STUDY PROTOCOL

Title: Physical Activity for Women's Health: Effects of a Sensorimotor Program on Body Image and Posture in Postpartum Women

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INTRODUCTION

The postpartum period represents a critical transitional phase in a woman's life, characterized by profound physical, physiological, and psychological changes. The World Health Organization (WHO) defines it as the most critical time for women's health, given the extensive adaptive processes required by the maternal body (Chauhan & Tadi, 2020). Also referred to as the puerperium or "fourth stage of labor," the postpartum period is generally divided into three phases: the acute phase (first 6–12 hours), the subacute phase (2–6 weeks), and a late recovery phase that may extend up to six months, during which connective tissues and muscle tone progressively return to pre-pregnancy conditions. However, although physiological recovery is often described within this six-month timeframe, the postpartum period is increasingly recognized as extending up to 12 months after childbirth, encompassing a broader process of maternal readjustment. Although recovery is often perceived earlier, full physiological restoration does not occur before six months, highlighting the importance of ongoing follow-up (Romano et al., 2010).

Recovery times and modalities vary depending on the mode of delivery. Vaginal birth is typically associated with faster functional recovery, shorter hospital stays, and a reduced traumatic impact; however, complications such as third- or fourth-degree perineal tears and episiotomies may arise, potentially leading to long-term pelvic floor dysfunctions including urinary incontinence, pelvic organ prolapse, or less frequently fecal incontinence (Adewale et al., 2023). Cesarean delivery, though sometimes essential to safeguard maternal or neonatal health, constitutes a major surgical procedure linked to increased risks such as wound infections, hemorrhage, postoperative fever, uterine infections, and dehiscence requiring additional intervention. Compared to vaginal birth, cesarean section generally involves longer hospitalization, more intense postoperative pain, and slower recovery. Abdominal scarring can also affect subsequent pregnancies, promoting conditions such as abnormal placental positioning or abnormally deep placental attachment (Mascarello et al., 2017).

One of the most frequently observed conditions in the postpartum period is diastasis recti abdominis (DRA), characterized by the separation of the rectus abdominis muscles along the linea alba as a response to increased abdominal volume and pressure during pregnancy. This condition affects between 30% and 60% of women in the first few weeks after giving birth (Cavalli et al., 2021). Its occurrence is independent of delivery mode, as it is primarily influenced by mechanical stress on the abdominal wall (Cardaillac et al., 2020). Additional risk factors for greater severity include advanced maternal age and gestational diabetes (Du et al., 2023).

Globally, the rate of cesarean deliveries has significantly increased over the past decades, rising from approximately 7% in the 1990s to over 21% today, with projections suggesting a possible increase to 28.5% by 2030. Nevertheless, vaginal birth remains the predominant mode of delivery, accounting for roughly 79% of births (Betran et al., 2021).

Although clinical attention is often concentrated on the moment of childbirth, scientific literature highlights that this event triggers a cascade of transformations profoundly influencing quality of life, mental health, physical functioning, and body image. Fatigue is among the earliest and most prevalent postpartum symptoms and can be highly debilitating. It goes beyond mere physical tiredness arising from labor and infant care, manifesting instead as a multidimensional phenomenon encompassing cognitive, emotional, and relational domains. Women frequently report an overall sense of exhaustion, accompanied by poor concentration, non-restorative sleep, irritability, and feelings of being overwhelmed (Wilson et al., 2019). Epidemiological data indicate that up to 67% of women experience high levels of fatigue as late as 12 months postpartum. Contrary to common belief, maternal fatigue does not resolve spontaneously in the short term; self-reported fatigue at 14 and 19 months remains comparable to levels observed at 6 weeks postpartum, suggesting a chronic trend in a significant proportion of new mothers (Meltzer-Brody et al., 2017). Fatigue, therefore, emerges as a strong psychological risk factor and a predictor for the onset of mood disorders, compromising not only physical and emotional recovery but also adaptation to the maternal role and the development of a healthy mother–infant bond.

