: recruitment (≤20 gestational weeks), 34 gestational weeks, and 12 weeks postpartum. Device-based activity and physiological data were collected continuously via the Oura smart ring. Data collection took place from April 2021 to May 2023. (Saarikko et al., 2023, 2025.) The flow diagram of participants is presented in Figure 9.

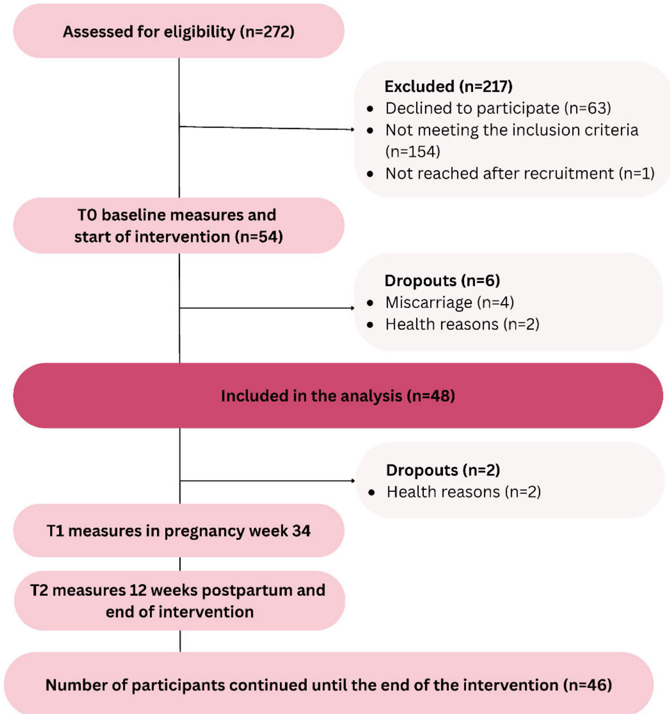

Figure 9. Flow diagram of the participants of sub-study III (Paper IV).

Measurements

Physical activity was assessed with the Oura ring and quality of life was assessed with The World Health Organization Quality of Life (WHOQOL–BREF) instrument (WHO, 2012b, 2012a).

At recruitment, participants completed a **background questionnaire** assessing sociodemographic characteristics (age, weight, height, marital status, education and employment). Additional information was obtained from patient records data collected during maternal care visits and delivery, including pregnancy complications and birth outcomes. Participants also reported the type, frequency and intensity of their habitual physical activity before pregnancy. Based on examples provided in the questionnaire, responses were categorised into light, moderate or vigorous intensity activities. Pre-pregnancy physical activity was assessed to provide a baseline reference of participants' habitual activity levels, enabling comparison with activity patterns during pregnancy and postpartum. Symptoms of depression were assessed with the Edinburgh Postnatal Depression Scale (EPDS), a 10-item instrument widely used during pregnancy and postpartum. Items are scored from 0 to 3, producing a total score of 0–30, with higher values indicating more depressive symptoms. (Cox et al., 1987.) A threshold score of ≥10 was used to identify possible depressive symptoms in this study (Saarikko et al., 2025).

Adherence to the intervention was assessed through Oura Ring wear time, as recorded in the device's non-wear data. Continuous wear was encouraged throughout the study, and non-wear time was used as an indicator of participant adherence.

Physical activity was assessed using **the Oura Ring**, a commercial wearable device equipped with an accelerometer and photoplethysmography sensors. The device captures step count, activity duration, energy expenditure, activity type, sleep parameters, body temperature, and heart rate–based signals. Data are automatically synchronised via Bluetooth to the Oura mobile application and then transferred to a cloud server. (Oura, n.d.) Weekly averages were computed for each participant at three predefined time points: T0 (baseline): gestational weeks 10–12, T1 (late pregnancy): gestational weeks 33–35, and T2 (postpartum): postpartum weeks 10–12. Non-wear time was used as an indicator of participant engagement with the intervention. Earlier validation studies show that the Oura Ring provides reliable estimates of sleep, physical activity, heart rate, and heart rate variability, making it suitable for longitudinal monitoring in free-living conditions (Asgari Mehrabadi et al., 2020; Cao et al., 2022; Niela-Vilen et al., 2022).

Physical activity intensity was described using metabolic equivalent of task (MET) values. The intensity of physical activity was divided into three commonly used categories: light, moderate, and vigorous intensity. Light-intensity physical activity is defined as activity between 1.5 and 2.9 METs, e.g. slow walking or light household tasks, moderate-intensity physical activity refers to activity performed at 3.0 to less than 6.0 METs, e.g. brisk walking or dancing, and vigorous-intensity physical activity is performed at 6.0 METs or more, e.g. hiking or running. (Jetté et al., 1990; WHO, 2020.) In addition, the inactivity time was reported.

Quality of life was assessed using **the WHOQOL-BREF**, a 26-item instrument that includes two general items (overall quality of life and general health) and four domains: physical health, psychological health, social relationships, and environment. Items are rated on a 1–5 Likert scale. Domain scores were converted to a 0–100 scale, with higher scores indicating better quality of life. (WHO, 2012b.) As the same instrument is used across sub-studies, a detailed description of the WHOQOL-BREF can be found in Chapter 4.2.3.

4.3.4 Data analysis

All data underwent a series of preprocessing steps prior to statistical analysis. Participant BMI values were calculated from baseline height and weight. Smart ring data were aggregated according to the predefined assessment periods. For each participant, daily mean MET-based activity variables were averaged within three time points: baseline (gestational weeks 10–12), late pregnancy (weeks 33–35), and postpartum (weeks 10–12) (Saarikko et al., 2025). Mean non-wear time across the three time points was estimated using linear mixed effects modelling. WHOQOL-BREF data were processed according to instrument guidelines. Forms missing more than 20% of items within a domain were excluded, and single missing items were replaced with the mean of the remaining items in that domain. Raw domain scores were calculated and transformed to a 0–100 scale, where higher scores represent better quality of life. (WHO, 2012b.)

Following data preparation, statistical analyses were performed. Normality of continuous variables was evaluated using histograms, Q–Q plots and the Shapiro–Wilk test, and subsequent analyses were selected according to distributional assumptions. Demographic data and baseline outcome measures were summarised using appropriate descriptive statistics based on distributional characteristics and variable type, including means and standard deviations (SD), medians and interquartile ranges (IQR), and frequencies (n) with percentages (%).

Because quality-of-life domains were measured repeatedly, linear mixed effects models for repeated measures were used to examine change over time and explore associations with selected background factors (age, EPDS score, number of previous children, education, and BMI), as well as smart ring non-wear time. Each model included one within subject factor (data collection time point), one between-subject factor (category) and their interaction (time point × category). An unstructured covariance matrix was used, and degrees of freedom were adjusted using the Kenward–Roger correction. A univariate screening phase was used to identify statistically significant factors. Significant factors were included in initial multivariable models, and non-significant factors were removed stepwise. Final models retained only statistically significant factors and the measurement time point. For physical activity data, weekly mean MET-based activity variables with 95% confidence intervals were plotted descriptively across the three time points to illustrate trends.

Wearable-derived physical activity data were averaged only for time points with adequate wear time. WHOQOL-BREF domain scores were processed based on established rules for missingness as noted above. No imputation was performed for other variables.

Statistical analyses were conducted in SAS (Version 9.4 for Windows) and IBM SPSS Statistics® version 28. Figures were generated using R (version 4.2.1) with the ggplot2 package. Statistical significance was defined as $p \leq 0.05$ for all two-sided tests. (Paper IV)

4.4 Ethical considerations

Research integrity

This study was conducted in accordance with the guidelines of The Finnish code of conduct for research integrity and procedures for handling alleged violations of research integrity in Finland (TENK, 2023). The study applied data collection, research, and evaluation methods that adhered to scientific standards and ethical principles of reliability, honesty, respect, and accountability (TENK, 2023).

Sub-study I adhered to ethical standards for secondary research. As the study synthesised findings from previously published literature, no new data were collected directly from human participants. Nevertheless, ethical integrity was maintained throughout the review process. The review process was transparent, with clear documentation of search strategies, inclusion criteria, quality assessment, and data extraction methods. The JBI Manual for Evidence Synthesis (Aromataris et al., 2024) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed (Page et al., 2021). The review protocol was registered in PROSPERO (CRD42020191591).

Sub-studies II and III underwent ethical reviews and relevant research permissions were obtained. Ethical approval for sub-study II was obtained from the Ethics Committee for Human Sciences at the University of Turku in June 2021 (18/2021) and the trial registration was done retrospectively to Clinicaltrials.gov (NCT06268782) in February 2024. The collaboration with the company in sub-study II did not affect the implementation of the study. The members of the research group had no personal ties to the company or its business activities. Ethical approval for sub-study III was obtained from the Joint Ethics Committee of the Hospital District of Southwest Finland in 2020 (113/1801/2020). Permissions to conduct sub-study III at the maternity clinics were obtained from each of the participating maternity clinics and the trial was registered at the Clinicaltrials.gov register platform (registration number NCT04826861) in March 2021.

In sub-study II, participants were recruited using a self-selection sampling method through an advertisement placed on the online exercise program’s website. Participants covered the cost of participating in the exercise program themselves; however, participation in the study did not incur any additional expenses. The regular price of the program was 89.00 €, but participants received a 20% discount after completing the first questionnaire as compensation for their involvement in the study. Participants were not informed about the discount at the time of enrolment. In sub-study III, the recruitment was done at the maternity clinics by the public health nurses using convenience sampling method.

Participants were informed about the aims, conduction and confidentiality procedures of the studies. Participants were provided with a possibility to discuss with researchers, and they were given time to consider participation, before providing a written informed consent for their participation. According to the Medical Research Act (Medical Research Act 488/1999, 1999), participants could withdraw or cancel their participation in studies at any time without the need to justify their decision. Data collections were planned carefully, and the ownership of the research data, rights to its use, processing, storage, and possible reuse were agreed with the partners and research groups in advance.

Participant data were collected through multiple methods by utilising online questionnaires (sub-studies II and III), smart ring (sub-study III), and patient records (sub-study III). Studies involved sensitive personal and health-related data, and various data management challenges were identified and addressed through careful planning. All collected data underwent pseudonymisation to ensure the confidentiality of personal information. To maintain confidentiality and data security, electronic data were stored in password-protected locations.

For reporting of sub-studies, the relevant guidelines were used according to the Enhancing the QUAlity and Transparency Of health Research (EQUATOR Network, n.d.). The principles of open science were followed whenever possible. The Vancouver recommendations of the authorship by the International Committee of Medical Journal Editors (International Committee of Medical Journal Editors ICMJE, 2025) were followed when defining the authorship of the publications.

Artificial intelligence has been used to support the structuring of the dissertation, refining the language, and enhancing clarity. Microsoft Copilot was utilised for developing the structure and improving grammar and expression, while DeepL was used for checking language and grammar. The use of artificial intelligence tools has followed the University of Turku’s guidelines Artificial Intelligence in Research (2023) and Artificial Intelligence in Teaching and Learning (2023), ensuring ethical and transparent application.

Vulnerability of the study participants

Pregnant and postpartum breastfeeding women (Medical Research Act 488/1999, 1999) are often considered a vulnerable population in research contexts. In this study, participants were also regarded as part of a vulnerable group. However, this designation does not imply compromised decision-making capacity, as may be the case with children or individuals with limited cognitive ability (Van Der Zande et al., 2017). Instead, the term "vulnerable" is used to emphasize the sensitive and transformative nature of the perinatal period in women's lives. During this time, women may experience heightened physical, emotional, and psychological sensitivity for example due to hormonal changes, medical conditions, and social pressures. Ethical considerations were carefully addressed to ensure that participants' rights, dignity, and safety were protected throughout the research process.

In sub-study II, the topics examined, might be considered as intimate and potentially stigmatising (Cox et al., 2023), which made ensuring confidentiality and using respectful language essential. In sub-study III, the study population consisted of overweight or obese pregnant women. Pregnancy is known to be an emotionally sensitive period, and obesity is often associated with negative attitudes and prejudices (Phelan et al., 2015). Stigma can negatively affect the experience of pregnancy and increase the risk of postpartum depression. Participation in a weight management study may also evoke past negative experiences and trigger a range of emotions, including anxiety (Nagpal et al., 2020).

The inclusion of pregnant and postpartum women in this study was ethically and scientifically justified due to the unique physiological and health-related characteristics inherent to the perinatal period. These distinct conditions cannot be adequately studied in other populations, making it essential to focus specifically on this group to obtain relevant and applicable results. Enhancing physical activity and quality of life among pregnant and postpartum women is critical not only for individual well-being but also for broader public health.

5 Results

In this chapter, the results of the study are presented in four parts. The first three parts summarize the main findings from the sub-studies (Papers I-IV). The fourth part synthesizes findings from all three sub-studies (Papers I-IV), organized according to the structure of the ICF framework, to provide a comprehensive understanding of how these interventions may affect maternal health during the perinatal period.

5.1 Effectiveness of exercise interventions (Sub-study I)

A review of previous reviews aimed to summarize the existing evidence about the effectiveness of exercise interventions for urinary incontinence and pelvic organ prolapse in pregnant and postpartum women (Paper I). The nine included reviews (Davenport, Nagpal, et al., 2018; Harvey, 2003; Lemos et al., 2008; Mørkved & Bø, 2014; Von Aarburg et al., 2021; Wagg & Bunn, 2007; Woodley et al., 2020; Wu et al., 2018; Yang, Zhang, et al., 2022) published between 2003 and 2022 consisted of 89 original studies. Their aims varied: two reviews focused exclusively on pregnant women, two on postpartum women, and five included both populations. The primary outcomes examined were urinary incontinence (n=8) and pelvic organ prolapse (n=1).

