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Physical Activity in Pregnancy: A Preventive Measure Against Postpartum Depression

Jakub Sadowski J.S.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0005-2259-0958
e-mail: medsadowski@gmail.com

Julia Dołęga J.D.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0001-0176-7145
e-mail: julkadolega1@gmail.com

Bartłomiej Zabawa B.Z.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0005-2419-4748
e-mail: bartek.zabawa1@gmail.com

Małgorzata Łabuś M.Ł.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0003-2799-4375
e-mail: gosia.labus@gmail.com

Karol Krzykawski K.K.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0007-4497-2927
e-mail: krzykawski1poczta@gmail.com

Łukasz Stanisław Papież Ł.S.P.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0000-1235-0057
e-mail: lukaszpap14@gmail.com

Tomasz Maciejczyk T.M.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0005-2517-2508
e-mail: tomasz.maciejczyk00@gmail.com

Antoni Sieńko A.S.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0001-6753-7895
e-mail: antsienko@gmail.com

Patrycja Hudzińska P.H.

Medical University of Silesia, ul. Poniatowskiego 15; 40-055 Katowice, Poland
https://orcid.org/0009-0000-5881-0733
e-mail: patrycjahudzinska@gmail.com

Piotr Mól P.M.

The Sergeant Grzegorz Załoga Hospital of the Ministry of the Interior and Administration, st. Wita Stwosza
39-41, 40-042 Katowice, Poland
https://orcid.org/0009-0006-8007-1934
e-mail:piotrmol1999@gmail.com

ABSTRACT

Introduction: The aim of this study is to present current knowledge on the role of physical activity during pregnancy in reducing postpartum depression (PPD) symptoms. PPD is a widespread mental health condition, which significantly impacts maternal and neonatal well-being. Exercises during pregnancy are recognized as a preventative strategy that promotes both physical and mental health, benefiting mothers and their children.

Materials and Methods: The study involved a systematic review of the literature using databases such as PubMed, NCBI, and Google Scholar. Key terms included "postpartum

depression", "physical activity", “baby blues” and "mental health." Articles without full-text access were excluded.
State of Knowledge: Postpartum depression affects up to 15% of women, while baby blues impact around 80% shortly after childbirth. Physical activity improves emotional health by alleviating stress, anxiety, and depressive symptoms. Evidence highlights that regular, moderate exercise during pregnancy can significantly reduce the risk of PPD, particularly in women with high-risk factors such as obesity or a history of mental health disorders. Mechanisms include hormonal regulation, endorphin release, and reduced inflammation. While light to moderate activities like walking, swimming, or yoga are beneficial, high-intensity exercise may pose risks and should be approached with caution.
Conclusions: Physical activity during pregnancy is a non-pharmacological intervention, which mitigate PPD risks. Tailored, safe exercise routines, improve mental resilience and overall health in pregnant mothers. Further research is needed to refine exercise recommendations based on individual health profiles.

Keywords: "postpartum depression", "physical activity", "baby blues", "mental health"

INTRODUCTION

Postpartum depression (PPD) and related maternal mood disorders represent a significant public health challenge, with depressive disorders affecting both maternal and newborn health [1,2]. During pregnancy and the postnatal period, women experience numerous physical and mental changes, with childbirth and the new role of motherhood sometimes associated with negative emotions, uncertainty, fear, anxiety, depression, or sadness [2].

The World Health Organization recognizes physical activity as any bodily movement requiring energy expenditure, including leisure, transport, work, and domestic activities [3]. Regular physical activity during pregnancy has emerged as a crucial factor in promoting both maternal and fetal health outcomes. Studies demonstrate that exercise during pregnancy reduces the risk of various complications, including pre-eclampsia, gestational hypertension, gestational diabetes, excessive weight gain, delivery complications, and notably, postpartum depression [3].
Quality sleep and physical activity during both pregnancy and the postpartum period may significantly reduce PPD risk or help improve PPD symptoms [4]. The evidence suggests that maintaining regular physical activity during pregnancy and the puerperium period can be an essential preventive measure against depressive disorders in the postnatal period [5]. This relationship between physical activity and mental health outcomes during pregnancy represents a promising avenue for intervention, particularly given the significant impact that maternal mental health has on both mother and child well-being [6].
Recent systematic reviews and meta-analyses have consistently shown that physical activity during pregnancy brings numerous benefits, including reducing the risk of complications during childbirth and PPD, while helping to maintain a healthy body weight [6]. This evidence underscores the importance of incorporating regular physical activity into prenatal care protocols as a preventive strategy against postpartum mental health challenges.