Compared to multiparous women, primiparas experience higher levels of anxiety, uncertainty, adaptive stress, and fatigue, representing an acute period of vulnerability. First-time mothers face a radical reorganization of identity and daily routines without prior experiential reference points, leading to greater difficulties in infant management, lower perceived self-efficacy, and greater exposure to performance-related stress. Social and personal expectations surrounding first-time motherhood may intensify frustration, feelings of inadequacy, and further emotional strain (Shakarami et al., 2021). A 2019 study by Wilson, Lee, and Bei demonstrated a significant correlation between fatigue and symptoms of postpartum depression (PPD); fatigue was present in 73% of women diagnosed with depression. PPD affects an estimated 10–15% of women within the first postpartum year, exerting profound effects not only on mothers but also on family dynamics and children's social and cognitive development (Pritchett et al., 2020).

Infant care entails unpredictable rhythms and adjustments, amplifying anxiety and restlessness, and worsening what is often described as "maternal brain fog." Failure to restore mental energy reserves can adversely affect everyday decision-making and emotional regulation (Okun et al., 2018). Physical fatigue is closely intertwined with emotional exhaustion. Holding the baby for prolonged periods, often in asymmetrical, repetitive positions during feeding, soothing, or rocking ,leads to compensatory postures, increased joint load, and biomechanical alterations during walking, as well as muscular overload and

postural imbalance, particularly affecting the upper limbs, spine, and weakened core muscles (Li et al., 2024).

During pregnancy, women undergo significant postural adaptations as the growing abdomen shifts the center of gravity forward, stretching the abdominal wall and increasing lumbar lordosis. To compensate for the added load of fetal growth, there is heightened neuromuscular activation of spinal extensors and hamstring muscles (Conder et al., 2019). Consequently, excessive spinal pressure and lumbar pain are common, often persisting beyond childbirth (Cheng et al., 2020). Lumbopelvic instability may also arise from pelvic floor hypotonia, caused by muscle fiber stretching or trauma during vaginal delivery. These changes hinder restoration of postural balance, as the deep abdominal muscles, pelvic floor, multifidus, and diaphragm, key components of central stability, become weakened and poorly coordinated. Uneven weight distribution may follow, resulting in localized overloading, back pain, balance difficulties, and early-onset fatigue (Diez-Itza et al., 2011).

Following delivery, although abdominal volume decreases markedly, muscular and connective integrity remain compromised. DRA may persist for several months or years postpartum, leading to reduced abdominal strength, impaired core stability, and postural alterations (da Mota et al., 2015). Musculoskeletal pain may cause varying degrees of disability, compromising psychomotor function, muscular strength, range of motion, and the ability to perform routine tasks such as breastfeeding, lifting the baby, dressing, or engaging in repetitive movements. The cervical region is the most frequently affected, followed by the shoulder, arm, wrist, and hand, revealing a widespread clinical picture across the upper limb. Chronic pain can alter self-perceived physical strength and motor capacity. Even without true neuromuscular deficits, women often experience fatigue and weakness, reducing confidence in their physical abilities, affecting movement, emotional well-being, and social functioning (Algabbani et al., 2025).

Empirical evidence reveals a strong correlation between depressive symptoms and musculoskeletal pain: women with higher scores on the Edinburgh Postnatal Depression Scale (EPDS) report greater pain intensity, suggesting that depression can heighten pain perception (Chen et al., 2021). This correlation may form a vicious cycle in which pain exacerbates depressive symptoms, and vice versa, negatively influencing quality of life and the mother–child relationship.

Beyond postural changes, women face additional physical transformations, weight gain, stretch marks, swelling, and abdominal shape alterations, which can diminish body satisfaction and self-esteem, key components of sexual desire and satisfaction. Dissatisfaction with body image, compounded by sleep deprivation, chronic fatigue, and relational stress, can profoundly affect psychosocial well-being, fostering feelings of inadequacy, decreased partner intimacy, and heightened anxiety, depression, and frustration (Gutzeit et al., 2020).