Across the reviews, considerable heterogeneity was evident in study designs, sample sizes, and the nature of the exercise interventions. Intervention components ranged from PFMT alone to programs combining PFMT with aerobic exercise. Two reviews included broader physical activity approaches incorporating strength training, stretching, and aerobic modalities. Delivery modes also differed: interventions were provided individually or in groups, and facilitated by professionals such as physiotherapists, midwives, nurses, or other trained personnel. Settings varied from hospital-based sessions to exercise classes and home-based programs.

The frequency and duration of exercise prescriptions showed marked variation, ranging from several sessions per day to once per week, with intervention periods lasting from four weeks to 17 months. The timing of intervention initiation also differed widely, beginning as early as gestational week nine and extending up to 12 months postpartum. Additional details of the reviews included are presented in Appendix 5.

In the review of reviews (Paper I), the highest level of evidence was found within preventing postpartum urinary incontinence symptoms with exercise and PFMT during pregnancy (Davenport, Nagpal, et al., 2018; Harvey, 2003; Lemos et al., 2008; Mørkved & Bø, 2014; Woodley et al., 2020), whereas the evidence on exercise during pregnancy reducing the severity of postpartum urinary incontinence symptoms was assessed as moderate (Davenport, Nagpal, et al., 2018). Moderate quality evidence was found that exercise and PFMT (Davenport, Nagpal, et al., 2018; Woodley et al., 2020), or PFMT alone (Woodley et al., 2020) during pregnancy, are likely to reduce the risk of urinary incontinence. The evidence on exercise and PFMT reducing the severity of urinary incontinence symptoms during pregnancy was low (Davenport, Nagpal, et al., 2018; Woodley et al., 2020), similarly to the evidence of the effectiveness of group PFMT during pregnancy on reducing prevalence of urinary incontinence symptoms (Yang, Zhang, et al., 2022), and the effectiveness of PFMT on treatment of urinary incontinence in pregnant women (Woodley et al., 2020). The evidence about the effectiveness of PFMT carried out during postpartum period reducing the risk of urinary incontinence (Woodley et al., 2020; Wu et al., 2018) was assessed as moderate, but the evidence on PFMT reducing the risk of pelvic organ prolapse (Wu et al., 2018), was assessed as low. Based on the summary of findings the recommendations were formulated by a clinical guideline working group following the NRF guideline handbook (Siltanen et al., 2023). The recommendations and the level of evidence are presented in Table 2.

Table 2. The recommendations for clinical practice (Paper I).

RECOMMENDATIONS	LEVEL OF EVIDENCE*
Encourage and guide pregnant women to exercise and train pelvic floor muscles because:	
• Exercise in general, and PFMT carried out according to instructions, is likely to reduce the risk of symptoms of UI during pregnancy	Moderate quality of evidence, B
• Exercise in general is likely to reduce severity of UI symptoms during pregnancy	Low quality of evidence, C
• Exercise in general, and PFMT carried out according to instructions, during pregnancy reduce risk of postpartum UI	High quality of evidence, A
• Exercise in general during pregnancy is likely to reduce severity of postpartum UI symptoms	Moderate quality of evidence, B
• In the prevention of UI, PFMT during pregnancy is likely to be beneficial for women without UI symptoms	Moderate quality of evidence, B
Encourage pregnant women to participate in group exercise for pregnant women, because:	
• Group PFMT during pregnancy is likely to reduce prevalence of UI	Low quality of evidence, C
Try to identify those women who have the symptoms of pelvic floor dysfunction and guide them to physiotherapist or other health care professional specialized in pelvic floor function because:	
• In treatment of UI, PFMT is unlikely to benefit pregnant women who already have UI symptoms	Low quality of evidence, C
• A validated survey, such as the PFDI-20, can provide a useful tool to assess pelvic floor symptoms	-
Encourage and guide postpartum women to exercise and train the pelvic floor because:	
• PFMT carried out according to instructions is likely to reduce risk of postpartum UI	Moderate quality of evidence, B
Guide postpartum women to contact physiotherapist or other health care professional specialized in pelvic floor function during the postpartum health check-up if women have symptoms of pelvic floor dysfunction, because:	
• PFMT performed under supervision postpartum may reduce risk of symptoms of POP	Low quality of evidence, C
• A validated survey, such as the PFDI-20, can provide a useful tool to assess pelvic floor symptoms	-

*According to GRADE: the grading of recommendations, assessment, development and evaluation approach; Abbreviations: PFMT: pelvic floor muscle training; PDI-20: the Pelvic Floor Distress Inventory; POP: pelvic organ prolapse: UI: urinary incontinence

5.2 Effectiveness of an online exercise program (Sub-study II)

A total of 309 women completed the pre-test questionnaire. Of these, 12 did not meet the eligibility criteria and were therefore excluded, resulting in a final sample of 297 participants for analysis. Following the intervention, 148 women completed the posttest questionnaire, and at the 6-month follow-up, 89 participants provided responses (Figure 7).

Dropout analyses showed that participants who remained in the study were largely comparable to those who dropped out, although some baseline differences emerged across outcomes. No differences were observed in demographic characteristics or baseline urinary incontinence scores between participants and dropouts (Paper II). However, participants who continued to the six-month follow-up were more likely to have higher educational attainment (Papers II and III). When quality-of-life outcomes were examined (Paper III), those who remained in the study had higher baseline quality-of-life scores than those who discontinued. Despite these differences, no meaningful discrepancies were observed in post-intervention outcomes, suggesting that attrition was unlikely to have substantially biased the main findings.

The mean (SD) age of the participants (n=297) was 33.1 (4.3) years and the mean (SD) BMI of the participants before the intervention was 26.4 (4.3). The mean (SD) time since the most recent childbirth was 4.5 (4.0) months. Most participants (77.8%, n=231) had given birth within the past six months. The majority (81.1%, n=241) had a vaginal birth, and 72.1% (n=214) reported no complications during childbirth. At baseline, most participants (58.6%, n=174) did not experience dysfunctions or symptoms related to the pelvic floor or core muscles. Among those who did, 24.2% (n=72) reported diastasis recti, 17.8% (n=53) urinary incontinence, 5.1% (n=15) pelvic organ prolapse, and 4.7% (n=14) pelvic pain. Most women had a bachelor's degree or higher (84.8%, n=252), were living with a partner (96.6%, n=287), and were at home with a child or children (70.7%, n=210) at the baseline of the study. Six months after the intervention, the majority (60.9%, n=53) were still at home with a child or children. (Papers II and III)

Because objective usage data from the online platform were not available, adherence to the intervention was assessed using participants' self-reported training frequency in the posttest questionnaire. This measure reflects how regularly participants engaged in the prescribed exercises during the intervention period. After the intervention, most participants (68.1%, n=98) reported exercising four times a week or more, while smaller groups exercised three times (17.4%, n=25), twice (6.9%, n=10), or once a week (7.6%, n=11). Most participants (71.5%, n=103) did not engage in additional exercise outside the online program. Six months after the intervention, 64.4% (n=56) continued exercising their pelvic floor and core muscles through activities such as yoga, Pilates, strength training, physiotherapy, or other online programs. Additionally, 34.5% (n=30) continued performing the specific exercises from the intervention. (Paper III)

5.2.1 Urinary incontinence

Urinary incontinence symptoms (UDI-6 scores) decreased statistically significantly over the course of the intervention (p<0.001), with improvements largely maintained at the 6-month follow-up. Mean UDI-6 scores decreased statistically significantly (p<0.001) from 18.8 (95% CI: 16.9, 20.7) at baseline to 13.2 (95% CI: 11.1, 15.4) at posttest, with no further change between posttest and the 6-month follow-up (13.2 to 14.1, 95% CI: 11.4, 16.9; p=1.00).

The perceived impact of urinary incontinence on daily activities (IIQ-7 scores) declined from baseline to the 6-month follow-up, although the change was not statistically significant over time (p=0.269). Mean IIQ-7 scores changed from 8.5 (95% CI: 6.9, 10.0) at baseline to 6.6 (95% CI: 4.7, 8.5) at posttest (p=0.474), and to 6.7 (95% CI: 3.9, 9.4) at the 6-month follow-up (p=1.00). The mean scores are presented in Figure 10.

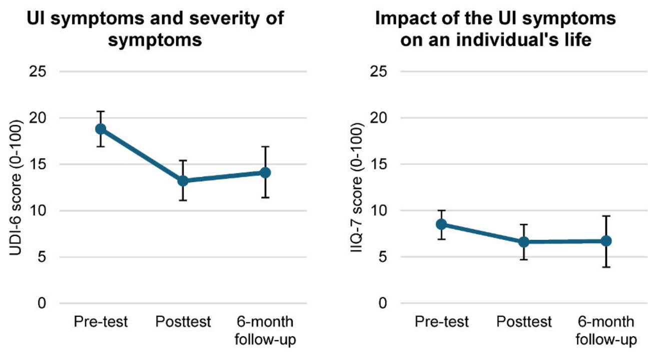

Figure 10. UDI-6 and IIQ-7 mean scores with 95% confidence intervals at three time points.

Several background factors were associated with UDI-6 and IIQ-7 scores at baseline. Women more than 6 months postpartum had higher UDI-6 and IIQ-7 scores than those ≤6 months postpartum (p<0.001 for both). Higher BMI (≥30) was linked with higher UDI-6 scores compared with BMI<25 (p=0.009). Mode of birth was associated with both UDI-6 and IIQ-7 scores (both p<0.001), with vaginal birth corresponding to higher scores than caesarean section. In addition, participants reporting pelvic floor or core dysfunctions had markedly higher UDI-6 and IIQ-7 scores than those without such symptoms (p<0.001 for both).

Among participants who reported urinary incontinence symptoms at baseline (UDI-6 or IIQ-7 scores > 0 at baseline), significant improvements were observed in both UDI-6 and IIQ-7 scores across the study period ($p<0.001$ for both). UDI-6 scores decreased from pre-test to posttest ($p<0.001$) and from pre-test to six-month follow-up ($p<0.001$), with no further change between posttest and follow-up ($p=0.875$), indicating maintained benefit. IIQ-7 scores followed a similar pattern, with significant reductions from pre-test to posttest ($p=0.016$) and to follow-up ($p<0.001$), and no additional change between posttest and follow-up ($p=0.483$).

Within subgroup analyses, age was the only baseline factor associated with symptom change. Participants under 30 years old experienced a greater reduction in UDI-6 scores from pre-test to posttest than those aged 30 or older (median change 11.1 vs. 5.6, $p=0.042$). No other background characteristics were associated with changes in UDI-6 or IIQ-7 scores during any interval.

5.2.2 Physical activity (self-assessed)

The self-assessed physical activity of the participants increased during the intervention and 6-month follow-up period. From baseline to post intervention, statistically significant increases were observed in moderate MET minutes/week (median 80.0 [0.0, 450.0] to 180.0 [0, 480.0], $p=0.013$) and total MET minutes/week (median 1386.0 [742.5, 2697.8] to 1660.5 [912.8, 3102.0], $p=0.014$), accompanied by a significant decrease in sitting time as minutes/week (median 2280.0 [1740.0, 3360.0] to 2040.0 [1560.0, 2550.0], $p<0.001$). At the 6-month follow-up, moderate (median 480.0 [240.0, 960.0], $p<0.001$), vigorous (median 960.0 [480.0, 1920.0], $p<0.001$), and total MET minutes/week (median 2826.0 [2269.0, 4872.0], $p=0.001$) continued to demonstrate statistically significant increases compared with baseline, while sitting time/week remained statistically significantly reduced (median 2100.0 [1395.0, 2692.5], $p<0.001$). (Paper III) The median MET minutes are presented in Figure 11.

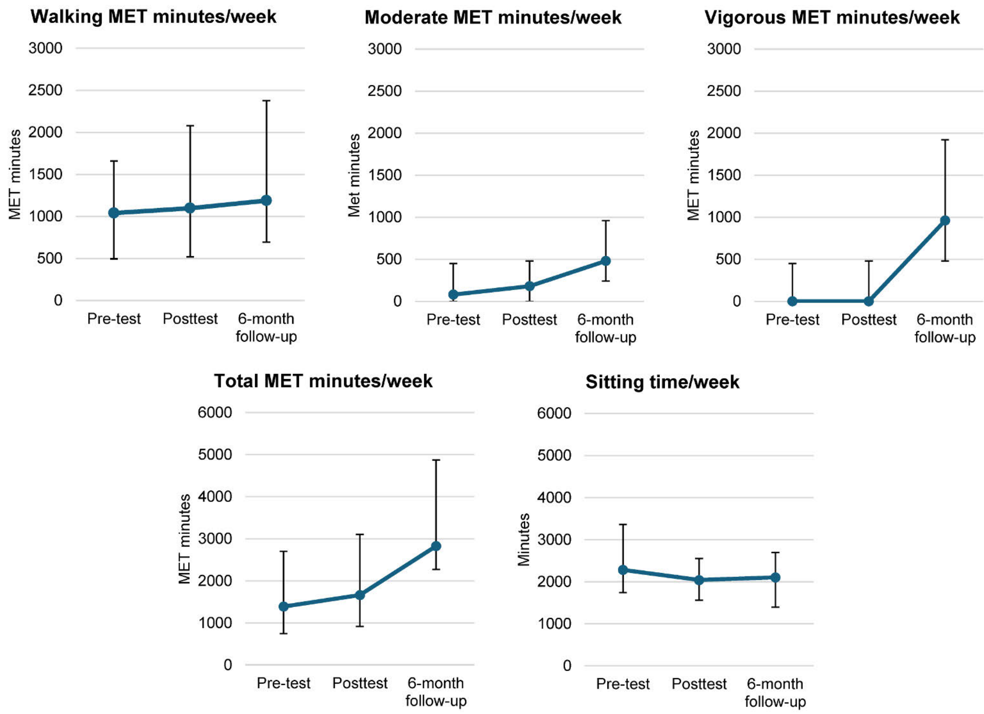

Figure 11. Physical activity and sedentary behaviour at three time points per week. Values are presented as medians with interquartile ranges (IQR).