MATERIALS AND METHODS

A review of the available literature was conducted using databases such as "PubMed," "NCBI," and "Google Scholar." The search was based on keywords including "postpartum depression," "physical activity," "baby blues," and "mental health." Articles that were not available in full-text format were excluded. This ensured the selection of publications that provide reliable information on the relationship between postpartum mental health and physical activity.

The collected information underwent careful analysis, involving a comprehensive evaluation of its reliability and a thoughtful assessment of its potential significance within the research context.

STATE OF KNOWLEDGE

1.Postpartum depression and baby blues - the prevalence and the scope of the problem

Postpartum depression and baby blues are emotional states that affect many women during the postpartum period. Their occurrence has significant implications for the mother's mental health, the quality of family relationships, and the child's development [7,8]. According to epidemiological studies, perinatal depression affects approximately 15% of individuals during the perinatal period, with prevalence varying depending on cultural, socio-economic factors, and the availability of healthcare [9]. Although the term "postpartum depression" is commonly used in popular literature, the more accurate term is "perinatal depression," as its onset can occur both before pregnancy (27% of cases), during pregnancy (33%), and after childbirth (40%) [10].

According to a report by the World Health Organization (WHO), up to 80% of women may experience various emotional difficulties during the postpartum period, commonly referred to as "baby blues" [11,12]. Symptoms of baby blues, such as mood swings, irritability, tearfulness, and anxiety, typically appear on the 3rd to 5th day after childbirth and last for about two weeks. Although this is a temporary condition that usually does not require medical intervention, it may act as a risk factor for the development of more severe PPD, especially if the symptoms worsen or persist for a longer period [13].
Perinatal depression is a topic extensively explored in the scientific literature; however, the issue of suicides within this population remains relatively under-researched and inadequately addressed in the current body of work [14]. A study conducted across three hospitals in Chongqing [14] involved 213 Chinese mothers to assess fluctuations in depression levels and suicidal ideation before and after childbirth, as well as their associations with socio-demographic and psychosocial factors. The results revealed that the prevalence of depressive symptoms was similar before childbirth (14.08%) and after childbirth (16.43%). However, a significant reduction in overall symptoms, such as anxiety, sadness, tearfulness, and sleep disturbances, was observed postpartum. At the same time, the prevalence of suicidal ideation increased from 5.16% before delivery to 11.74% after delivery. The findings suggest that while depressive symptoms may improve postpartum, suicidal ideation becomes more prevalent. In another cohort study conducted by Yu et al. [15], which included 952,061

participants and a maximum follow-up of 18 years, mothers with clinically diagnosed perinatal depression were found to have a threefold increased risk of suicidal behavior compared to those without perinatal depression. The highest risk was observed within the first year following the diagnosis of PPD (HR 7.20; 95% CI 6.07–8.54), with the elevated risk persisting over a period of 5 to 18 years and remaining statistically significant (HR 2.34; 95% CI 2.12–2.57).
One of the most widely employed screening instruments for assessing the risk of PPD is the Edinburgh Postnatal Depression Scale (EPDS), developed in 1987 by Cox and colleagues [16]. The EPDS scale consists of 10 questions that relate to the emotions and experiences of a woman over the past week. These questions cover areas such as the ability to feel pleasure, mood, sleep disturbances, anxiety, and thoughts of self-harm. Each question offers four possible responses, rated from 0 to 3, with a maximum score of 30 points. Typically, a score exceeding 10-13 points suggests the need for further diagnostic evaluation. However, it is important to note that the EPDS serves as a screening tool and does not replace a full clinical diagnosis. The results may be influenced by subjective responses from patients, who, fearing stigma, may not disclose their true feelings.

2.The impact of hormonal changes on perinatal mental disorders

The causes of postpartum depression stem from a complex interplay of biological, psychosocial, and environmental factors. Hormonal changes are considered one of the key factors in the development of perinatal mental disorders, as during pregnancy and after childbirth, there are drastic fluctuations in hormone levels, which significantly impact the functioning of the brain and nervous system. [7] During pregnancy, the level of estradiol in a woman's body increases by as much as 100 times, and then rapidly drops in the first few days after childbirth. Such a drastic change in hormone levels can have neurobiological consequences that predispose individuals to develop PPD [7].

There is no conclusive evidence of a direct link between hormone levels and PPD, although the timing of symptom onset correlates with dramatic changes in reproductive hormone levels, making it difficult to completely rule out their role in the development of depression. The brain's sensitivity to fluctuations in these hormones may vary. A study by M. Bloch and colleagues [17] showed that low levels of estradiol and progesterone exacerbate depressive symptoms only in women with a previous history of PPD, suggesting their brains may react differently to hormonal changes. There is also the possibility that estrogen therapy could reduce the risk of PPD [18], but further research is needed to confirm this.