Global health authorities, including the National Institute for Health and Care Excellence (NICE) (Lowenhoff et al., 2017) and the American College of Obstetricians and Gynecologists (ACOG,

2018), acknowledge pharmacological interventions (e.g., SSRI antidepressants) for postpartum mood disorders, though they recommend personalized assessments before prescription. Nonetheless, public healthcare systems often fail to provide timely and adequate responses, and untreated emotional distress may result in severe outcomes such as impaired mother–infant bonding, recurrent depressive episodes, and intensified emotional suffering. Psychotropic medications, particularly in treatment-resistant depression or PPD, entail significant costs, estimated at €2,600–€4,000 annually per patient in Italy, alongside indirect economic burdens such as lost work productivity, approximately €7,000 per year (Ruggeri et al., 2022).

Studies suggest that psychological interventions may be more cost-effective and beneficial compared to pharmacological treatments, especially concerning mother–infant relational health (Verbeke et al., 2022). Complementarily, Kołomańska-Bogucka and Mazur-Bialy (2019) highlight adapted physical activity as a preventive and therapeutic strategy both during and after pregnancy. Empirical evidence confirms that women who remain physically active before and during pregnancy exhibit significantly lower risk of developing emotional and musculoskeletal disorders, with enhanced muscular tone and readiness for childbirth (Sánchez-Polán et al., 2021).

Through exercises targeting joint mobility, muscle elasticity, and pelvic floor function, antenatal exercise programs improve body awareness and posture perception during pregnancy while promoting stress and anxiety reduction. A meta-analysis of 32 randomized controlled trials found that structured prenatal exercise does not significantly reduce the incidence of pelvic girdle pain (PGP), low back pain (LBP), or lumbopelvic pain (LBPP), but notably diminishes their intensity during pregnancy and early puerperium (Davenport et al., 2019).

While prenatal physical activity is now widely recommended and integrated into childbirth preparation programs, postpartum exercise remains underemphasized despite growing evidence of its efficacy in enhancing physical, psychological, and functional health. The postpartum phase, though critical, offers an opportunity for optimal recovery and a safe reintroduction to daily activities and, for some, sports (Liu et al., 2019). Recent Canadian guidelines (2025) recommend at least 150 minutes per week of moderate-intensity physical activity incorporating strength and pelvic floor exercises (Davenport et al., 2025). Australian and global postpartum guidelines further underline the need for personalized exercise programs that consider delivery mode, muscle function, DRA, pelvic floor dysfunction, mental well-being, sleep, and stress management (Evenson et al., 2024).

The 2022 report Maximizing Recovery in the Postpartum Period proposes a progressive rehabilitation model beginning in the first weeks postpartum with breathing and core activation exercises, and advancing toward full return to sport, emphasizing personalized follow-up (Selman et al., 2022). Meta-analyses confirm that structured physical activity, especially low-intensity group-based aerobic exercise, significantly reduces depressive and anxiety symptoms, both preventively and therapeutically (Xu et al.,

2023). Integrating exercise with social support further enhances mood-related benefits (Singh et al., 2023).

Trials by Nicklas et al. (2024) demonstrate that well-structured programs, supported by apps or online platforms, effectively reduce body weight and improve metabolic parameters (e.g., glucose, lipids) while promoting healthy lifestyle habits. Structured resistance training (LeCheminant et al., 2014) improves maternal self-efficacy, infant management, body image, and overall quality of life (Anggraeni et al., 2019). Incorporating psychoeducational, musical, or interactive components increases engagement and reduces mother–infant sedentary behavior (Tuominen et al., 2015). Combined physical and emotional training enhances both mood and life satisfaction.