No statistically significant correlations were found between participant characteristics and changes in the physical activity or sedentary behaviour from pre- to posttest. However, at the 6-month follow-up, a longer time since childbirth was associated with a larger decrease in median sitting time per week (r=0.24, p=0.033). (Paper III)

5.2.3 Quality of life

Within quality of life, a statistically significant improvement was observed only in the physical health domain, with mean scores increasing from 72.5 (95% CI: 70.6, 74.4) at baseline to 74.6 (95% CI: 72.4, 76.7) at posttest (p=0.025). However, no significant changes were found in the other quality-of-life domain scores when comparing baseline to the 6-month follow-up. (Paper III) The mean domain scores are presented in Figure 12.

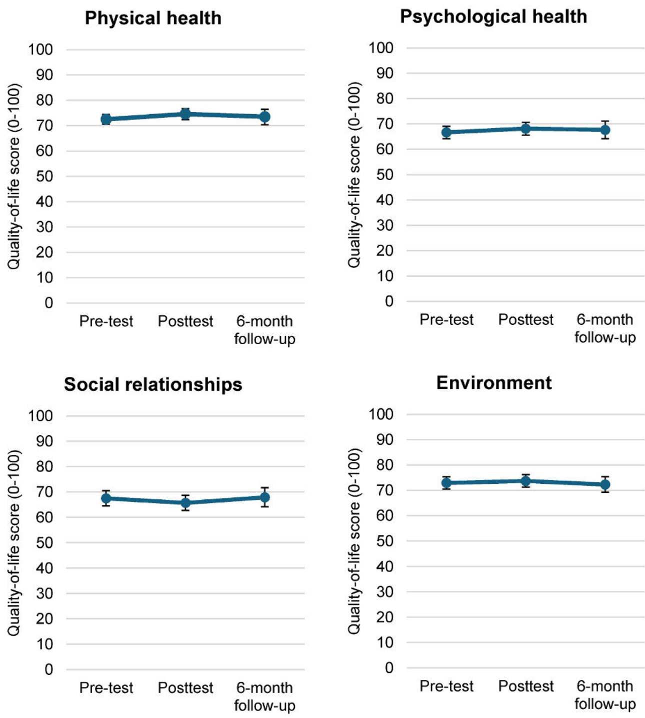

Figure 12. WHOQOL-BREF domain mean scores with 95% confidence intervals at three time points.

When comparing pre-test and posttest results, several characteristics of the participants were found to correlate with changes in quality-of-life domains. A greater number of children in the family correlated with an increase in the social relationships domain (r=0.18, p=0.036). Additionally, BMI was linked to changes in psychological health: participants with a BMI between 25.0 and 29.9 showed a greater improvement in psychological health scores compared to those with a BMI over 30 (mean difference 6.2 points, p=0.033). At the 6-month follow-up, a greater number of children continued to show positive correlations with both the physical health (r=0.27, p=0.012) and social relationships (r=0.26, p=0.014) domains. Furthermore, participants whose highest educational level was secondary school experienced significantly greater improvements in psychological health compared to those with a bachelor's degree or higher (mean difference 13.8 points, p=0.002). (Paper III)

A statistically significant correlation was found between reduced sitting time and improved physical health-related quality-of-life scores when comparing pre- and posttest results (r=−0.17, p=0.046). Participants who had less sedentary time showed greater improvement in physical health. Regular exercise was also associated with better psychological health: participants who exercised almost daily had greater improvements in psychological quality-of-life scores compared with those who exercised twice a week or less (mean 2.7, SD 8.6 vs. mean -4.2, SD 9.6, p=0.024). However, no significant associations were found between physical activity and quality of life when comparing pre-test results to the 6-month follow-up. (Paper III)

5.3 Effectiveness of the SLIM intervention (Sub-study III)

A total of 55 women initially enrolled in the study. One participant withdrew immediately after recruitment, four experienced an early miscarriage, and two discontinued participation due to health-related reasons. Thus, 48 women were included in the baseline analyses, and 46 completed the study through the final assessment (Figure 9).

The mean (SD) age of the participants was 29.6 (4.7) years and the median (IQR) BMI of the participants before the intervention was 30.4 (6.7). Most women had secondary education or below (58.3%, n=28), were living with a partner (97.9%, n=47), and were working (77.1%, n=37) at the baseline of the study. Median (IQR) EPDS score at baseline was 5.0 (7.0). Most participants (64.6%, n=31) had previous children. The majority (73.9%, n=34) had a vaginal birth. At baseline, most participants (81.3%, n=39) were able to use the smart ring at work. (Paper IV)

Indicators of adherence based on Oura ring use showed a gradual decline over the course of the intervention. Non-wear time increased progressively, suggesting reduced consistency in wearing the device. By 12 weeks postpartum, participants wore the ring on average 75 minutes less per day compared to baseline (95% CI 28, 147; p<0.001). The largest increase occurred between baseline and 34 gestational weeks, with an additional 20 minutes of non-wear time per day (95% CI 3, 54; p=0.003), followed by a further increase of 18 minutes per day between late pregnancy and postpartum (95% CI 1, 57; p=0.015). This pattern reflects a gradual decline in adherence to the device-based monitoring protocol toward the end of pregnancy and into the postpartum period.

5.3.1 Physical activity (device-based)

In the baseline questionnaire, participants were asked to report the type, frequency and intensity of their physical activity before becoming pregnant. Before pregnancy, light-intensity activities, such as household chores and other everyday movements, were the most frequently reported form of physical activity. Altogether 27.1% (n=13) indicated engaging in light activity daily, and an equal proportion (27.1%, n=13) reported doing so at least four times per week. Moderate-intensity activity, including brisk walking, jogging or other recreational exercise, was also common.

Half of the participants (50.0%, n=24) reported engaging in moderate-intensity activity three times per week or more, while 35.4% (n=17) reported participating once or twice weekly. Vigorous-intensity exercise, such as running or circuit training, was the least common form of activity. Over half of the participants (52.1%, n=25) reported that they did not engage in any vigorous activity before pregnancy, whereas 39.6% (n=19) reported doing vigorous exercise once or twice per week.

Based on data collected with Oura ring, across all intensity levels, physical activity decreased as pregnancy progressed. After childbirth, physical activity increased and reached the same or even higher level than at the baseline. (Paper IV; Figure 13.) Over the course of the intervention, changes in light-intensity ($p<0.001$) and moderate-intensity activity ($p<0.001$) were statistically significant, whereas changes in vigorous-intensity activity ($p=0.608$) and inactive time ($p=0.194$) were not.

For light-intensity activity, mean values decreased from 225.2 min/day (95% CI 205.7, 244.8) at baseline to 209.5 min/day (95% CI 190.0, 229.1) at 34 gestational weeks, although this change was not statistically significant ($p=0.054$). From 34 gestational weeks to 12 weeks postpartum, mean light-intensity activity increased significantly from 209.5 min/day (95% CI 190.0, 229.1) to 251.3 min/day (95% CI 226.5, 276.1) ($p<0.001$). Between baseline and 12 weeks postpartum, the overall increase was 26.1 minutes (95% CI 7.0, 45.2, $p = 0.009$).

For moderate-intensity activity, mean values declined significantly from 108.0 min/day (95% CI 88.7, 127.4) at baseline to 65.9 min/day (95% CI 53.7, 78.0) in 34 gestational weeks ($p<0.001$) and increased again to 118.9 min/day (95% CI 92.2, 145.7) 12 weeks postpartum ($p=0.001$). However, mean moderate-intensity activity did not differ significantly between baseline and 12 weeks postpartum ($p=0.391$). (Paper IV)

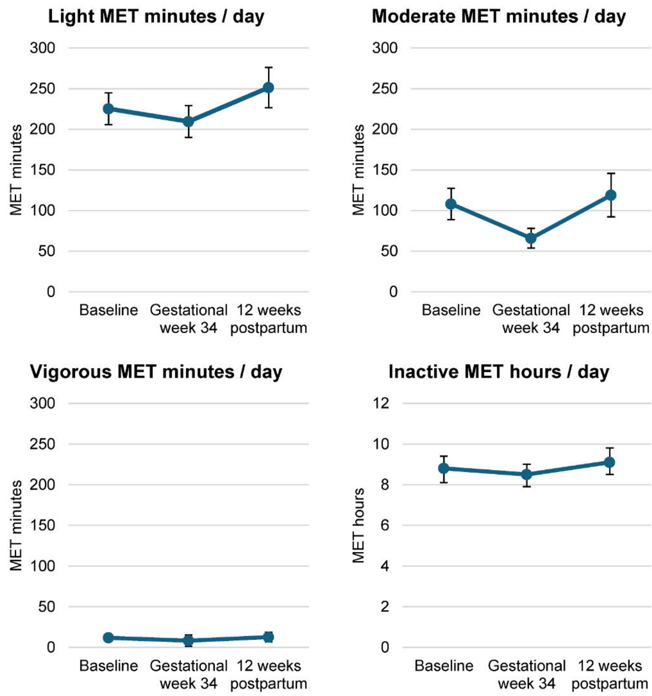

Figure 13. Mean MET minutes with 95% confidence intervals at three time points per day.

5.3.2 Quality of life

The WHOQOL-BREF results showed statistically significant changes over time in the domains of physical health (p=0.002), social relationships (p<0.001), and environment (p=0.037), whereas psychological health remained unchanged across the measurement points (p=0.427). For the physical health domain, mean scores declined from baseline (71.9, 95% CI 67.5, 76.3) to gestational week 34 (63.6, 95% 57.5, 69.7) (p=0.002) and subsequently increased from week 34 to 12 weeks postpartum (72.0, 95% CI 66.6, 77.5) (p=0.002). However, physical health scores at 12 weeks postpartum (72.0, 95% CI 66.6, 77.5) did not differ significantly from baseline (p=0.935). The social relationships domain demonstrated a consistent downward trend. Scores decreased significantly from baseline (79.1, 95% CI 73.6, 84.7) to week 34 (71.3, 95% CI 64.8, 77.9) (p<0.001) and from baseline to 12 weeks postpartum (68.1, 95% CI 60.8, 75.3) (p<0.001), whereas the change between week 34 and postpartum was not statistically significant (p=0.256). For the environment domain, mean scores decreased from baseline (74.7, 95% CI 70.0, 79.3) to 12 weeks postpartum (69.9, 95% CI 64.8, 75.0) (p=0.010). (Paper IV) Mean scores for each domain are presented in Figure 14.

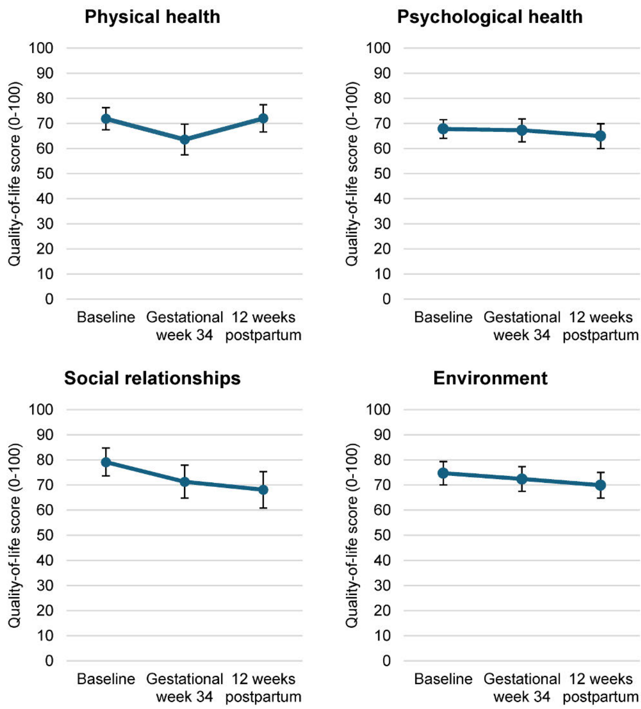

Figure 14. WHOQOL-BREF domain mean scores with 95% confidence intervals at three time points.

Depressive symptoms assessed with EPDS was the only factor explaining the variation in the physical health, psychological health and social relationships domains. Compared with women with depressive symptoms, women without depressive symptoms had, on average, 12.1 points higher scores in the physical health domain (95% CI 6.2, 17.9; p<0.001), 12.0 points higher scores in the psychological health domain (95% CI 7.4, 16.6; p<0.001), and 15.2 points higher scores in the social relationships domain (95% CI 8.5, 22.0; p<0.001). EPDS and education together best explained the variation in the environment domain. Compared with women with depressive symptoms, women without depressive symptoms had, on average, 7.1 points higher scores in the environment domain (95% CI 1.9, 12.2; p=0.002). Women with higher education (college or university) had, on average, 10.7 points higher scores in the environment domain than women with secondary education or below (95% CI 2.5, 18.9; p=0.012). (Paper IV)

5.4 Summary of the results

Figure 15 positions the main outcomes within the relevant ICF domains and illustrates how the interventions relate to body functions and structures, activities, and participation, offering a visual map for interpreting the findings. In the following paragraphs, each domain is addressed, highlighting how findings from sub-studies I-III align with and contribute to the broader structure of the ICF in the context of the perinatal period.

