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The Role of Physical Activity in Pregnancy: Impact on Preeclampsia, Gestational Diabetes Mellitus, and Labor Outcomes

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Abstract

Physical activity (PA) is of crucial importance when aiming to maintain a healthy lifestyle. Pregnancy is a period in which many hormonal and physiological changes occur, sometimes leading to development of diseases such as gestational diabetes (GDM) and preeclampsia. In this systematic review the influence of regular PA both before and during gestation is investigated. The research gathered points towards the preventive nature of PA against GDM and preeclampsia, proving that regular exercise, especially of moderate and moderate-to-vigorous intensity, significantly reduces the risk of the development of both of these. Additionally, women with GDM treated with insulin who regularly participate in PA require a lower dosage compared to those leading sedentary lifestyles. On top of that, PA

seems to have a beneficial influence on various labor outcomes, such as shortened active labor duration, lowered reported levels of pregnancy-related pain, improved psychological well-being, and increased chances of natural vaginal birth as opposed to cesarean section or instrumental birth.

Keywords
preeclampsia, gestational diabetes mellitus, labor outcomes, physical activity, exercise

Introduction

Physical activity (PA) during pregnancy is considered to have beneficial effects on its course and to prevent complications such as excessive weight gain, gestational diabetes mellitus, hypertensive disorders, and cesarean or preterm birth [1]. The American College of Obstetricians and Gynecologists (ACOG) recommends that women with uncomplicated pregnancies participate in aerobic and strength-conditioning exercises before and during pregnancy, as well as in the postpartum period [2]. This is consistent with World Health Organization (WHO) 2020 guidelines that advise at least 150 minutes of moderate-intensity aerobic exercises per week for all pregnant and postpartum women without contraindications [3]. PA benefits maternal mental health during pregnancy and reduces the risk of postpartum depression [4][5], improves cardiorespiratory and vascular health [6][7], reduces the intensity of lumbopelvic pain and protects against urinary incontinence [8]. According to ACOG, activity restrictions during pregnancy do not prevent preterm birth or preeclampsia and should not be routinely recommended. Moreover, prolonged bed rest may lead to bone demineralization, deconditioning, increased risk of deep venous thrombosis, and negative psychosocial effects [1]. An exercise prescription typically consists of the following components: duration, intensity, type, and frequency. Intensity of PA is categorized by a number of METs (metabolic equivalents) it requires. Light PA is defined as requiring less than 3 METs, moderate 3-6, and strenuous more than 6 METs [9].

Preeclampsia is one of the leading causes of maternal and perinatal mortality, and affects 2-8% of pregnancies [10]. It is usually diagnosed after 20 weeks of gestation and often near term. Preeclampsia is defined by a new-onset hypertension with systolic blood pressure (SBP) ≥ 140 mm Hg and/or diastolic blood pressure (DBP) ≥ 90 mm Hg on two occasions, at least 4 hours apart, or SBP ≥ 160 mm Hg and/or DBP ≥ 110 mm Hg measured in a short period of time. Another common preeclampsia criterion is new-onset proteinuria, sometimes replaced with other symptoms, such as thrombocytopenia, renal insufficiency, impaired liver function, pulmonary edema or new-onset headache not explained by other medical conditions [11]. Etiology of the disease is still not fully understood. Placental ischemia is considered a fundamental mechanism of preeclampsia. This is caused by abnormal vascular remodelling and insufficient invasion of cytotrophoblasts of maternal spiral arteries, ultimately leading to shallow placentation [12]. Local hypoxia and oxidative stress activate systemic reaction in forms of chronic activation of CD4+ T lymphocytes, production of inflammatory cytokines, such as Tumor Necrosis Factor α (TNF-α) and Interleukin 6 (Il-6), elevated nitric oxide (NO) levels, release of anti-angiogenic factors, dysregulation of Renin-Angiotensin system (RAS) and others, resulting in endothelial dysfunction identified by increased endothelin concentration, reactive oxygen species (ROS) and amplified reactivity to angiotensin II. That leads to increased vascular permeability, vasoconstriction and hypertension [13,14]. Management of preeclampsia involves pharmacological treatment of hypertension,

corticosteroid therapy and magnesium sulphate to prevent seizures (eclampsia), however the only definitive treatment is delivery [15]. Risk factors for preeclampsia include a history of preeclampsia in previous pregnancy, antiphospholipid syndrome, chronic hypertension, pregestational diabetes mellitus, a BMI greater than 30, chronic kidney disease, use of assisted reproductive technology, multifetal pregnancy, a family history of preeclampsia and others. Initiating aspirin therapy before 16 weeks of gestation has been proven to lower the risk of developing preeclampsia [16][17].