Pelvic floor rehabilitation, including biofeedback, online support, and physiotherapy, is proven to strengthen perineal muscles, reduce incontinence, and prevent pelvic organ descent (Tennfjord et al., 2020; Höder et al., 2023). Given that vaginal delivery carries higher risk of pelvic dysfunctions than cesarean, adequate postnatal motor programs are crucial.

However, barriers such as time constraints, fatigue, and family responsibilities often hinder regular postpartum physical activity, and the discontinuation of exercise may become persistent. Conventional resistance and aerobic programs alone often fail to meet holistic postpartum needs, highlighting the demand for specialized interventions such as neuromuscular exercise (NEMEX), sensorimotor, and task-oriented training focused on stability, balance, proprioception, and motor control (Saadat et al., 2019). Proprioceptive training, in particular, aims to restore sensory and motor joint function by improving alignment, posture, and joint control (Jeong et al., 2019).

Beyond functional recovery, such methods enhance body awareness, a key factor in self-perception and confident reintegration into daily life. A particularly relevant technique for postpartum rehabilitation is the Gyrokinesis® Method, developed in the 1980s initially for dancers and subsequently introduced into fitness and rehabilitation contexts. This neuro-sensorimotor approach blends elements of Yoga, Tai Chi, and dance, emphasizing proprioception, breathing, and fluid, curvilinear movements that stimulate somatic receptors (muscle spindles, Pacinian and Ruffini corpuscles), improve posture, and reduce joint stress. In postpartum contexts, Gyrokinesis® can be easily adapted for new mothers and practiced with music to enhance relaxation and motivation. Studies on Gyrokinesis® in individuals with chronic low back pain indicate improvements in strength, lumbar stability, and functionality comparable to traditional stabilization exercises (Seo & Kim, 2019). Likewise, targeted sensorimotor training in the postpartum phase significantly reduces lumbopelvic pain and disability (Min et al., 2025).

The Pilates method, similar in its objectives, emphasizes posture, core stability, breathing, and joint control, proving effective in restoring muscle function and postural balance postpartum (Manca et al., 2024). By acting on the abdominal wall, Pilates reduces inter-recti distance in cases of diastasis, enhances abdominal strength, and alleviates lumbopelvic pain (Lee et al., 2023).

Among sensorimotor approaches, Yoga, thanks to its integration of controlled movement, mindful breathing, and relaxation techniques, has emerged as a valuable addition to postpartum rehabilitation protocols, promoting proprioception, balance, and body awareness (Buttner et al., 2015).

RESEARCH OBJECTIVES

The primary objective of this randomized study will be to analyze the effect of an innovative, 24-week integrated sensorimotor training protocol combining Pilates, GYROKINESIS®, and yoga on body image awareness, assessed using the Body Image Dimensional Assessment (BIDA), as well as on postural alignment and body composition in women during the postpartum period. Postural alignment will be objectively assessed using the Gyko inertial sensor and Moti Physio, while body composition will be evaluated through bioelectrical impedance analysis (BIA). Second, the effect of the protocol on perceived quality of life will be assessed through the evaluation of depression, stress, and sleep quality using validated scales: the Edinburgh Postnatal Depression Scale (EPDS), the Perceived Stress Scale (PSS), and the Pittsburgh Sleep Quality Index (PSQI). Functional parameters, including the Single-Leg Stance Test, 30-Second Sit-to-Stand Test, Handgrip Strength Test, and the International Physical Activity Questionnaire (IPAQ), will also be assessed to evaluate physical fitness, activity levels, and adherence to the motor protocol through participation rates. The effects of the sensorimotor protocol will be compared with those of a more conventional strength training protocol and with those of a usual-care group that will receive information regarding the importance of engaging in physical activity after childbirth. To achieve these objectives, the experimental design involves 45 women who will be divided into 3 groups:

• **SENSOMOTOR training group (SEN Experimental Treatment 1):** will follow a specific training program based on a combination of Pilates, GYROKINESIS®, and yoga. This is the main experimental treatment, on which the assessment of postural, perceptual, and psychological effects will focus.