It is known that estrogen signaling affects the function of the hypothalamic-pituitary-adrenal (HPA) axis, suggesting that dysregulation of reproductive hormone levels may disrupt the balance of stress hormones, which are considered another potential biochemical mediator of depression, thereby contributing to the development of PPD [7].

The research on the impact of progesterone on PPD is inconclusive - some studies suggest that higher levels of progesterone are correlated with worse outcomes in PPD [19], and that progesterone treatment increases the risk of PPD [18]. Other studies have shown that progesterone treatment reduced the recurrence of PPD in women with previous postpartum depressive episodes [20]. Clinical studies leave the impact of progesterone on the treatment of PPD unresolved, highlighting the need for further research.

Studies have shown that lower levels of oxytocin may predict the onset of PPD and the severity of its symptoms [21]. On the other hand, another study by Massey SH et al. indicated that oxytocin levels only predicted PPD symptoms in patients with a significant history of depression [22].
Changes in reproductive hormone levels can lead to PPD by influencing neurosteroids such as dehydroepiandrosterone (DHEA) and allopregnanolone (ALLO). These neurosteroids modulate neurotransmitters, including GABA and glutamate, which play a crucial role in mood regulation. DHEA has antidepressant effects, and its abnormal secretion is linked to depression [23]. However, most research focuses on ALLO, which modulates the GABA receptor, influencing anxiety reduction. ALLO levels are lowered in depression but increase with effective treatment. Its absence can lead to anxiety symptoms and disruptions in nervous system function. ALLO also impacts biological processes associated with depression, such as HPA axis regulation, neuroprotection, and immune function [24]. Postpartum women have lower levels of ALLO and GABA compared to healthy women in the follicular phase of the cycle. Although ALLO levels may be normal in women with PPD, reduced connectivity between brain structures such as the anterior cingulate cortex, amygdala, and hippocampus suggests that fluctuations in ALLO during the postpartum period may trigger depressive symptoms in vulnerable women [25].

3.Predictive factors and risk factors for the development of perinatal mental disorders

Predictive factors and risk factors for the development of perinatal mental disorders are complex and include both biological and psychosocial aspects. Research indicates that previous mental disorders play a key role in predicting the occurrence of perinatal mood disorders. Past episodes of mental disorders, such as PPD or anxiety disorders, especially during previous pregnancies, are a strong indicator of the risk of their recurrence in subsequent pregnancies [26].

M. Kaźmierczak et al. [26] conducted a prospective cross-sectional study involving 106 women in the third trimester of pregnancy and up to 6 weeks postpartum to assess the severity of risk factors in the treatment of perinatal mental disorders and to determine the conditions underlying mood disorders. The EPDS scale and the Life Orientation Test were used to evaluate the mental state. Among the participants, 9.43% experienced mental health problems, and 8.49% received treatment in a psychiatric ward. Antidepressants were taken by 6.6% of the respondents. The analysis of the above data demonstrated a statistically significant correlation between EPDS scale parameters postpartum and pre-pregnancy mental disorders ($p < 0.01$) [26].
Moreover, women with a history of menstrual disorders, such as premenstrual syndrome (PMS) or premenstrual dysphoric disorder (PMDD), have a higher risk of developing mental disorders during pregnancy and postpartum. These disorders may indicate pre-existing issues with hormonal regulation, which intensify during pregnancy. In the study by M. M. Buttner et al., the role of PMS/PMDD as a risk factor for PPD was examined. The occurrence of symptoms of these conditions was assessed retrospectively using the Premenstrual Symptoms Screening Tool (PSST), and depression was diagnosed according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), and evaluated using the Hamilton Depression Rating Scale (HDRS). It was established that PMS/PMDD is a significant risk factor for PPD and that women with a history of PMS/PMDD should be monitored during the perinatal period [27].

Biological factors, such as BMI and chronic somatic illnesses, play a significant role in the context of PPD risk. Studies by K. Howard et al. indicate that women with a higher BMI during pregnancy have an increased risk of developing PPD. In this case as well, the researchers used the EPDS to assess the severity of depressive symptoms in the participants. It was established that women with overweight and obesity scored higher on the EPDS compared to women with a normal BMI before pregnancy. Gestational diabetes and pre-gestational diabetes may also significantly increase the risk of PPD [28,29].
An elevated level of inflammatory markers is another risk factor correlated with an increased risk of PPD. A systematic review by A. Silva-Fernandes et al. of 56 cross-sectional and case-control studies aimed to analyze the association between PPD and inflammatory biomarkers during pregnancy and the postpartum period. The results of the systematic review support the hypothesis that several inflammatory markers may be

associated with PPD symptoms. These associations varied somewhat between pregnancy, delivery, and the postpartum period and primarily involved elevated levels of IL-6, IL-8, CRP, and TNF-α in individuals with depression [30]. Increased activity of pro-inflammatory cytokines affects the functions of the hypothalamic-pituitary-adrenal axis, which is crucial for mood regulation [31].