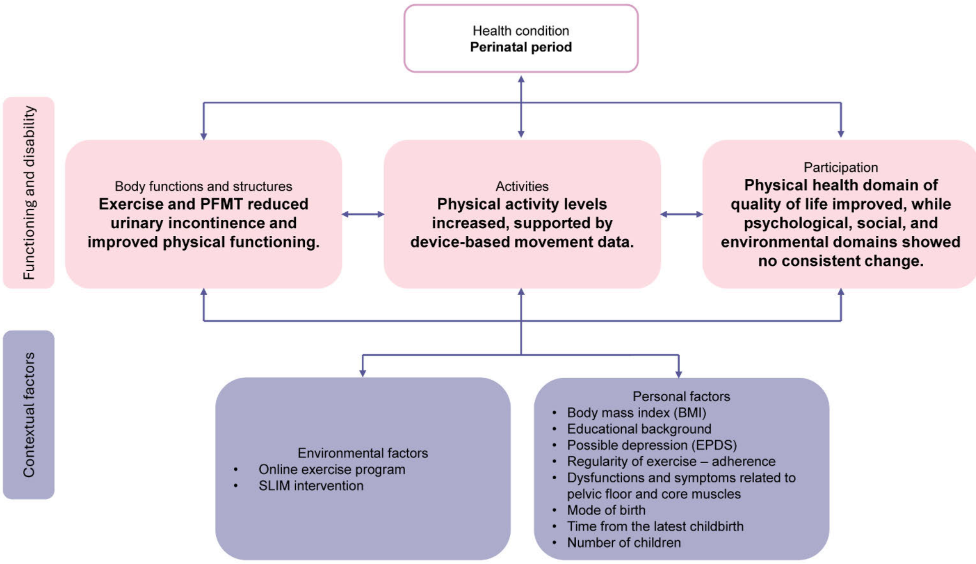

Figure 15. The main findings described according the ICF framework.

Within the ICF framework, the domain of **body functions and structures** captures the physiological and anatomical functions of body systems, including pelvic floor function, physical functioning, and perceived bodily well-being. In the ICF framework, these functions are understood in interaction with contextual and environmental factors, which shape how individuals meet the functional demands of daily life. Across the sub-studies, the interventions appeared to influence several aspects of body functions relevant to maternal health during the perinatal period.

Evidence from sub-study I demonstrated that PFMT is supported by the strongest existing evidence base. High-level evidence indicates that exercise and PFMT during pregnancy can prevent postpartum urinary incontinence symptoms, while moderate-quality evidence supports their effectiveness in reducing the risk of urinary incontinence during the perinatal period. More recent systematic reviews reinforced these findings, showing consistent benefits of PFMT, particularly when supervised or combined with modalities such as biofeedback or electrical stimulation, although heterogeneity in intervention protocols and outcome measures, reduces overall certainty. The results of sub-study II were in line with these findings, highlighting similar patterns in the postpartum period. Participants demonstrated improvements in both urinary symptom severity (UDI-6) and symptom related impact (IIQ-7) across the intervention period, with reductions largely maintained at 6-month follow-up. However, only the results related to symptom severity were statistically significant. Together, sub-studies I and II reinforce the role of targeted exercise, particularly PFMT, in improving pelvic floor–related body functions.

Additionally, across sub-studies II and III, improvements in general physical functioning, energy levels, and well-being were observed through higher WHOQOL-BREF physical health scores. These changes likely reflect enhanced physical capacity during the intervention periods and correspond to ICF domain of body functions related to movement and perceived physical capacity.

The interventions had effects on outcomes related to the ICF domain of **activities**. In both sub-studies II and III, participants maintained or increased their engagement in physical activity. In sub-study II, women reported stable or improved activity levels, and in sub-study III, device-based measures confirmed increases in daily movement from baseline measures to postpartum, particularly moderate-intensity physical activity. These findings indicate improved ability to perform physical activities and integrate movement into daily routines during the perinatal period.

Outcomes related to **participation** also showed changes, although in a more limited scope. Improvements in urinary continence and perceived physical functioning were accompanied by indications of enhanced participation in everyday life. Reduced symptom burden and better physical capacity likely enabled greater ease in fulfilling routine tasks and meaningful daily roles. Improvements in the WHOQOL-BREF physical health domain further reflected broader engagement in daily activities during the perinatal period. However, across sub-studies II and III, the interventions did not demonstrate consistent improvements with the psychological, social, or environment domains of the WHOQOL-BREF, suggesting that participation-related effects were largely confined to the physical health domain.

Within the ICF framework, the primary **environmental factors** in this dissertation were the online exercise program and the SLIM intervention, which provided structured guidance and support for physical activity. Participation in these interventions in sub-studies II and III offered an external facilitative environment that supported engagement in physical activity and promoted daily movement.

Personal factors showed several associations with outcomes across the sub-studies. In sub-study II, urinary incontinence symptoms (UDI-6 and IIQ-7) varied according to women's health and life-history characteristics: women more than six months postpartum, those with higher BMI, those who had a vaginal birth, and those reporting pelvic floor or core muscle dysfunctions had more bothersome symptoms. Time since the latest childbirth was also relevant, as women further postpartum demonstrated greater reductions in sitting time at follow-up. Other personal factors were linked with quality-of-life outcomes. Women with BMI 25–29.9 showed greater improvements in psychological well-being than those with BMI ≥30, and more educated women reported higher perceived environmental support. Regular exercise behaviour was associated with improved psychological health, and reduced sedentary time was related to better physical health-related quality of life. In sub-study III, EPDS scores were the strongest predictor of quality of life, with women without depressive symptoms reporting substantially higher scores across domains. Together, these environmental and personal contextual factors help explain variability in outcomes across the domains of body functions and structures, activities, and participation. They demonstrate how both individual life situations and the support provided by interventions shape maternal health during the perinatal period.

Overall, the results across the sub-studies demonstrate that technology-supported exercise and physical activity interventions can positively influence maternal health during the perinatal period by improving pelvic floor–related body functions, enhancing physical activity, and supporting women's participation in daily activities. Consistent evidence from the review of reviews, supported by empirical findings from the quasi-experimental studies, highlights the beneficial role of PFMT and general physical activity in reducing urinary incontinence symptoms and improving perceived physical functioning. Nevertheless, improvements in quality of life were limited to the physical health domain, with no consistent changes detected in the psychological, social, or environment domains, suggesting that the broader dimensions of well-being remained largely unchanged. At the same time, environmental and personal factors, including family context, postpartum timing, BMI, education, exercise habits, and emotional well-being, shaped individual responses to the interventions. Overall, these findings provide a comprehensive, ICF-based understanding of how different components of functioning interact within perinatal physical activity interventions. This forms the basis for the interpretations and implications discussed in the following chapter.

6 Discussion

This study investigated the role of exercise and physical activity in supporting and promoting maternal health during the perinatal period, with a particular focus on urinary incontinence, physical activity and quality of life. In addition to synthesizing existing evidence, this study generated new empirical findings through two quasi-experimental sub-studies, which examined the effectiveness of two technology-supported exercise and physical activity interventions. These novel results provide valuable insights into how exercise and physical activity interventions can influence maternal health outcomes of urinary incontinence, physical activity, and quality of life, in real-world perinatal settings, where evidence has previously been limited. Guided by the ICF framework, the results illustrate the dynamic and multidimensional nature of maternal health and demonstrate how targeted interventions can support functioning across several domains. In this chapter, the findings are discussed in relation to previous literature and research. The validity and reliability of the study are evaluated, and implications and suggestions for future research are presented.

6.1 Discussion of the results

Sub-study I summarized the existing evidence about the effectiveness of exercise interventions for urinary incontinence and pelvic organ prolapse. It showed that PFMT during pregnancy has the strongest evidence base for preventing postpartum urinary incontinence, with moderate-level evidence for reducing symptom severity, while evidence for pelvic organ prolapse remains limited. Sub-study II assessed the effectiveness of an online exercise program targeted at postpartum women, demonstrating significant reductions in self-assessed urinary incontinence symptoms, increases in physical activity, and short-term improvements in physical health–related quality of life, although other quality-of-life domains remained unchanged. These findings provide new empirical evidence on the impact of digital exercise interventions in the postpartum period, an area where robust effectiveness studies have been scarce. Sub-study III assessed the effectiveness of the SLIM intervention among pregnant women with overweight, showing that while physical health–related quality of life improved postpartum and physical activity rebounded to baseline or higher levels after childbirth, psychological, social, and environment quality-of-life domains declined or remained stable throughout pregnancy and three months postpartum. This study offers novel insights into how wearable technology can be used to support maternal health during pregnancy and the postpartum period. It offers valuable device-based information on women's physical activity levels during pregnancy and after childbirth, as well as on their quality of life, particularly among women with overweight, a group underrepresented in previous intervention research. Together, these findings integrate evidence from traditional exercise-based interventions and technology-supported programs, providing new and complementary knowledge on how exercise and physical activity interventions influence urinary incontinence, pelvic organ prolapse, physical activity patterns, and multiple domains of quality of life across the perinatal period.

6.1.1 Changes in body functions and structures

Consistent with the conclusions of sub-study I, which identified exercise and PFMT during pregnancy preventing urinary incontinence postpartum and reducing symptom severity, sub-study II demonstrated statistically significant reductions in symptom severity. These results align with most recent research, which has supported the evidence that exercise and PFMT during pregnancy (Santos et al., 2024; Zhang et al., 2024) and the postpartum period (Beamish et al., 2025; Chen et al., 2024; Gallego-Gómez et al., 2025) can prevent and reduce urinary incontinence symptoms. The findings of sub-study II suggest that exercise and PFMT delivered in digital and self-directed formats may be similarly effective as more traditional, supervised approaches. This is notable because previous reviews have highlighted supervision and individual instruction as key factors influencing effectiveness (Chen et al., 2024; Mantilla Toloza et al., 2024). Some previous digital health interventions have been shown to significantly reduce urinary incontinence symptoms among women in general (Asklund et al., 2017; Hoffman et al., 2017; Keyser et al., 2023; Rygh et al., 2021; Wadensten et al., 2022). Similarly, the findings of sub-study II suggest that online, self-directed exercise interventions may lead improvements in urinary incontinence symptoms among postpartum women, consistent with earlier digital intervention studies conducted in other populations.

Based on the previous evidence, women who already have PFD during pregnancy or postpartum should be referred to a physical therapist or another health care professional specializing in pelvic floor health (Paper I). Nevertheless, digital health interventions could provide valuable support in the management of symptoms when used alongside consultation with a qualified health care professional, and it may also contribute to the prevention of urinary incontinence symptoms and support women with milder symptoms.

The estimates of urinary incontinence prevalence among perinatal women are relatively high (Abramowitch et al., 2009; Dai et al., 2023; Giugale et al., 2021; Moossdorff-Steinhauser et al., 2021b; Sangsawang & Sangsawang, 2013; Thom & Rortveit, 2010; Wesnes et al., 2017), and it remains undertreated. Many perceive urinary incontinence as a normal consequence of pregnancy and childbirth, leading to the belief that symptoms will be resolved on their own. This normalization, combined with feelings of embarrassment and stigma surrounding urinary incontinence symptoms, might discourage open discussion and prevent help-seeking. In addition, there might be practical barriers such as time constraints, childcare responsibilities (Lim et al., 2019; Makama et al., 2021), and lack of access to specialized services further hinder women from seeking support. Digital health interventions, like the online exercise intervention studied in sub-study II, can offer promising, easily accessible solutions to these challenges. Because the training can be performed easily at home and the exercises are intentionally designed to be short, they can be more easily integrated into daily routines. Moreover, when seeking help feels difficult, providing a structured and accessible exercise program to all women could help standardize care and ensure more equitable opportunities to support one's own well-being. The prevention and treatment of urinary incontinence is essential because it can affect postpartum women's physical, emotional and sexual well-being (Corrado et al., 2020), limit activity and daily functioning (Chen et al., 2024; Corrado et al., 2020), strain social relationships (Leroy & Lopes, 2012) and consequently lower quality of life (Curillo-Aguirre & Gea-Izquierdo, 2023; Dai et al., 2023).

Beyond pelvic floor–specific outcomes, across sub-studies II and III, minor improvements in general physical functioning, energy levels, and overall well-being were observed, as indicated by scores in the WHOQOL-BREF physical health domain. In addition, in sub-study II, a minor, but non-significant improvement was found in the WHOQOL-BREF psychological health domain, whereas in sub-study III, scores decreased slightly. The perinatal period represents a complex interplay of biological changes, such as musculoskeletal adaptations (Berber & Satılmış, 2020; Fonti et al., 2009; Gilleard & Brown, 1996; Ospina Romero et al., 2012; Yoo et al., 2015) and ligamentous laxity (Liddle & Pennick, 2015; Selman et al., 2022), psychological factors such as fatigue (Ospina Romero et al., 2012), mood variability (ACOG, 2018; Ospina Romero et al., 2012), disrupted sleep (Facco et al., 2010), and social demands such as caregiving responsibilities and reduced personal time (Aber et al., 2013; Ospina Romero et al., 2012), all of which can constrain women's functional capacity. Within the ICF framework, these influences may manifest as impairments in body functions, activity limitations, and potential participation restrictions.

Because psychological functions are also part of the ICF domain of body functions (WHO, 2002, 2013), these results illustrate how physical and psychological aspects of functioning are interconnected during the perinatal period. Improving physical health alone is unlikely to significantly enhance psychological well-being during the perinatal period, given the many interconnected factors involved. To truly support mental well-being these elements should be intentionally built into interventions as explicit goals rather than assumed to follow from better physical functioning. Interventions that include targeted strategies, such as mood support, stress management, social connectedness, or sleep guidance, are therefore more likely to yield broader and more consistent psychological benefits.