• **COUNTER-RESISTANCE Training Group (CR Experimental Treatment 2):** will participate in a strength training program with counter-resistance exercises, already widely used in clinical practice and postpartum functional rehabilitation. This group allows for a comparison of the effects of the sensorimotor protocol with a validated and widely used treatment.

• **USUAL CARE (UC) Group:** This group will not follow any structured program but will receive general usual care guidelines provided by medical staff. This group serves as a control and allows for distinguishing the specific effects of the two interventions compared to the absence of treatment.

All assessments will be conducted according to the following timeline:

• T0 (third trimester of pregnancy): baseline assessment of inclusion and exclusion criteria, administration of psychological questionnaires, and postural assessment.

• T1 (3 months postpartum): prior to the start of the project activities, administration of psychological questionnaires, postural assessment, and fitness tests.

• T2 (6 months postpartum): interim assessment after 3 months of intervention; see T1.

• T3 (9 months postpartum): final assessment at the end of the 24-week training period; see T1.

• Follow-up (6 months after the end of the protocol): re-administration of questionnaires to analyze long-term effects.

METHODS

Patient recruitment will take place through the Obstetrics and Obstetric Pathology Unit at the Isola Tiberina Gemelli-Isola Hospital. The inclusion criteria are women in their third trimester of pregnancy, aged between 18 and 45 years, who engage in less than 150 minutes of physical activity per week. Exclusion criteria include the presence of severe comorbidities and higher levels of physical activity. Before the study begins, participants will receive a detailed explanation of the study design and procedures. Informational materials outlining the potential risks and benefits will be provided. Recruitment will be voluntary, without any external coercion. Participants may withdraw from the study at any time without penalty. After fully understanding the study, participants will be asked to provide written informed consent authorizing the researchers to proceed with the intervention. To ensure data confidentiality, each participant will be assigned a unique identification number. Data collection will be limited to information necessary for the study, avoiding the collection of direct or indirect identifiers unrelated to the research objectives. The intervention protocol will begin only after approval by the ethics committee.

PARTICIPANTS AND STATISTICAL POWER ANALYSIS

The randomized controlled trial aims to enroll at least 45 women to form three study groups of 15 women each: the SENSOMOTOR training group (SEN), which will perform the 24-week integrated sensorimotor training program; the resistance training group (RTG), which will undergo 24 weeks of resistance training; and the control group (CG), which will continue standard care. The total number of subjects required for participation was estimated based on a priori statistical power analysis. This analysis was calculated using the G*Power software (G*Power V 3.1.3 Franz Faul, University of Kiel, Germany), assuming a multivariate approach for within-group effects (MANOVA for repeated measures). The following parameters were considered for the procedure: the effect size for the main variable f=0.25 (calculated from a partial framework of age $\eta 2p=0.10$ - medium effect); $\alpha=0.05$; and the correlation for repeated measures r=0.5032 (Raposo, Ramos, & Lúcia Cruz, 2021).

EVALUATION AND TRAINING PROTOCOL

All women included in the project will undergo postural evaluations and fitness tests at the Laboratory of Exercise Science and Sports at the University of Rome "Foro Italico," under the guidance of kinesiologists specializing in adapted physical activity.

(Table 1).