Estrogen has a protective effect on the nervous system, and its dysregulation can lead to mood disorders during the perinatal period. This hormone acts neuroprotectively and enhances serotonin function, thereby also contributing to the reduction of inflammation. Sudden drops in estrogen levels are associated with the development of PPD [32,7].
Other hormonal disorders that are a risk factor for the development of perinatal mental disorders include increased cortisol levels and the presence of thyroid dysfunction [33,34]. M. Aas et al. studied 14 women with postpartum psychosis (PP) and 14 at risk for PP (with a history of bipolar or schizoaffective psychosis) and measured their salivary cortisol levels compared to a control group of 26 healthy women. They found higher cortisol levels 30 minutes after awakening in women with PP compared to the control group [33]. In contrast, the study by V. Bergnik et al. involved measuring thyroid hormone levels (TSH and free thyroxine) in the blood of 31 primiparous women with PP compared to a control group of 177 healthy women. Their work resulted in the detection of autoimmune thyroid disease (ATID) four weeks postpartum in 19% of women with PP, compared to only 5% of women with ATID in the control group [34].
An important non-modifiable risk factor for PPD is the age of the pregnant woman. M.E.Sliverman et al. conducted a nationwide prospective cohort study of all women who delivered a live birth in Sweden between 1997 and 2008. They showed that advanced age increased the risk of PPD [29].

4.The relationship between exercise and mental health

Regular exercise is not only beneficial for the body, but also for the mind. Research indicates a significant connection between training intensity and the occurrence of dysphoric disorders. Engaging in physical activity may also positively influence psychological factors like self-esteem and perceived physical competence [35], as enhanced fitness levels contribute to both subjective and objective improvements in physical health [36]. Other studies highlight a dose-response relationship, showing that greater engagement in moderate-to-vigorous physical activity (MVPA) is linked to reduced likelihood of experiencing depressive symptoms. The

study by Laird E et al. reported that engaging in 600–1200 metabolic equivalent minutes(MET) minutes per week of MVPA reduced the odds of major depression by 44%, with the greatest decline observed at 2400 MET-minutes or more per week, being a 49% lower risk [37]. It's worth noting that physical activity has protective effects on depression across different geographical regions, and for people of all ages [35]. Also the performed training does not have to be challenging, since even minimal exercise, such as 20 minutes per week of activities like household tasks, walking, or sports, was associated with reduced levels of psychological distress [38].

On the other hand, a meta-analysis of 49 prospective cohort studies covering 1,837,794 person-years found a 17% decrease in odds of depression in people with high levels of physical activity compared to people with low physical activity [35]. Furthermore, a meta-analysis of 11 prospective studies revealed that sedentary behavior is linked to a higher risk of developing depression over time [39].
Kandola A et al. also has examined how moderate-to-vigorous physical activity helps reduce symptoms of depression and anxiety by triggering neurochemical changes, including elevated serotonin and dopamine levels. Exercise also combats inflammation and enhances resilience to oxidative and physiological stress. A promotion of self-esteem, social support and self-efficacy was also observed [40].
A notable study conducted by Pearce M et al. [41] highlighted that the beneficial effect of physical activity has a threshold. Compared to adults who reported no physical activity, those engaging in half the recommended amount (4.4 marginal metabolic equivalent task hours per week [mMET-h/wk]) experienced an 18% reduction in risk of depression. What's more, adults accumulating the recommended volume of 8.8 mMET hours per week had 25% lower risk. Similarly, Hamer M et al. demonstrated a dose-response relationship, showing a greater reduction in risk with higher volumes and/or intensities of physical activity [38]. However exposure levels exceeding 8.8 mMET show diminishing benefits and higher inconstancy [41].
There are reports suggesting that average scores on the Center for Epidemiologic Studies Depression scale (CESD-10) decreased, while mental health scores improved with higher levels of past, current, and habitual physical activity. Women engaging in at least 60 minutes of moderate-intensity exercise per week had 30% to 40% lower odds of having CESD-10 scores ≥10 or mental health scores ≤52 at S3, compared to those who exercised less than this amount [42].
According to the work of Galper DI et al. [43], which analyzed 5451 men and 1277 women (20-88 yr), inactive people exhibit greater depressive symptom severity than insufficiently active people and highly active people. Moreover, insufficiently active individuals exhibited greater depressive symptom severity than those

who were sufficiently and highly active, implying the existence of the previously mentioned dose-response pattern. A similar positive association, between physical activity and estimated mean General Well Being (GWD) scores, was also identified in men as well as in women [43].