The improvements observed in this study can be interpreted as positive adaptations across these domains. Although based on self-assessment, both sub-studies indicated trends toward slightly increased physical capacity alongside reduced symptom burden, changes that may be indirectly associated with increased engagement in physical activity during the intervention periods. These findings suggest modifications in movement-related body functions, endurance, and perceived physical capacity, supporting the interpretation that participation in structured and technology-supported interventions can influence women's functional health at the bodily level. However, although these interventions may influence certain psychological determinants of well-being, they are not sufficient in their current form to meaningfully enhance psychological health.

6.1.2 Physical activity

In the two empirical sub-studies, both interventions appeared to be effective in increasing and maintaining participants' physical activity levels. While sub-study II evaluated postpartum physical activity through self-assessment, sub-study III assessed physical activity during pregnancy and the first 12 weeks postpartum device-based using a smart ring.

In sub-study II, physical activity increased following the intervention, and these improvements were sustained at 6-month follow-up, an encouraging finding given that physical activity among postpartum women is generally reported to be low (Bacchi et al., 2016; Daly et al., 2016; Dipietro et al., 2019; Evenson & Wen, 2011; Nascimento et al., 2012; Okafor & Goon, 2020). Increases in median MET minutes per week were observed across all three activity intensities, light, moderate, and vigorous, although statistically significant changes were found only in moderate- and vigorous-intensity physical activity. Even though self-reported measures may be influenced by overestimation, either in the total amount of activity or the perceived intensity, the participants in sub-study II still appeared to be physically highly active, engaging in substantially more activity than current recommendations suggest (ACOG, 2020; W. J. Brown et al., 2022; Davenport et al., 2025; Mottola et al., 2018; UKK Institute, 2022, 2023; US Department of Health and Human Services, 2018;

WHO, 2020). For example, at least 150 minutes of moderate-intensity physical activity per week is recommended (ACOG, 2020; W. J. Brown et al., 2022; Hamari et al., 2022; Mottola et al., 2018; UKK Institute, 2022, 2023; US Department of Health and Human Services, 2018; WHO, 2020), whereas the median minutes per week among participants after the intervention was 180 minutes, increasing to 480 minutes at the 6-month follow-up.

Additionally, sedentary time decreased significantly. Contemporary physical activity guidelines emphasize not only the importance of regular activity but also the health benefits of reducing sedentary time, breaking up prolonged sitting has been associated with several positive health outcomes (W. J. Brown et al., 2022; Hamari et al., 2022; UKK Institute, 2022, 2023; WHO, 2020). Despite these recommendations to limit sedentary behaviour during pregnancy and postpartum (Bull et al., 2020; WHO, 2020), sedentary time has rarely been used as an outcome in exercise interventions involving this population (Turner et al., 2023).

In sub-study III, physical activity followed a pattern consistent with earlier research (Nascimento et al., 2012; Santo et al., 2017), with activity levels declining as pregnancy progressed, particularly for moderate-intensity activity. Despite this decline, participants remained physically active throughout pregnancy, continuing to accumulate meaningful amounts of light-intensity activity even in late pregnancy. Although a reduction was observed, overall activity levels still exceeded current recommendations for moderate-intensity physical activity. Participants averaged 108 MET minutes of moderate-intensity activity per day at baseline, 66 MET minutes per day at gestational week 34, and 119 MET minutes per day at 12 weeks postpartum, indicating that even during late pregnancy their activity substantially passed the minimum weekly recommendation.

This activity pattern contrasts with previous studies reporting low physical activity levels during pregnancy (Bacchi et al., 2016; Daly et al., 2016; Dipietro et al., 2019; Evenson & Wen, 2011; Nascimento et al., 2012) and particularly among women with overweight or obesity (Bacchi et al., 2016; Daly et al., 2016). The ability of participants in this sample to sustain activity suggests that promoting physical activity in women with overweight and obesity is feasible and remains important, given the elevated risk of adverse outcomes in this group (Abdi et al., 2025). Maintaining physical activity during pregnancy is known to improve maternal health (Díaz-Burrueco et al., 2021) and reduce pregnancy-related complications (Davenport, Ruchat, et al., 2018; Díaz-Burrueco et al., 2021; Ruchat et al., 2018).

The rapid increase in activity observed postpartum further indicates positive recovery and engagement in health promoting behaviours, potentially reflecting the effectiveness of the SLIM intervention. This interpretation aligns with previous evidence showing that self-monitoring tools (Collado-Mateo et al., 2021; Liu et al., 2024; Maugeri et al., 2023), goal setting (Collado-Mateo et al., 2021), and professional reinforcement and guidance (Collado-Mateo et al., 2021; Makama et al., 2021) can enhance physical activity behaviours, supporting the relevance of using the Oura Ring, motivational interviewing, and goal setting as key components of the SLIM intervention.

However, it is important to consider that the interventions may not directly increase physical activity for all participants. Rather, they may create conditions that enable or facilitate higher levels of physical activity for those who are willing or able to take advantage of the support provided. This distinction is important when interpreting the observed changes, as the interventions may function more as an enabler rather than direct drivers of increased activity.

When interpreted findings through the ICF framework, the physical activity outcomes from both sub-studies suggest meaningful changes across several domains of functioning. In both sub-studies, participants were able to integrate regular physical activity into their daily lives despite the known barriers to activity during pregnancy and the postpartum period (Angrish et al., 2023; Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; Makama et al., 2021; May et al., 2024; Ryan et al., 2022; Sparks et al., 2023; Thompson et al., 2017). This integration reflects not only increased bodily capacity, such as decreased urinary incontinence symptoms or improved physical health, but also an enhanced ability to perform health-promoting behaviours and meaningful daily activities, which may consequently support sustained engagement in active lifestyles during this transitional life phase. Furthermore, within the ICF framework it is important to recognise that these relationships are not unidirectional. Increased engagement in physical activity may itself contribute to improvements in body functions and structures, for example, through enhanced muscular strength, better neuromuscular control, or reduced symptom burden, which can further facilitate participation in daily activities and reinforce a positive cycle of functional recovery.

Several features of the interventions may help explain their effectiveness from an ICF perspective. The digital components, such as the online exercise program and the smart ring, acted as environmental facilitators by providing reminders, opportunities for self-monitoring, and immediate feedback, all of which may have strengthened personal factors facilitating physical activity, such as motivation, self-efficacy (Harrison et al., 2018; Makama et al., 2021; Thompson et al., 2017), and perceived capability. In sub-study II, the integration of PFMT alongside more comprehensive and progressive exercise may have further enhanced the meaningfulness of the program, supporting regular engagement. By reducing common barriers such as limited time (Coll et al., 2017; Edie et al., 2021; Makama et al., 2021; Ryan et al., 2022; Skjold et al., 2022; Thompson et al., 2017), the need for childcare responsibilities (Coll et al., 2017; Edie et al., 2021; Harrison et al., 2018; Ryan et al., 2022; Sparks et al., 2023; Thompson et al., 2017), and restricted access to in-person services (Coll et al., 2017; Edie et al., 2021; Makama et al., 2021; Thompson et al., 2017), both interventions created enabling conditions that supported ongoing participation in physical activity. Both interventions also included guidance from healthcare professionals, which is known to enhance physical activity during the perinatal period (Angrish et al., 2023; Coll et al., 2017; Harrison et al., 2018; Makama et al., 2021; May et al., 2024; Thompson et al., 2017). Support from a spouse, friends, and family likewise plays a key role in initiating and maintaining physical activity during pregnancy (Angrish et al., 2023; Coll et al., 2017; Harrison et al., 2018; May et al., 2024; Thompson et al., 2017) and postpartum (Makama et al., 2021; Ryan et al., 2022). In the samples of sub-studies II and III, most participants lived with a partner, which may have supported sustained engagement in physical activity by providing help with childcare and other responsibilities.

Although the interventions differed in structure, they ultimately targeted similar ICF components what it comes to enhancing physical activity: enhancing movement-related body functions, supporting activity performance in daily life, and creating environmental conditions that facilitated sustained participation. This convergence across two distinct formats strengthens the interpretation that technology-supported physical activity interventions can play a meaningful role in supporting women’s functional health during pregnancy and the postpartum period.

6.1.3 Quality of life

After both interventions, the scores of physical health domain increased. On the contrary, there were no statistically significant changes within other three domains of quality of life: psychological health, social relationships, and environment.

The results of sub-study II indicated that after the 6-week online exercise program, only the physical health domain of quality of life increased compared with baseline. However, no statistically significant changes in quality of life were observed at 6-month follow-up, and the hypothesized correlation between physical activity and quality of life was not supported. The previous research concerning physical activity interventions enhancing quality of life of postpartum women is scarce, and the research have mainly focused on pregnant women. In one recent systematic review of telehealth interventions for physical activity and exercise, it was reported that only 4 of 16 included studies used quality of life as an outcome, and among those, statistically significant change from baseline was observed in only two, similarly confined to physical functioning, with no significant changes in general health, mental health, or social functioning (Turner et al., 2023).

Findings of sub-study II, together with previous research (Turner et al., 2023), indicate that online exercise interventions may enhance the physical health domain of quality of life. However, future research should explore ways to support other quality-of-life domains, for example utilizing increased peer support. When comparing mean quality-of-life domain scores in sub-study II to the Finnish general population, all domains remained lower even after the intervention (Vaarama et al., 2012). This difference is understandable given that becoming a mother fundamentally changes life: women acquire new roles and responsibilities (Romano et al., 2010; Stowe et al., 2005), often prioritize childcare, and have less time for self-care (Lim et al., 2019; Makama et al., 2021). Shifts in family, partner, and friendship dynamics may also be reflected in the social relationships domain.

Findings from sub-study III suggest that the SLIM intervention may have supported the physical health domain of quality of life by facilitating a rapid increase in physical health scores after childbirth. However, it did not appear to positively influence psychological, social, or environment aspects of quality of life during pregnancy or postpartum. Depressive symptoms were the strongest predictor of quality of life, explaining variations in physical health, psychological health, and social relationships; women without depressive symptoms scored significantly higher across all domains.

This pattern aligns with previous evidence: behaviour change support and technology-based monitoring have been shown to improve physical health outcomes and, consequently, physical health-related quality of life (Adusei-Mensah et al., 2025; Mohamed et al., 2025; Overdijkink et al., 2018; Van Den Heuvel et al., 2018). Conversely, limited effects on psychological, social, or environment domains reflect prior findings (Altazan et al., 2019; Dodd et al., 2016) and are consistent with the primary outcome of the SLIM intervention (self-efficacy), where no significant improvement was observed (Saarikko et al., 2025).

Consistent with prior research, level of quality of life of the participants of sub-studies II and III were lower than those reported in the general population (Boutib et al., 2022, 2023; Lagadec et al., 2018), the physical health domain was particularly affected (Da Costa et al., 2006; Elsenbruch et al., 2007; Nakamura et al., 2019), which is understandable given the physical changes of pregnancy. While factors such as age, obesity, and mental health have been linked to reduced quality of life during pregnancy (Bai et al., 2019; Boutib et al., 2022; Evans et al., 2022; Lagadec et al., 2018), in sub-study III only depressive symptoms and educational level explained variation across quality-of-life domains. Depressive symptoms explained variation in physical health, psychological health, and social relationships; women without depressive symptoms averaged higher scores across all three. In the environment domain, EPDS and educational level together explained the variation; women without depressive symptoms and women with higher education averaged higher scores, aligning with prior findings that higher education is linked to higher quality of life (Lagadec et al., 2018; Valla et al., 2022). There is a need to integrate mental health support into lifestyle interventions through depression screening, counselling, and digital tools. Women may also benefit from personalized guidance during routine visits, structured counselling time, and strategies to strengthen social support (Wan Mohd Yunus et al., 2022). Combining behaviour change techniques with emotional support, stress management, and fatigue coping may better enhance psychological and social well-being and quality of life.

Viewed through the ICF framework, quality-of-life domains reflect participation, engagement in life situations affected by health status, personal factors, and environmental context. Across both interventions, the most consistent changes occurred in physical health, suggesting improvements in movement-related body functions and activity performance that can support participation. In contrast, psychological, social, and environment quality-of-life outcomes remained unchanged. These domains are influenced by determinants, such as sleep (Boutib et al., 2022; Lagadec et al., 2018; Peters et al., 2023), mental health (Bai et al., 2019; Boutib et al., 2022; Lagadec et al., 2018), and partner and family support (Boutib et al., 2022; Lagadec et al., 2018), which were not directly targeted by the interventions and require longer, more multidimensional approaches to shift meaningfully.

Quality-of-life outcomes were included in this study because both interventions were expected to improve physical fitness, and, through this, quality of life. This assumption aligns with the ICF framework, which emphasizes the role of body functions and activity in facilitating participation (WHO, 2013). However, the findings suggest that meaningful improvements in quality of life may require additional intervention components, such as psychosocial, social, or environmental support, that directly target the broader determinants of well-being. Without such components, substantial changes in psychological, social, or environment domains are unlikely, which may help explain the limited effects observed.

Overall, the findings related to quality of life mirror the physical activity results. Structured, technology-supported interventions can enhance body functions and activity, with partial translation into participation (WHOQOL-BREF physical health); however, broader participation (psychological, social, environment) appears to require longer, more personalized, and mental health-integrated approaches.

6.2 Validity and reliability

In this chapter, the validity, reliability, and limitations of the study are discussed. This research consisted of three sub-studies, employing different designs, data collection methods, and analytical approaches. The PRISMA guidelines were used for the review of reviews (Page et al., 2021), and the Transparent Reporting of

Evaluations with Nonrandomized Designs (TREND) guidelines were followed for the quasi-experimental studies (Des Jarlais et al., 2004). In addition, the intervention in sub-study II (Papers II and III) was described using the Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann et al., 2014).