Gestational diabetes mellitus (GDM) is defined as a type of hyperglycemia that occurs and is diagnosed during pregnancy [18]. As gestation progresses, insulin resistance gradually develops, beginning around the middle of pregnancy and worsening up to the third trimester. By this point, the level of insulin resistance can be similar to what is observed in type 2 diabetes [19]. This is caused by placental hormones that have a diabetogenic effect, such as human placental lactogen (hPL), human placental growth hormone (hPGH), adrenocorticotropic hormone (ACTH), prolactin (PRL), estrogens, gestagens, and growth hormone (GH). Moreover, during pregnancy, anti-inflammatory cytokines are released, adiponectin levels decrease, hyperleptinemia develops, and expression of GLUT-4 decreases. These factors often coexist with pancreatic β-cell dysfunction. All of the above cause an increase in insulin resistance [20][21][22][23][9]. Some of the risk factors associated with GDM are ethnicity [24][25], obesity [26][27], history of previous GDM, and polycystic ovarian syndrome [27]. Additionally, during pregnancy women on average increase their sedentary behavior, especially in the third trimester [28]. It is estimated that around 80% of pregnant women are physically inactive, which could lead to further weight gain and thus increased insulin resistance [29][9][23]. A 2017 meta-analysis determined the prevalence of GDM in Europe to be 5.4% (3.8-7.8) [30] and 14% worldwide [31]. It is worth noting, however, that there is no universal criteria for GDM diagnosis around the world, which might lead to differences in statistics depending on the country where a study takes place. WHO guidelines, used in Europe and updated in 2013, state that GDM should be diagnosed at any time in pregnancy if one or more of the following criteria are met: fasting plasma glucose 5.1-6.9 mmol/l (92-125 mg/dl), 1-hour plasma glucose ≥ 10.0 mmol/l (180 mg/dl) following a 75 g oral glucose load, 2-hour plasma glucose 8.5-11.0 mmol/l (153-199 mg/dl) following a 75 g oral glucose load [32]. GDM is associated with several long- and short-term adverse outcomes for both mother (increased cardiovascular risk [33][34], pre-eclampsia, metabolic syndrome, diabetes mellitus type 2 [35][36], cesarean section [37][34]) and fetus (perinatal morbidity, stillbirth, macrosomia [38][39], prolonged stay in the intensive care unit, and obstetric trauma [40]). Management of GDM is focused on maintaining normoglycemia. It usually involves proper low glycemic index diet and pharmacotherapy with insulin and metformin [41].

Materials and methods

To review the literature on the topic of the role of physical activity in pregnancy and its impact on preeclampsia, gestational diabetes mellitus, and labor outcomes PubMed, Cochrane Library, Science Direct, and Google Scholar were searched using the following keywords: *preeclampsia, gestational diabetes mellitus, labor outcomes, physical activity, exercise*. Articles published between 2001-2024 were selected.

Physical Activity and Gestational Diabetes

Multiple studies have shown that PA has a positive effect on glycemic control, insulin sensitivity, and body mass [42], and is also known to facilitate increased GLUT-4 translocation to the sarcolemma, thus influencing pathophysiological aspects of GDM

development [43]. Therefore, it should be considered as one of the ways to prevent and mitigate the symptoms of GDM.

A 2024 meta-analysis by Xie, W., Zhang, L., Cheng, J. et al. investigated the relationship between PA in the first and second trimesters and the risk of developing GDM. Analyzing 20 different articles the researchers found that higher levels of PA during pregnancy lowered the risk of GDM by 35% in Asian and 38% in Caucasian populations. Similarly, a notable link between regular PA and reduced GDM risk has been identified among multi-ethnic groups. It was found that pregnant women with PA energy expenditure of 10 MET-h/week, 20 MET-h/week, and 50 MET-h/week during the first trimester had a 13%, 22%, and 29% decrease in risk of developing GDM respectively, compared to those who were sedentary. An additional, albeit weaker, inverse correlation was found between PA in the second trimester and GDM risk [44]. Schoenaker et al. concluded that any type of PA during pregnancy, especially in the early gestation period, decreases risk of developing GDM by 24%, however type and intensity of exercise were found to lead to no significant difference. PA before conception was also found to have negative correlation with GDM prevalence. The links between preconceptional PA and lowered GDM risk were stronger than those previously reported for PA during early pregnancy [45]. A cross-sectional observational study by Mellem et al. found a significant inverse correlation between PA before pregnancy and the prevalence of GDM. GDM was diagnosed only in women who did not participate in any type of moderate PA in the periconceptional period, and sedentary sitting lifestyle was found to be the most important indicator of the GDM risk. The sturdy did not report a protective influence of light exercise during pregnancy on GDM chance [46]. A cross-sectional study by Aburezq et. al. provided results showing that vigorous activity was a significant protective factor against GDM [47]. A randomised clinical trial by Wang et. al. provided results suggesting that moderate to vigorous PA is highly beneficial for pregnant women. In the trials, the exercise group had a significantly lower incidence of GDM when compared to the control (inactive) group - 22.0% vs 40.6%. PA also correlated with lesser insulin resistance and gestational weight gain [48]. A meta-analysis by Doi et al. confirmed that PA started before 16th-20th gestational week significantly reduced GDM risk in high-risk women [49].