5.Physical activity during pregnancy - limitations, guidelines and benefits

The limitations of physical activity (PA) during pregnancy are an important aspect of caring for the health of the mother and fetus, particularly in cases of specific conditions and risks. Generally, pregnant women without comorbidities can engage in moderate physical activity, which provides numerous benefits, including improved cardiovascular fitness, reduced risk of

depression, and decreased prevalence of obesity in society [44,45]. A systematic review and meta-analysis by M.H. Davenport et al. [46], analyzing 106 studies, demonstrated that regular exercise during pregnancy was associated with approximately a 40% reduction in the risk of major pregnancy complications, such as preeclampsia, gestational hypertension, and gestational diabetes

[46].On the other hand, B. Muktabhanti et al. [47] conducted a meta-analysis of 24 randomized clinical trials involving 7,096 participants and demonstrated that interventions involving diet, physical exercise, or both reduced the risk of excessive gestational weight gain (GWG) by an average of 20% (mean relative risk [RR] 0.80, 95% CI 0.73 to 0.87) [47]. This indicates significant health benefits for both the fetus and the pregnant individual resulting from regular PA.

According to 2019 Canadian Guidelines [48], if there are no contraindications, every pregnant woman should take up physical activity for 150 min/week, 3 times a week. Exercises should include aerobic, resistance training and training Kegel muscles in order to prevent urinary incontinence.

What's worth mentioning is that women who don't meet those requirements can still benefit from physical workout. Upper limit of physical activity wasn't established. Canadian Guidelines recommend regular exercise the most for women who were inactive before however it's significant to introduce training volume considerably and gradually. Statistically speaking only 15% of women during pregnancy will achieve the recommended 150 min of exercise per week.

Gentle forms of physical activity, such as walking or exercises strengthening the upper body, are recommended [44]. The American College of Obstetricians and Gynecologists (ACOG) from the year of 2017 recommended that pregnant women partake in regular PA during pregnancy by engaging in at least 150 min of moderate-intensity aerobic on a weekly basis. On the other hand, yoga and/or gentle stretching was recommended on the basis of Canadian guidelines from 2019. Regarding the optimal frequency and intensity, ACOG indicates the need for additional research "to create an improved evidence base concerning the effects of occupational physical activity on maternal-fetal health" [49, 50].

Main absolute contraindications for physical workout during pregnancy are: ruptured membranes, premature labour, unexplained persistent vaginal bleeding, placenta praevia after 28 weeks' gestation, pre-eclampsia, incompetent cervix, intrauterine growth restriction, high-order multiple pregnancy, uncontrolled type I diabetes, uncontrolled hypertension, uncontrolled thyroid disease, other serious cardiovascular, respiratory or systemic disorders [48].

For instance, in women with cervical insufficiency, the premature dilation of the cervix may occur, increasing the risk of miscarriage or preterm labor [44]. Similarly, in women with severe pre-eclampsia, PA may decrease placental blood flow [51].

Relative contraindications include: recurrent pregnancy loss, gestational hypertension, a history of spontaneous preterm birth, mild/moderate cardiovascular or respiratory disease, symptomatic anaemia, malnutrition, eating disorder, twin pregnancy after the 28th week, other significant medical conditions [48].

V.L. Meah et al. [44] also mentions moderate-to-heavy smoking (>20 cigarettes per day) in the presence of comorbidities as relative contraindication to physical activity. In the case of having an absolute contraindication, MVPA should be completely avoided, though daily living activities, or low-intensity PA in case of relative contraindications should still be maintained.

The type of the sport is also relevant. Pregnant women should avoid physical activities that carry a great deal of risk such as: scuba diving, contact sport, skiing, biking. Generally speaking every type of sport that poses a risk of falling is contraindicated [48]. Intensive exercises, especially those that may exert pressure on the abdominal cavity, should be avoided during pregnancy [49].
Canadian Guidelines [48] encourage taking safer sports in terms of falling risk: stationary biking, swimming, brisk walking. Not only the type of workout is relevant but also the environment. It is not recommended to train in extreme heat, especially with high humidity. Additionally, working out above 2500m above mean sea level is not endorsed. It is of great importance for women during pregnancy to monitor how they feel during exercising. If any of these symptoms occur, it is significant to stop the activity and contact a medical doctor: shortness of breath, severe chest pain, vaginal bleeding, regular and painful contractions.
Kelly R Evenson et al. [52] compared guidelines regarding physical activity for pregnant women. It

analyzed 11 guidelines from 9 countries including : Australia, Canada, Denmark, France, Japan, Norway, Spain, United Kingdom and United States.