6.2.1 Sub-study I

A review of reviews was conducted to provide a comprehensive overview of the topic and identify areas for future research. The review process followed methodological standards, including the JBI Manual for Evidence Synthesis (Aromataris et al., 2024) and the study protocol was registered in PROSPERO, ensuring transparency. Literature searches were conducted in nine databases with the assistance of an experienced information specialist, and due to the overlap in search results, it is unlikely that relevant studies were omitted. However, only the reviews published either in Finnish or English were eligible. Screening, methodological quality assessments, and data extraction were conducted by two researchers independently. As a part of the analysis, the GRADE assessments were conducted (Siltanen et al., 2023).

The critical appraisal indicated variation in methodological quality across the included reviews, with scores ranging from 6/11 to 11/11. Four reviews received full scores, while assessment of publication bias was the most commonly unreported criterion (Appendix 4). These variations influence the degree to which firm conclusions can be drawn from the synthesized evidence. To complement this methodological appraisal, certainty of evidence was assessed using the GRADE approach. When GRADE ratings were already provided in the included reviews, those ratings were used. In cases where ratings differed, the appraisal considered the methodological quality, publication year and clinical relevance of the reviews, following the NRF guideline handbook for interpreting evidence levels (A = high, B = moderate, C = low, D = very low).

The validity of this review was influenced by several factors, with the main limitation being the heterogeneity of the included reviews. This variability made it impossible to conduct a meta-analysis and posed challenges for applying the GRADE criteria. As the review included any type of physical activity intervention, ranging from everyday movement to PFMT, strength training, and stretching, the diversity of interventions limited the ability to provide specific recommendations regarding exercise frequency, intensity, or type. Additional limitations included inconsistent reporting of exercise adherence and insufficient descriptions of control groups in the original studies.

6.2.2 Sub-studies II and III

Sub-studies II and III were both conducted using a quasi-experimental design without a control group (Capili & Anastasi, 2024; Shadish et al., 2001). This design limits the ability to establish certain causal relationships between the interventions and the observed changes in urinary incontinence, physical activity, and quality of life. Without randomization the influence of confounding factors, such as socioeconomic status, psychological characteristics, or engagement in other physical activity, cannot be excluded. (Capili & Anastasi, 2024.) Additionally, it was not possible to assess how these outcomes might have changed naturally during the perinatal period in the absence of the intervention.

Nevertheless, a quasi-experimental pre–post design was appropriate for early-phase evaluation of these interventions, allowing feasibility and preliminary effects to be assessed under real-world conditions (Capili & Anastasi, 2024; Waddington et al., 2023). Randomization was not ethically or practically feasible, and quasi-experimental designs are considered justified when withholding potentially beneficial support from a vulnerable population, such as perinatal women, would be unethical or when feasibility constraints related to time or resources prevent random allocation (Capili & Anastasi, 2024). The duration of the interventions also differed between the sub-studies and may influence the interpretation of their effects. In sub-study II, the intervention lasted six weeks, providing only a short window for behavioural change to occur, whereas in sub-study III, participants used the wearable device from early pregnancy until 12 weeks postpartum, resulting in a substantially longer and more variable exposure period. These differences may affect the extent to which the observed changes can be attributed to the interventions themselves.

Both sub-studies relied on self-selected samples, introducing potential selection bias. In sub-study II, participants were recruited through an online exercise program’s website, whereas in sub-study III, recruitment was conducted at maternity clinics by public health nurses. In both cases, individuals who chose to participate may have been particularly motivated or better resourced to engage in health-promoting behaviours, which may not reflect the broader target population. For example, participants in sub-study II were likely to have the financial means to access the intervention, and in sub-study III, a high refusal rate was reported, with the most common reason being a lack of energy or resources. It is possible that women facing greater life challenges, those who might have benefited most from the intervention, were also the ones who chose not to participate, potentially introducing bias into the study outcomes. Consequently, the overall levels of well-being and functioning in the study samples were likely higher than in a population-representative cohort. This also raises the possibility that the effects of the interventions might have been greater in a more diverse sample including women with greater needs or lower baseline functioning.

A range of validated instruments were used to assess urinary incontinence, physical activity, and quality of life. The selection of instruments was guided by their relevance to the study population and the availability of psychometric evidence supporting their use in similar contexts.

In sub-study II, urinary incontinence symptoms were assessed using **the UDI-6**, a widely used short-form instrument derived from the original 19-item UDI. The UDI-6 has repeatedly demonstrated good psychometric performance across different languages and clinical populations. Its total score correlates strongly with the long-form version (r = 0.93) (Shumaker et al., 1994; Uebersax et al., 1995), and several validation studies have reported acceptable to excellent internal consistency, with Cronbach’s alpha values typically ranging from 0.74 to 0.83 (Cam et al., 2007; S. S. C. Chan et al., 2010; Mikuš et al., 2020). Test–retest reliability has also been shown to be good to excellent (ICC=0.72 to 0.99) (S. S. C. Chan et al., 2010; Mikuš et al., 2020; Utomo et al., 2015). Although some studies have reported lower internal consistency (α=0.44 to 0.66) in certain subscales (Utomo et al., 2015), the full scale has demonstrated good stability over time and appropriate construct validity, including strong correlations with urodynamic findings (Mikuš et al., 2020). Overall, available evidence supports the UDI-6 as a reliable and valid measure for assessing urinary incontinence symptoms in women.

In sub-study II, impact of urinary incontinence on quality of life was assessed with **the IIQ-7**. The IIQ-7 has demonstrated strong psychometric properties across validation studies. Its total score shows excellent correspondence with the long form instrument (r=0.97), and the short form subscales maintain a high degree of fidelity to the original domains, with correlations ranging from 0.88 to 0.94 (Uebersax et al., 1995). International validation studies have consistently reported high internal consistency, with Cronbach’s alpha values typically ranging between 0.86 and 0.93 (Cam et al., 2007; S. S. C. Chan et al., 2010; Utomo et al., 2015). Test–retest reliability has also been shown to be good, with intraclass correlation coefficients of 0.75 to 0.76 (S. S. C. Chan et al., 2010; Utomo et al., 2015) and, in some studies, even higher rank order stability (r=0.99) (Cam et al., 2007). The IIQ-7 is a reliable, valid and responsive instrument for assessing the impact of urinary incontinence on daily life across diverse cultural and clinical populations.

In the future, another choice for assessing urinary incontinence, or PFD more broadly, could be the Pelvic Floor Distress Inventory (PFDI-20), which includes the UDI-6 as one of its subscales (Hamari et al., 2022; Mattsson et al., 2017). Finnish validated translation of the PFDI-20 has acceptable psychometric properties (Mattsson et al., 2017) and can be used for both research purposes and clinical evaluation (Hamari et al., 2022; Mattsson et al., 2017).

In sub-study II, physical activity was assessed using **the IPAQ-SF**. The IPAQ-SF is widely used self-report instrument for assessing physical activity in adult populations and has demonstrated acceptable measurement properties in international validation studies. Overall repeatability has been reported as good, with pooled test–retest correlations around 0.76 (95% CI 0.73, 0.77), and the majority of reliability coefficients exceeding 0.65, with some short form versions reaching correlations above 0.74–0.79. (Craig et al., 2003.) In terms of validity, correlations between IPAQ-SF–derived total physical activity and objective measures have generally been low to moderate (r=0.09 to 0.39), which is consistent with evidence that self-report instruments often overestimate physical activity (Lee et al., 2011; Meh et al., 2023) and underestimate sedentary behaviour (Lee et al., 2011) and short bouts of movement (Bull et al., 2020). Overestimation relative to device-based standards has been reported in the range of 36 to 173%, with an average overestimation of approximately 84% (Lee et al., 2011). Despite these limitations, the IPAQ-SF has acceptable construct validity for distinguishing relative activity levels and is recommended as a feasible tool for population level surveillance (Craig et al., 2003; Sember et al., 2020). Among pregnant women, the IPAQ-SF has demonstrated good test–retest reliability but low to fair concurrent validity when compared with device-based measurements, and similar patterns of under- and over-reporting have been observed as in non-pregnant populations (Sanda et al., 2017). Taken together, the IPAQ-SF provides sufficiently reliable estimates for categorising activity levels in large scale studies, but its limited criterion validity should be considered when interpreting absolute levels of physical activity.

In future studies, other questionnaire-based options could also be considered, including pregnancy-specific instruments such as the Pregnancy Physical Activity Questionnaire (PPAQ) (Evenson et al., 2012; Gascoigne et al., 2023), as well as broader population-level tools like the European Health Interview Survey-Physical Activity Questionnaire (EHIS-PAQ) (Finger et al., 2015; Husu et al., 2024), or the Global Physical Activity Questionnaire (GPAQ) (Armstrong & Bull, 2006; Husu et al., 2024).

In sub-study III, physical activity was assessed using **the Oura smart ring**, a wearable device that uses a 3D accelerometer to track movement, steps, and activity type. It integrates demographic data (e.g., age, weight, height, gender) to estimate energy expenditure. Previous studies have supported the reliability of the Oura ring in assessing physical activity, heart rate, and heart rate variability (Cao et al., 2022; Niela-Vilen et al., 2022). However, its use in pregnant populations has not been specifically validated. In this study, some participants experienced finger swelling during pregnancy or were unable to wear the ring at work, which reduced wear time and may have affected data reliability. An additional limitation is that users may not notice battery depletion unless they actively check the mobile application, which can lead to unintentional gaps in data collection. Although the Oura app allows users to monitor their data in real time, there is no evidence on whether these features enhance adherence in research settings. These practical limitations highlight the need to consider the suitability of this device in future studies, particularly in populations in which continuous wear may not be feasible.

Other device-based options for assessing physical activity could be other accelerometers, such as ActiGraphs, activity watches or wrist-worn trackers, which have been used also among pregnant women (Sharp et al., 2022). ActiGraph accelerometers have been the most used devices (De Wolf et al., 2024; Wijndaele et al., 2015), but in behaviour-change–oriented studies, such as the SLIM intervention, the ability for participants to view and monitor their own data is an essential component. For this reason, a wrist-worn tracker or activity watch may represent a feasible alternative to the Oura ring, as they allow users to access real-time feedback that may support engagement and adherence.

The WHOQOL-BREF was used in both sub-studies to assess quality of life. It is a widely used and validated instrument developed by the WHO for evaluating quality of life across diverse populations (WHO, 2012a). It is well accepted among postpartum women and is recommended for assessing intervention effects in both clinical and research settings (Webster et al., 2010). In the context of pregnancy, the Swedish version of the WHOQOL-BREF has demonstrated good psychometric properties, particularly in the physical and psychological domains (Rondung et al., 2023). The instrument has also shown reliability in other cultural contexts, such as among pregnant women in Romania (Radu et al., 2025). A recent review identified the WHOQOL-BREF as one of the most extensively evaluated generic quality of life instruments used during pregnancy and the postpartum period, with strong evidence supporting its psychometric properties (Brekke et al., 2022). Although the WHOQOL-BREF is a well-validated and widely used instrument, its broad scope raises the question of whether it was the most sensitive choice for detecting changes resulting from the present interventions. Many of the instrument's domains encompass areas, such as social relationships, environment conditions, and aspects of psychological well-being, that the interventions did not explicitly target. As a result, substantial change across all domains cannot reasonably be expected. More targeted instruments focusing specifically on physical functioning or postpartum recovery might have been more responsive to the types of changes the interventions were designed to influence. Nonetheless, the WHOQOL-BREF provided a valuable general overview of well-being, while highlighting the limitations of using a broad quality-of-life measure to capture domain-specific intervention effects.

A recent review identified 19 different instruments used to assess parental quality of life during the perinatal period. Of these, 12 (63%) were generic quality-of-life measures, while 7 (37%) were pregnancy- or postpartum-specific instruments

(Brekke et al., 2022). Although condition- or period-specific measures may capture perinatal experiences more sensitively, the use of a generic instrument provides the important advantage of enabling comparisons with the general population and with life stages outside the perinatal period. Future studies could consider widely used generic tools such as the 36-Item Short Form Health Survey (SF-36) or the 12-Item Short Form Health Survey (SF-12), which offer comprehensive domains and strong psychometric properties, making them suitable for both clinical and population-level comparisons (Brekke et al., 2022). In addition, a recent study developed and validated an adapted version of the SF-36 designed for pregnant women, the SF-34 PREG, which could also be one option in the future (Martín-Vázquez et al., 2025).

Adherence to the interventions could not be objectively verified in either study. In sub-study II, researchers did not have access to the online platform, which prevented tracking of participant engagement (e.g., visit frequency or content usage). Adherence was assessed solely through self-reports, which indicated high engagement but lacked external verification. In sub-study III, participant adherence to the intervention appeared high, as indicated by consistent use of the Oura ring. However, there were shortcomings in the documentation by public health nurses, suggesting a need for improved implementation support and data recording practices from the healthcare provider side. (Saarikko, 2025.) These limitations raise the possibility of confounding variables influencing the results.

Sample sizes in both studies were determined through power analysis and methodological literature, and recruitment continued until the targets were reached. In sub-study II, dropout rate at the 6-month follow-up was higher than anticipated, though a dropout analysis revealed only minor differences between participants and dropouts, suggesting limited impact on internal validity. However, the power analysis was based on WHOQOL-BREF instrument, which may have reduced statistical power for other outcomes. In sub-study III, power calculations were based on two instruments, WEL and PASE, that were not included as outcome measures in this study, which may affect the interpretation of the sample adequacy. Similarly to sub-study II, final number of participants that could be included in the analysis was less than targeted.