Assessment	**Variable assessed**	**Assessment timing**
Body Image Dimensional Assessment (BIDA)	Self-acceptance	T0, T1, T2, T3, T4
Edinburgh Postnatal Depression Scale (EPDS)	Postnatal depressive symptoms	T0, T1, T2, T3, T4
Perceived Stress Scale (PSS)	Perceived Stress	T0, T1, T2, T3, T4
Pittsburgh Sleep Quality Index (PSQI)	Perceived sleep quality	T0, T1, T2, T3, T4
Short Form Health Survey 36 (SF-36)	Perceived physical, mental, and general health	T0, T1, T2, T3, T4
IPAQ	PA level	T0, T1, T2, T3, T4
Physical Functioning Assessment		
Moti-Physio	Body posture	T0, T1, T2, T3, T4
Gyko inertial sensor	Postural alignment	T0, T1, T2, T3, T4
Trunk Rotation, Scratch Teste and Sit And Reach	Range of motion and flexibility	T0, T1, T2, T3
Single Leg Stance and Step Test	Balance, static and dynamic, and postural sway (using inertial sensor)	T0, T1, T2, T3
Handgrip Strenght Test	Overall muscle power	T0, T1, T2, T3
30" Sit to Stand	Indirect lower strength and power	T0, T1, T2, T3
BIA	Body Composition	T0, T1, T2, T3, T4

Tab. 1: Variables analysed and timing

At the end of this preliminary phase, participants will be randomly assigned to three groups. The two activity groups will meet twice a week for training sessions lasting approximately 60 minutes each, for a total duration of 6 months. One session will be held in person at the University of Rome "Foro Italico" gyms, and one online via Google Meet. All sessions will be led by kinesiologists specializing in preventive and adapted physical activity.

COMPLIANCE:

Although it is difficult to find reference values, analyzing compliance with a specific training protocol can improve our understanding of the phenomenon. Compliance with the current intervention will therefore be assessed based on the rate of participation in scheduled sessions, which will be divided into quartiles as follows:

High compliance (75–100%);

Moderate compliance (50–75%);

Low compliance (25–50%);

Very low compliance (0–25%).

Arm Description 1 – Sensorimotor Training (SEN)

Participants will follow a 24-week integrated sensorimotor training program combining principles of Pilates, Gyrokinesis®, and Yoga. The intervention is designed to enhance proprioception, motor control, breathing coordination, and postural alignment through controlled, low-impact, and fluid movements. Specific focus is placed on deep core activation (transversus abdominis, pelvic floor), spinal mobility, and neuromuscular coordination. Exercises include multi-planar movements, balance challenges, and breathing-integrated sequences. Sessions are performed twice weekly (one in-person, one online), lasting ~60 minutes, and are supervised by qualified exercise professionals.

Arm Description 2 – Resistance Training (CR)

Participants will engage in a structured 24-week resistance training program aimed at improving muscular strength and functional capacity. The protocol includes progressive exercises targeting major muscle groups (lower limbs, upper body, and core) using bodyweight, resistance bands, and light external loads. Intensity and volume will be progressively increased according to individual capacity. Sessions are conducted twice weekly (one in-person and one online), lasting approximately~60 minutes, and follow standard guidelines for postpartum exercise.

Arm Description 3 – Usual Care (UC)

Participants in the control group will receive standard postpartum care, including general recommendations on physical activity, recovery, and healthy lifestyle provided by healthcare professionals. No structured or supervised exercise program will be prescribed. This group will serve as a comparator to evaluate the specific effects of the two exercise interventions.

STUDY RELEVANCE

Perceptual changes in body image and postural alignment in women after their first childbirth represent some of the most significant and debilitating aspects of this delicate period, with serious repercussions on both the psychosocial and motor levels. A central focus of this study is the analysis of the effects of a well-structured exercise program on body image and postural alignment. Pilates and Yoga, which have been extensively studied in the literature, along with the innovative and relatively recent GYROKINESIS® method, could serve as effective and easily accessible tools for improving body function and body awareness. Furthermore, thanks to the progressive nature, adaptability, and safety of the proposed exercises, these methods could significantly help combat postpartum depression, improve the mother-child relationship, and reduce feelings of fatigue and anxiety levels associated with the physical, hormonal, and emotional changes typical of the postnatal period. This training method could promote increased levels of physical activity and greater adherence to the exercises recommended by the WHO.

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