Absolute contraindications among mentioned countries are pretty similar to those presented by 2019 Canadian Guidelines described above. Study revealed that Canada, Japan, Norway, Spain, UK and US contraindicate working out when any of the conditions are present: cardiovascular disease, cerclage or incompetent cervix, anemia, persistent bleeding, multiple gestation, premature contractions or labor, thyroid disease, preeclampsia or pregnancy induced hypertension, premature rupture of membranes [52].
Every guideline agrees that women during pregnancy should avoid sports with a risk of fall. The vast majority contraindicate working out in a supine position because it can decrease cardiac output and induce orthostatic hypotension. This can be caused by the uterus compressing the vessels.
N.D. Avery et al. [53] studied the fetal heart rate (fHR) response to maternal resistance exercises performed in seated and supine positions during the third trimester of pregnancy. They observed significantly greater fHR accelerations during resistance exercises in the supine position. Additionally, transient mild bradycardia (<3 minutes) was occasionally noted. The presence of bradycardia may have resulted from changes in blood flow redistribution before and after exercise due to alternating postures (supine/sitting). This study highlights the potential adverse effects of supine exercises on the fetus [49,53]. Pregnant women should therefore avoid resistance exercise in the supine position since no benefit for the fetus has been observed and because harm cannot be categorically ruled out [49].
Also, strenuous physical exercises and high-intensity workouts are contraindicated for pregnant women. Performing them is associated with an increased direct risk of placental abruption [54].
Countries suggest that physical activity shouldn’t be taken up above 1800m above mean sea level (USA) and 2500m (Canada). Sedentary behavior (UK) and working out in extreme heat (Canada, Japan, Spain, UK) are not recommended. Eight out of nine countries advise aerobic exercises and half of them state that adding strengthening exercises is beneficial. The duration, frequency and intensity of the activities by country: Denmark: 30 min daily, moderate intensity. Japan: 60 minutes, 2-3 times a week. Norway: 30 min daily. Spain: 3 times a week. [52]
Many authors agree that physical activity during pregnancy is beneficial in a great amount of ways. It helps to control glucose, HbA1C and insulin levels in Gestational Diabetes Mellitus

(GDM) [55] and lowers the risk of preterm birth and hypertensive disorders of pregnancy [56]. Active women tend to gain less weight and have less symptoms of postnatal depression [57]. Another study states that high volume of physical activity correlates with shorter active labor phase and decreases the risk of prolonged first stage [58].

6.Biological and hormonal mechanisms linking physical activity to mental health

Physical activity as a non-pharmacological intervention has shown promise in supporting the treatment of severe diseases. In the meta-analysis conducted by Kulchycki et al. [59], 25 randomized clinical trials (RCTs) were analyzed to assess the impact of aerobic exercise on depression in cancer patients. The trials compared interventions involving aerobic exercise with usual care, waitlist controls, or attention controls, regardless of participants' age or cancer type. The included studies involved a total of 1931 patients aged 18 to 80 years.

The primary outcome measured was the severity of depressive symptoms within one month after the intervention (short-term effect). Secondary outcomes included the severity of depressive symptoms evaluated between 1 and 6 months post-intervention (medium-term effect) and between 6 and 12 months post-intervention (long-term effect). The results demonstrated that aerobic exercise was associated with a reduction in self-reported depressive symptoms in adults with cancer. Furthermore, the decrease in depression scores was significant for long-term outcomes but not for medium-term outcomes.

A meta-analysis conducted by Rebar et al. [60] investigated the effects of physical activity on depression and anxiety in non-clinical populations. The analysis encompassed 92 studies involving 4,310 participants to evaluate the impact on depressive symptoms, and 306 studies including 10,755 participants to assess its effects on anxiety. The findings demonstrated that physical activity significantly reduces depressive symptoms to a moderate extent and alleviates anxiety symptoms to a lesser degree.

Can physical activity act as a protective measure against depression? A meta-analysis led by Pearce et al. [41] explored this question by analyzing prospective cohort studies that tracked participants for at least three years and included no fewer than 3,000 adults. The studies categorized physical activity into three levels of intensity. The analysis incorporated 15 studies, encompassing 191,130 individuals and 2,110,588 person-years. The results revealed a non-linear inverse relationship between physical activity and the risk of depression, with a sharper reduction in risk observed at lower levels of physical activity. Substantial heterogeneity was noted across the studies ($I^2 = 74\%$; $P < .001$). Compared to individuals who were entirely inactive, those achieving half of the recommended physical activity guidelines (4.4 metabolic equivalent task-hours/week) experienced an 18% lower risk of depression. Individuals meeting the full recommended level of activity (8.8 metabolic equivalent task-hours/week) had a 25% lower risk. However, additional benefits beyond this threshold were less

pronounced and carried a higher degree of uncertainty. As evident, physical activity can serve as a significant lifestyle factor that reduces the risk of depression.