Overall, the generalizability of findings from both sub-studies is limited due to the homogeneity of the samples, the absence of randomization and control groups, and challenges in verifying adherence. In addition, the samples were likely to be selective: participants in sub-study II appeared to be physically active, highly educated, and generally well-functioning, whereas participants in sub-study III were predominantly overweight or obese, raising questions about the extent to which the findings can be directly compared with outcomes in normal-weight populations. In both sub-studies, only Finnish-speaking participants were eligible because the interventions were delivered in Finnish. This language restriction further limits generalizability, particularly given that the proportion of women with foreign background among birthing women in Finland has increased substantially in recent years, 17.3% in 2023 (Austero et al., 2025), indicating growing linguistic and cultural diversity in maternity populations. These factors should be considered when interpreting the results and applying them to broader populations.

Although quasi-experimental designs lack randomization and control groups, reliability can still be supported through careful planning and consistent implementation of study procedures. In sub-studies II and III, several measures were taken to enhance reliability. The data collection procedures were standardized, and both studies used automated systems (REDCap and SLIM application) to distribute questionnaires and reminders at consistent time points, ensuring uniformity in how data were collected across participants. All instruments used in the studies, the UDI-6, the IIQ-7, the IPAQ-SF, the Oura ring, and the WHOQOL-BREF, have demonstrated acceptable reliability in previous research. This supports the consistency of the measurements across time and populations. The same instruments were used at baseline, post-intervention, and follow-up, which strengthens the reliability of longitudinal comparisons. For instruments requiring translation (the UDI-6 and the IIQ-7), a double translation process was used, and a professional translator ensured linguistic accuracy. Data were processed according to established guidelines for each instrument, including handling of missing data. Statisticians were consulted to ensure appropriate handling of data and robust analysis procedures.

The use of the ICF framework strengthened the conceptual clarity and internal consistency of this dissertation. By providing a biopsychosocial lens, the ICF framework enabled a structured examination of maternal health by linking body functions and structures (urinary incontinence), activities (physical activity), and participation (quality of life), while accounting for the influence of environmental and personal factors. This helped interpretation of findings, especially in illustrating the multidimensional nature of well-being during the perinatal period. For instance, improvements in physical health but not in psychological, social, or environment quality-of-life domains aligned with the ICF distinction between activities and participation. The framework also reflects the physiotherapeutic orientation of the dissertation by emphasizing functional ability, participation, and holistic health. However, the ICF framework has limitations: it does not provide detailed operational guidance for measurement within each domain, requiring interpretive decisions when categorizing variables such as quality of life, and personal factors are only loosely defined, which may affect comparability across studies. Despite these constraints, the ICF framework offered a robust and transparent foundation for structuring the theoretical background, interpreting results, and situating the findings within the broader context of maternal health.

As a conclusion, the review of the reviews and the quasi-experimental studies offer important and complementary evidence on the maternal health, demonstrating the potential of technology-supported interventions in promoting physical activity and quality of life. These findings not only strengthen the foundation for future research but also provide practical insights into how such interventions can be effectively utilised in real-world settings.

6.3 Implications and future research

The following suggestions for practical implications are presented based on this study:

- The findings underscore the need to strengthen consistent, evidence-based counselling on PFMT and exercise for urinary incontinence and pelvic organ prolapse in maternity care. Although evidence-based recommendations are already available, their systematic incorporation into routine care varies. Enhancing the implementation of these guidelines could promote more uniform, high-quality support for women across different maternity care contexts.
- The findings highlight the potential for scalable and cost-effective digital interventions that can be delivered uniformly without increasing the workload of health care professionals, complementing existing lifestyle counselling practices at the maternity care.
- Web-based programs can function as low-threshold support tools, making it possible to offer consistent and equal lifestyle counselling to all mothers, regardless of geographical location, local service availability, or the individual competence of maternity clinic personnel.
- Technology-supported interventions may help address the societal challenge of physical inactivity by supporting mothers, and indirectly their families, to engage in healthier behaviours.

This study strengthened the body of research on technology-supported physical activity interventions for maternal health during the perinatal period. However, there is a need for future research on these topics. The following suggestions are presented:

- Investigate the implementation and real-world use of the Finnish National Clinical Practice Guideline, “Pregnant and postpartum women in health care: justification and guidance for physical activity” guideline in maternity care settings.

- Conduct high-quality RCTs to examine the impact of digital physical activity interventions on both physical activity and broader well-being outcomes such as quality of life, during the perinatal period, especially postpartum.
- Examine whether integrating psychological, social, and motivational components, such as stress-management and peer support, into physical activity interventions could enhance maternal well-being during the perinatal period. In this study, improvements were seen mainly in the physical domain of quality of life, whereas psychological, social, and environmental domains showed only modest changes, likely due to the intervention's strong focus on physical activity.
- Conduct studies with more diverse and heterogeneous populations, including women from different regions, socioeconomic backgrounds, cultural backgrounds, and health statuses.
- Assess user experiences and barriers among different demographic groups to identify accessibility and usability gaps within the interventions.

7 Conclusions

This dissertation aimed to investigate how exercise and physical activity interventions, including technology-supported interventions, can promote maternal health during the perinatal period, with a specific focus on urinary incontinence, physical activity and quality of life. The perinatal period represents a particularly vulnerable yet impactful phase in women's lives, during which declines in physical activity and challenges such as urinary incontinence can negatively affect well-being. Ultimately, the goal of this dissertation was to generate new, empirical knowledge that can guide the development, targeting, and implementation of health-technology–assisted physical activity interventions that can enhance maternal health.

Across the three sub-studies, the findings demonstrate that exercise and physical activity interventions may contribute to the prevention and treatment of urinary incontinence and to support physical activity during the perinatal period. Within the quality of life, improvements were only found in the physical health domain, suggesting positive effects on movement-related body functions and activity performance. However, the interventions did not meaningfully influence the psychological, social, or environment domains of quality of life. These domains are shaped by complex determinants, such as mental health, social support, and sleep, which typically require more comprehensive, multidimensional approaches than exercise and physical activity interventions alone can provide.

Interpreted through the ICF framework, the results indicate that the interventions were successful in influencing body functions and structures and activity, but less so in broader participation or contextual aspects of functioning. This highlights both the strengths and limitations of physical activity–focused interventions: while they are powerful tools for supporting physical health, they must be complemented by additional strategies to address psychological and social well-being more holistically.

This dissertation makes several contributions to maternal health research and practice. Sub-study I synthesizes existing evidence and offers practical guidance for healthcare professionals, supporting more consistent and evidence-based counselling on pelvic floor health through exercise-focused guidance that promotes pelvic floor function. Sub-studies II and III provide novel empirical insights on the effectiveness of technology-supported interventions that have the potential to increase accessibility and equity in maternity care. As digital health becomes increasingly integrated into everyday life, these findings underscore the potential of technology-supported interventions to complement traditional maternity services without increasing workload for healthcare professionals.

Several components are ready for integration into Finnish maternity care. Structured DHIs during the perinatal period can support physical activity, recovery, and the prevention and management of urinary incontinence. Such digital formats increase reach by enabling evidence-based support regardless of time, place, or life circumstances, and may particularly benefit women facing geographic or socioeconomic barriers. By delivering timely guidance during the perinatal period, scalable, low-threshold digital solutions may reduce long-term burdens related to urinary incontinence and inactivity, while allowing professionals to focus resources on those needing individualized care. These findings provide a foundation for the further development and controlled evaluation of digitally delivered maternity-care models in Finland.

The results should be interpreted with awareness of certain limitations, including the quasi-experimental designs, relatively small sample sizes, and follow-up periods that, while a strength of the study, could have been longer or included additional measurement points. These factors may constrain the generalizability of the findings and limit conclusions about long-term effectiveness. Nonetheless, the consistency of results across the sub-studies provides a foundation for further development of digital and physical activity–based solutions.

As a conclusion, this research underscores the importance of supporting physical activity during the perinatal period and highlights the potential of accessible, cost-effective, and sustainable interventions to promote maternal health. The findings offer insights for both clinical practice and future intervention development and research. Continued efforts to integrate digital tools with multidimensional approaches will be essential to holistically support the health, functioning, and well-being of pregnant and postpartum women.

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Appendices

Appendix 1. Characteristics of previous reviews (UI & POP)

AUTHOR(S), YEAR	NUMBER OF INCLUDED STUDIES	POPULATION, PARTICIPANTS/ RANGE OF SAMPLE SIZE	INTERVENTION(S)	PRIMARY AND SECONDARY OUTCOMES	MAIN FINDINGS RELATED TO UI AND/OR POP
Beamish et al. 2025	N=65, n=40 focused on pelvic floor disorders	Pregnant and postpartum women, N=21 334, 18-13 670	F: 1-7x/week, 5-60 minutes/session I: light to maximal contractions T: 4 weeks to 17 months T: PFMT (e.g. Kegel), abdominal muscle training- only, PFMT + co-interventions (e.g. biofeedback devices, therapeutic modalities, smartphone app) S: supervised and/or unsupervised training, individual and group exercise	Primary: UI, AI, POP, diastasis recti abdominis and sexual function	Evidence supports the effectiveness of postpartum PFMT in reducing the odds of UI and POP.
Cabrera-Martos et al. 2025	N=9	Pregnant and postpartum women, N=2694, 60-947	F:1-7x/weeks, 5-60 minutes/session I: not reported T: 3 weeks to 16 months T: a physical therapist intervention including PFMT (e.g. Kegel), direct low-frequency electrical stimulation, perineal massage S: supervised and/or unsupervised training	Primary: UI	Physical therapist interventions, especially PFMT, may help prevent postpartum UI compared to usual care or no intervention. However, heterogeneity and limited number of studies highlight the need for more high-quality RCTs.

Chen et al. 2024	N=17	Postpartum women, N=not reported	F:1-7, 15-60 minutes/session I: not reported T: 3-36 weeks T: PFMT, biofeedback therapy, electrical stimulation, bladder training, core training, vaginal cones, acupoint stimulation, acupuncture, electroacupuncture, stabilization exercises focusing on the PFM S: supervised and/or unsupervised training, interventions were performed at the participant's home or medical institution	Primary: UI, secondary: incontinence-specific QoL	Supervised PFMT and use of vaginal cones were more effective in reducing UI rates than individual PFMT. Combining PFMT or electrical stimulation and biofeedback with other therapies may further reduce UI severity. These approaches also improve incontinence-specific QoL.
Gallego-Gómez et al. 2025	N=19	Postpartum women, N=2737, 9-371	F: 3-7x/weeks, 10-60 minutes/session I: PFMT low to close maximum T: 4 to 36 weeks T: PFMT, PFMT through electrical stimulation/biofeedback, PFMT combined with abdominal muscle training, PFMT combined with education, abdominal muscle training S: supervised and independent home exercise, phone applications	Primary: UI	PFMT alone or combined with electrical stimulation, biofeedback, or abdominal muscle training are suitable conservative approaches for treating postpartum UI. More research is needed to evaluate abdominal muscle training alone.
Höder et al. 2023	N=8	Postpartum women, N=765, 50-175	F: daily home exercise, supervised exercise 1-4x/months, duration of daily exercise not reported, supervised exercise 45-60 minutes/session I: not reported T: 6-24 weeks T: PFMT, PFMT including biofeedback devices S: supervised by physiotherapist and/or unsupervised training	Primary: UI and AI	It is not possible to draw conclusions about the effectiveness of PFMT with feedback due to limited evidence. However, individualized treatment with physiotherapist-provided feedback may be beneficial for certain patients.

Mantilla Toloza et al. 2024	N=7	Pregnant and postpartum women, N=1401, 87-301	F:1-7x/week, 20-60 minutes/session I: not reported T: 6-16 weeks T: PFMT (e.g. Kegel) S: supervision by physiotherapist or certified exercise instructor and/or unsupervised exercise	Primary: SUI	PFMT initiated early in pregnancy has positive effects on postpartum UI. Individualized instruction and follow-up by a physical therapist may enhance adherence, motivation, and correct performance of exercises.
Santos et al. 2024	N=3 (from 5 publications)	Pregnant women, N=1091, not reported	F:1-3x/week, 60 min/session I: moderate T: 12-22 weeks T: aerobic activity, strength training including PFMT, light stretching, breathing, and relaxation exercises, instruction on anatomy and correct contraction of the PFM S: supervised by physiotherapists or certified aerobics instructors taught by a physical therapist	Primary: UI, secondary: e.g. psychological measures; general health status, delivery outcome, POP	Moderate evidence suggests that aerobic and/or resistance exercise combined with PFMT can reduce UI postintervention and at 3-month follow-up and improve UI-specific QoL. Certainty of evidence for QoL improvement is low.
Zhang et al. 2023	N=30, n=12 focused on UI	Pregnant women, N=6691, 42-762	F: 1-7x/week, 12-60 min/session I: low to high T: 6-28 weeks T: PFMT, or exercise program including PFMT S: six studies reported that the exercise classes were supervised.	Primary: UI, secondary: episiotomy and third- or fourth-degree perineal tear	PFMT alone or as part of a general exercise program during pregnancy is effective in preventing UI. These findings support the development of PA programs that integrate PFMT during pregnancy.
Yu et al. 2024	N=10	Pregnant and postpartum women, N=720, 18-137	F: 3-7x/week, 45-60 minutes/session I: not reported T: 8 weeks to 6 months T: physiotherapy modalities, stabilization exercises, PFMT, biofeedback, abdominal muscle training	Primary: UI, pelvic floor muscle strength, PFM endurance, QoL, transverse muscle	Core stabilization exercises are safe and beneficial for pregnant and postpartum women with UI. They help alleviate UI symptoms, improve QoL, strengthen PFM and enhance transverse abdominal muscle function.

			S: supervised and individual training	strength, voiding function, pain score.	