What mechanisms underlie the positive effects of physical activity on alleviating symptoms of depression? In their study, Silverman et al. [61] addressed this issue and concluded that regular physical activity leads to lower activity of the hypothalamic-pituitary-adrenal axis, reduced sympathetic nervous system activity, decreased inflammatory responses, enhanced

insulin sensitivity, greater neuroplasticity, and elevated levels of neurotrophic factors (e.g. BDNF).
Harber and Sutton [62] observed that physical exercise increases the concentration of beta-endorphins, among other substances. They associate the presence of these endorphins with exercise-induced euphoria and the stress responses of various hormones, including growth hormone, ACTH, prolactin, catecholamines, and cortisol.
In the study conducted by Wipfli et al. [63], a prospective randomized 7-week intervention trial was implemented. Untrained participants were randomly assigned to either an aerobic exercise group or a control group performing stretching exercises. Participants completed various psychological questionnaires to assess variables such as depression and anxiety levels. Blood samples were collected pre- and post-intervention to measure serum serotonin levels. The results showed that the exercise group exhibited lower depression levels compared to the stretching control group. Additionally, the exercise group experienced a greater percentage decrease in serum serotonin levels compared to the control group. This reduction in blood serotonin following exercise was found to resemble the effects of selective serotonin reuptake inhibitors

7.Current evidence on the impact of physical activity during pregnancy on the risk of perinatal depressive disorders

The relationship between physical activity and perinatal depressive disorders has gathered attention in recent research. This emerging focus reflects a growing recognition of the potential benefits of physical activity during the perinatal period. Studies aim to explore how exercise may serve as a protective factor (or therapeutic tool) in addressing mental health challenges associated with this hard time for many future mothers.

The influence of physical activity on the development of prenatal and postnatal depressive symptoms was examined by Ana et al. in the MAASTHI cohort study conducted in South India [64]. Among 1,406 pregnant women, 7.2% had low physical activity levels, the majority (92.8%) performed moderate levels of physical activity. Prevalence of prenatal and postnatal depressive symptoms was 9.0% and 31.9%, respectively. Women with low physical activity levels during pregnancy had 3.15 times higher odds of developing postpartum depressive symptoms (95% CI: 1.98–5.02, $p < 0.001$) after adjusting for confounders such as prenatal depressive symptoms, social support, and health conditions. While prenatal depressive symptoms were strongly associated with postnatal depressive symptoms (55.6% of affected women remained depressive postpartum), no significant link was found between physical activity and prenatal depressive symptoms.
A longitudinal study by Baran et al. [65] assessing the relationship between prenatal physical activity, postnatal depression and anxiety included 187 women aged 19–41 years. Depression prevalence, measured using the EPDS, increased from 5.3% before birth to 22.5% immediately postpartum and 16% at six months postpartum ($p < 0.001$). Anxiety symptoms, assessed using the Generalized Anxiety Disorder-7 (GAD-7), were highest before birth and decreased over time ($p < 0.001$). Women with lower physical activity, defined by fewer daily steps and reduced moderate-to-vigorous physical activity, were significantly more likely to experience depressive symptoms before birth, immediately postpartum, and six months postpartum ($p < 0.001$). Sedentary behavior also correlated with higher depression scores postpartum ($p = 0.008$). While light physical activity reduced depression risk, no significant relationship was found between physical activity and anxiety symptoms.

Xu et al. [66] investigated the relationship between physical activity and postnatal depression while aiming to identify optimal exercise patterns for pregnant women. The research included 95 women, aged 18-45 years, observed during their third trimester until one week postpartum. Participants were divided into three groups based on their EPDS scores: healthy controls with EPDS < 9 (n = 40), screening positive with EPDS 9–11 (n = 31), and PPD with EPDS ≥ 12 (n = 24). Physical activity was assessed using the Physical Activity Rating Scale (PARS-3) and smartphone pedometers recording daily steps. Results demonstrated that optimal exercise duration (31–59 minutes/session) and frequency (3–5 times per week) were associated with significantly lower EPDS scores ($p < 0.001$). Higher daily steps during the second trimester ($r = -0.262$, $p < 0.05$) and third trimester ($r = -0.411$, $p < 0.001$) proved to be correlated with lower EPDS scores in the week after birth. Greater exercise volume, indicated by higher PARS-3 scores, was inversely correlated with PPD risk ($r = -0.368$, $p < 0.001$).
On the other hand, Susukida et al. [67] hints that combining light, moderate and vigorous physical activity can bring the opposite effect. The study, which included 92,743 pregnant women from the Japan Environment and Children's Study, indicated that engaging in such physical activities was associated with a 32%

higher likelihood of moderate distress (adjusted odds ratio [AOR] 1.32, 95% CI 1.18–1.48) and a 42% increased risk of developing PPD (AOR 1.42, 95% CI 1.24–1.61). Conversely, light physical activity alone reduced the odds of moderate prenatal psychological distress (AOR 0.86, 95% CI 0.82–0.90) and severe distress (AOR 0.64, 95% CI 0.58–0.72) compared to no activity. These findings emphasize that while light activity can reduce psychological distress, combining varying intensities may increase risk in developing PPD, highlighting the need for tailored physical activity recommendations during pregnancy.

Although it might not be the case for individuals who enter pregnancy with overweight and obesity. In a study of 205 pregnant individuals with overweight (BMI ≥25 kg/m²) or obesity (BMI ≥30 kg/m²) by Karim et al. [1] adherence to physical activity guidelines (≥150 minutes/week of moderate-to-vigorous intensity activities, such as walking, objectively measured using the SenseWear Armband) at both time points during pregnancy (≤16 and 32 weeks' gestation) reduced the odds of probable PPD at six months by 92% (AOR: 0.08; 95% CI: 0.01–0.69). Those who met physical activity guidelines at one time point during pregnancy (≤16 or 32 weeks' gestation) also had significantly lower odds of developing PPD at six months postpartum (AOR: 0.07; 95% CI: 0.01–0.76). No significant effect was observed at 12 months postpartum.
Postpartum depression, as well as other depressive syndromes, is a multifactorial disease [7]. One particular study, by Yuan et al. [68], showed weaker association between physical activity and reduced PPD risk in Asian women compared to women from Europe. The results suggest that cultural and societal factors may moderate PA's effectiveness in preventing PPD in this demographic . In many Asian cultures, traditional confinement practices, such as "doing the month," emphasize maternal rest, restricted physical activity, and specific dietary regimens to aid postpartum recovery. While these practices may offer physical benefits, they can also contribute to interpersonal conflict, emotional stress, and reduced autonomy, thereby increasing PPD vulnerability. For instance, a cohort study in Singapore [69] reported that 33% of participants experienced negative psychological impacts from traditional confinement practices, significantly contributing to depressive symptoms. Similarly, evidence from Vietnamese populations showed persistent PPD symptoms despite adherence to traditional postpartum customs [70].

Postpartum fatigue is another prevalent and weakening condition experienced by many women during pregnancy and the postpartum period, often impacting maternal health, mental well-being, and overall quality of life. Exercise has been widely recognized as a potential intervention to address fatigue. Structured exercise programs, particularly supervised interventions lasting more than eight weeks, significantly reduce fatigue levels in pregnant and postpartum women. Postpartum exercise demonstrates greater efficacy compared to prenatal exercise, emphasizing its importance in alleviating fatigue during this critical period. [71].

CONCLUSIONS

Physical activity during pregnancy plays a critical role in enhancing maternal mental health and reducing the risk of postpartum depression. Research demonstrates that moderate exercise improves mood, alleviates depressive symptoms, and improves overall mental well-being. Activities such as walking, swimming, or prenatal yoga have proven beneficial, enhancing resilience against stress and hormonal fluctuations that can contribute to perinatal mood disorders.

Regular exercise also stimulates the release of endorphins and serotonin, promoting feelings of happiness and reducing anxiety. It has other benefits like improving self-esteem, reducing fatigue, and fostering better sleep, all of which are essential for emotional stability during this period. Furthermore, tailored physical activity can provide a safe, non-pharmacological method to mitigate the effects of PPD. It is important especially for women at higher risk due to obesity or pre-existing mental health conditions.
However, exercise recommendations must consider individual health circumstances, as certain conditions like preeclampsia or placenta previa may require restrictions. Light to moderate activities are generally safe and effective, offering mental health benefits without posing risks to the mother or fetus.

Authors' Contributions Statement:

●Conceptualization: J.S.

●Data Curation: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H.
●Formal Analysis: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.
●Investigation: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.
●Methodology: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.
●Project Administration: J.S., J.D., Ł.S.P.
●Resources: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H.
●Software: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.
●Supervision: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.
●Validation: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.
●Visualization: J.S., J.D., B.Z., M.Ł., K.K., T.M., A.S., P.H., P.M.

●Writing – Original Draft: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.

●Writing – Review & Editing: J.S., J.D., B.Z., M.Ł., K.K., Ł.S.P., T.M., A.S., P.H., P.M.

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