Abbreviations: AI: anal incontinence; F: frequency; FI: faecal incontinence; GW: gestational week; I: intensity; PA: physical activity; PFM: pelvic floor muscles; PFMT: pelvic floor muscle training; POP: pelvic organ prolapse; QoL: quality of life; RCT: randomised controlled trial; S: setting; SUI: stress urinary incontinence; T: time; Ty: type; UI: urinary incontinence

Appendix 2. Characteristics of previous reviews (QoL)

AUTHOR(S), YEAR	NUMBER OF INCLUDED STUDIES	POPULATION, PARTICIPANTS/ RANGE OF SAMPLE SIZE	INTERVENTION(S)	QOL MEASUREMENT TOOL(S)	MAIN FINDINGS RELATED TO QOL
Bernardo et al. 2024	N=6	Pregnant women, N=2684, 54-1933	F: 1-7x/week, 25-50 min/session I: 12–15 on the Borg scale, moderate intensity T: not reported Ty: counselling, walking, recreational activities, aerobic exercise (treadmill/stationary biking), PFMT S: Exercise was supervised by health professionals in two studies. Hospital infrastructures; public setting (n=5) and private setting (n=1)	EQ-5D, SF-36, SF-12, WHOQOL-BREF	PA interventions during pregnancy for women with overweight or obesity did not significantly improve QoL. However, consistent adherence was associated with better physical health, weight control, and aerobic fitness.
Cai et al. 2022	N=44, n=6 focused QoL	Pregnant women, N=132 399, n=1582/56-578	Not reported.	SF-36, QoL Questionnaire, SF12, WHOQOL-BREF	High levels of PA during pregnancy were associated with improved QoL.
Castro et al. 2022	N=31, n=3 focused on QoL	Pregnant women, N=7560, n=995 /105-761	F: 1-3x/week, 60 min/session I: Moderate; Borg Scale (12–14) T: 12-17 weeks Ty: Cardiovascular training, strength training, core strength, stretch and relaxation, water exercise S: The interventions were supervised by an exercise specialist	GHQ, SF-36, PGWBI	Two studies reported better QoL outcomes in the intervention group compared to control. One study found no difference between groups.

Chan et al. 2019	N=29, n=2 focused on QoL	Pregnant women, N=not reported, n=169/64-105	F: 2-3x/week, 60 min/session I: not reported T: 12 weeks Ty: walking, aerobic exercises, dancing, stretching and relaxation S: supervised group exercise in hospital and local community, supervised group exercise + unsupervised independent exercise	SF-12, WHOQOL-BREF, SF-36	With only two studies reporting contrasting results, the effectiveness of PA interventions on QoL in pregnant women remains unclear.
Ferraz et al. 2023	N=2	Pregnant women, N=83, 83/33-50	F: 1-2x/week, 55-70 min/session I: not reported T: 8-12 weeks Ty: pilates clinical exercises including mat pilates exercises S: guided group training	NHP	Pilates improved the QoL of pregnant women in a significant way.
Liu et al. 2019	N=13	Pregnant women, N=2022,64–855	F: 1-5x/week, 15-60 min/session I: light to vigorous T: 8-16 weeks Ty: aerobic exercise, e.g. water aerobics, resistance exercise, combined exercise, yoga, general physical activity S: supervised individual or group exercise	SF-12, WHOQOL, WHOQOL-BREF, SF-36, PGWBI	Aerobic and resistance training had mixed effects on QoL during pregnancy. However, combining these with yoga or other PA led to significant improvements. High-frequency group-based exercise was particularly beneficial.
Mérida-Téllez et al. 2025	N=10	Pregnant women, N=499, 14–159	F: 1-2x/week, 50-70 min/session I: low to moderate intensity T: 4-12 weeks Ty: Clinical pilates exercises including warm-up, main workout and cool-down, without and with equipment (e.g. pilates ball, resistance band) S: guided group training, home program	NHP, SF-12	Two studies found significant improvements in QoL among pregnant women who practiced pelvic movements as part of a PA program.

Redondo-Delgado et al. 2025	N=9	Pregnant women, N=1581, 72-962	F: 1-3x/week, 50-60 min/session I: moderate to vigorous intensity T: 12 weeks Ty: strength training with/without aerobic exercise e.g. dance, circuits, walking, training with equipment (e.g. elastic bands, barbells, machines)	SF-36, WHOQOL-BREF	Strength training during pregnancy significantly improved physical, emotional, and social well-being. It increased vitality and energy, and reduced fatigue, sadness, anxiety, and pain, leading to better social life and functional status.
Sánchez-Polán et al. 2023	N=7	Pregnant women, N=678, 46-210	F: 1-5x/week, 15-60 min/session I: light and moderate intensity T: 6-20 weeks Ty: aerobics, strengthening, PFMT, stretching, and relaxation exercises S: Six of seven interventions were supervised	SF-8, SF-12, SF-36, WHOQOL-BREF	Supervised PA interventions during pregnancy may significantly improve mental and physical self-perceived health. High-quality evidence supports that PA during pregnancy improves QoL, with significantly better outcomes in intervention groups compared to controls.
Zhao et al. 2024	N=10, n=4 focused on QoL	Pregnant women, N=1949, n=493, 31-258	F: 2-3x/week, 45-60 min/session I: not reported T: 12-21 weeks Ty: water exercise e.g. swimming, AquaMama Exercise, water aerobics, relaxation S: not reported	GH-VAS, EQ-5D, SF36v2, WHOQOL-BREF	Prenatal water activities significantly improved maternal QoL compared to standard prenatal care or no exercise, according to meta-analysis findings.

Abbreviations: EQ-5D: EuroQol Five Dimension Questionnaire; F: frequency; GH-VAS: the Visual Analog Scale for Self-rated General Health; GHQ: General Health Questionnaire; I: intensity; NHP: Cross-cultural adaptation of the Nottingham Health Profile questionnaire; PA: physical activity; PFMT: pelvic floor muscle training; PGWBI: Psychological General Well-being Index; QoL: quality of life; S: setting; SF-12: the Medical Outcome Study Short-Form Health Survey; SF-36: The Short Form (36) Health Survey; SF36v2: Short-form Health Questionnaire version 2

Appendix 3. Search terms (Paper I)

Population	pregnancy, pregnant, nulliparous, prenatal, maternal, antenatal, pregnancy, pregnant, nulliparous, prenatal, maternal, postpartum, postnatal, after delivery, after cesarean section, cesarean section, labor, delivery
Intervention	physical activity, exercise, movement, motor activity, physiotherapy, rehabilitation, pelvic muscle exercises, yoga, pelvic floor muscle training, guidance, guidelines, health promotion, counselling, exercise, therapy, support, education, patient education, prevention, management
Comparison	usual care, no-intervention
Outcome	pelvic floor dysfunction, pelvic floor muscle syndrome, overactive pelvic floor, myofascial pelvic pain, levator tension myalgia, hypertonic pelvic floor muscles, pelvic health, pelvic floor disorder, pelvic girdle pain, pelvic girdle function, pelvic girdle dysfunction, cystocele, urethrocele, rectocele, cystourethrocele, enterocele, anterior vaginal wall prolapse, pelvic organ prolapse, posterior vaginal wall prolapse, pelvic fullness, pubocervical vesical fascia weakness, pelvic pressure, vaginal fullness, vaginal pressure, urinary incontinence

Appendix 4. Methodological quality of included reviews (Paper I)

	Items[a]											
Review (n=9)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
von Aarburg et al 2021	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	9/11
Davenport et al 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11/11
Harvey 2008	N	N	N	Y	Y	N	Y	Y	N	Y	Y	6/11
Lemos et al 2008	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	9/11
Mørkved & Bø 2014	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	9/11
Wagg & Bunn 2007	N	N	N	Y	Y	Y	Y	Y	N	Y	Y	7/11
Woodley et al 2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11/11
Wu et al 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11/11
Yang et al 2022	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11/11

[a] Items from the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses:

1. Is the review question clearly and explicitly stated?
2. Were the inclusion criteria appropriate for the review question?
3. Was the search strategy appropriate?
4. Were the sources and resources used to search for studies adequate?
5. Were the criteria for appraising studies appropriate?
6. Was critical appraisal conducted by two or more reviewers independently?
7. Were there methods to minimize errors in data extraction?
8. Were the methods used to combine studies appropriate?
9. Was the likelihood of publication bias assessed?
10. Were recommendations for policy and/or practice supported by the reported data?
11. Were the specific directives for new research appropriate?

Appendix 5. Characteristics of included reviews (Paper I)

AUTHOR(S), YEAR	NUMBER OF INCLUDED STUDIES	POPULATION, PARTICIPANTS/ RANGE OF SAMPLE SIZE	INTERVENTION(S)	PRIMARY AND SECONDARY OUTCOMES	MAIN FINDINGS RELATED TO UI AND/OR POP
von Aarburg et al. 2021	N=7	Pregnant and postpartum women, N=12 479, 40–10418	F: not reported I: not reported T: not reported Ty: walking, running, bicycling/ spinning, strength and weight training, gymnastics, jumping, swimming, aerobics (low and high impact), aerobic dance/step, prenatal aerobic classes, dancing, pilates, cross-country skiing/roller skiing, ball games, horseback riding, skating/rollerblades S: pregnancy follow-ups or postpartum consultations in hospitals or clinics, sports organizations	Primary: UI	Low-quality evidence suggests no association between PA during pregnancy or postpartum and UI. UI recovery could not be assessed due to insufficient data. Moderate PA is still recommended for its benefits on other obstetrical outcomes.
Davenport et al. 2018	N=24	Pregnant women, N=15 982, 64–10098	F: 1-7x/week I: light to moderate T: duration of interventions was not reported. Interventions were initiated between 9 and 30 GWs. Ty: aerobic exercise, PFMT S: at clinics and home, both independently and/or supervised	Primary: UI	Prenatal exercise including PFMT reduced the odds and severity of UI in women who were continent before the intervention. No therapeutic effect was observed in women who were already incontinent during pregnancy.
Harvey 2003	N=9	Pregnant and postpartum women,	F: 3-7x/week I: one study reported training intensity being 60–70% maximal heart rate	Primary. UI, POP, pelvic floor strength	Postpartum PFMT appear effective in reducing postpartum UI. No data available on POP prevention.

		N=3573, 45–1169	T: one study reported duration of intervention being 12 weeks Ty: PFMT, Kegel contractions, aerobic exercise S: at home and in clinics, direct teaching and supervision of the technique by experienced physiotherapists, both individually and in groups		
Lemos et al. 2008	N=4	Pregnant women, N=675, 72–301	F: 1-10x/a day I: varied T: 16 to 20 weeks. Interventions were initiated in 20 GW. Ty: PFMT S: at home	Primary: UI	PFMT may be effective in reducing the development of postpartum UI, although clinical heterogeneity among RCTs limits the strength of conclusions.
Mørkevd & Bø 2014	N=22	Pregnant and postpartum women, N=3731, not reported	F: varied I: varied; strong (near maximal) contractions T: 12 to 20 weeks. Interventions were initiated between 11 and 24 GWs. Ty: PFMT S: both regular home training and follow-up (monthly and weekly) by a physical therapist	Primary: UI	PFMT is effective when supervised and based on strength-training principles, with near-maximal contractions over at least 8 weeks. Further high-quality RCTs are needed, especially postpartum. PFMT should be routinely included in women's exercise programs due to the prevalence and impact of UI.
Wagg & Bunn 2007	N=6	Postpartum women, N=4380, 72-1800	F: not reported I: not reported T: not reported Ty: PFMT S: interventions were led by nurses, midwives, or physiotherapists and conducted individually or in groups	Primary: UI	Three out of four studies showed short-term improvement in UI symptoms, statistically significant in two. No significant long-term effect was observed. Few trials, variable quality, and heterogeneity in interventions and outcomes limit conclusions. Standardized, high-

					quality studies with long-term follow-up are needed.
Woodley et al. 2020	N=46	Pregnant and postpartum women, N=10832, 20–1800	F: 1-7x/week I: mainly not reported, one study reported progressive PFMT with increased intensity every week T: 8 weeks to 17 months Ty: strength training, physical conditioning program, aerobic fitness, stretching, stabilization exercises, Kegel exercises, PFMT S: at home and/or in exercise class, independently and/or under supervision by a physiotherapist, midwife, nurse, or other qualified person in hospitals	Primary: UI, FI, incontinence specific QoL	Structured PFMT in early pregnancy may prevent UI onset in continent women. Population-based approaches (regardless of continence status) show smaller or no effect. PFMT as treatment for UI in pregnant and postpartum women remains uncertain.
Yang et al. 2022	N=5	Pregnant and postpartum women, N=1132, 70–301	F: home exercises twice a day, in one study not reported, group sessions from once a week to once a month I: not reported T: 6 weeks to 4 months. Interventions were initiated between 16 GWs to 6 weeks after birth. Ty: PFMT S: training was instructed by physiotherapists or midwives in groups	Primary: UI	Weak evidence supports the effectiveness of group-based PFMT during pregnancy in preventing UI. No evidence supports its effectiveness when delivered in the postpartum period.
Wu et al. 2018	N=15	Postpartum women N=3845, not reported	F: not reported I: not reported T: 4 weeks to 9 months. Interventions were initiated between 1 week postpartum to 12 months after birth, but most interventions were initiated at 6–8 weeks after birth.	Primary: POP, Secondary: UI	Postpartum PFMT likely reduces the risk of UI, particularly stress UI. It may improve sexual function. PFMT is unlikely to change POP staging, and its effect on POP symptoms remains uncertain due to very low-quality evidence. Little evidence

			Ty: structured PFMT S: taught and supervised by trained personnel		exists on long-term pelvic floor function.

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