PA is not only beneficial due to its preventive action against GDM, but could also be a way of symptom management in women with the diagnosis. However, it is important to remember that the ACOG 2020 recommendations regarding PA in pregnancy are aimed at uncomplicated pregnancies and specific guidelines regarding women with GDM are not available as of now [50]. A systematic review by Laredo-Aguilera et al. confirms the positive influence of PA on plasma glucose levels and HbA1c, though the study did not find any significant evidence suggesting an advantage of aerobic exercise over resistance training and vice versa. Additionally, the study indicates that women who previously required insulin to control GDM were able to reduce the dosage they needed [29]. A meta-analysis by Huang et al. investigated the influence of PA on maternal and child outcomes in patients with GDM. It was determined that aerobic exercise reduced postprandial plasma glucose and HbA1c, while resistance training allowed patients to decrease the doses of insulin they required. The best patient outcomes were achieved when a combination of different types of PA was implemented [51]. A prospective cohort study by Ehrlich et al. found that regular moderate exercise significantly improved glycemic control in pregnant women diagnosed with GDM, with an inverse correlation between the volume of exercise and postprandial plasma glucose [52].

Reviewing available literature regarding PA in pregnancy it can be concluded that regular exercise, performed consistently before or during gestation period, lowers the incidence of GDM. There were no significant findings as to which type of exercise (aerobic vs resistance) is more impactful, and many studies claimed that the best patient outcomes were reached

when a combination of these two was applied. When considering the intensity of PA, the majority of sources agree that moderate and moderate-to-vigorous types of exercise are best for decreasing the risk of GDM. The findings also agree that PA is advantageous in women with GDM diagnosis as exercise can help to maintain normoglycemia and to reduce the doses of insulin needed by women with GDM.

Physical Activity and Preeclampsia

Metabolic comorbidities play an important role in the development of preeclampsia. Obesity, insulin resistance, dyslipidemia, hyperhomocysteinemia and hypertension prior to pregnancy are associated with endothelial dysfunction, inflammation and oxidative stress that are considered major components in preeclampsia pathophysiology [13][14]. Regular exercise has been shown to reduce blood pressure [53], improve lipid profile [54] and glycemic control in diabetes mellitus type 2 [55], and help to reduce BMI and body fat percentage [56], which are risk factors for developing preeclampsia.

There are multiple studies that demonstrate the preventative effect of PA on preeclampsia [57][58][59][60][61]. Spracklen et al. in their case-controlled study showed a significant decrease in risk of developing preeclampsia and gestational hypertension in women who performed occupational activity, and an increase in risk in sedentary women [57]. Aune et al. in their meta-analysis demonstrated that PA before and during pregnancy lowers the risk of preeclampsia, with the lowest risk present in women who exercised both before and during early pregnancy. In this paper even as simple activity as walking proved to be effective [58]. Raguema et al. found that intensity of activity was inversely correlated with SBP and DBP. Moreover, in women with preeclampsia gestational duration was positively correlated with cumulative energy expenditure, regardless of the intensity of PA [59]. In a study conducted by Chen et al. different types of exercises were compared. Aerobic exercise, resistance training and mixed training all improved pregnancy outcomes in women with gestational hypertension, enhanced their sleep quality, reduced morning blood pressure, improved lipid profile and renal function, with mixed training having the greatest impact [60]. In a systematic review and meta-analysis by Magro-Malosso aerobic exercise in singleton pregnancy significantly reduced risk of gestational hypertension but, surprisingly, not preeclampsia, however authors admitted that in regards to preeclampsia the meta-analysis was underpowered [61].

Proposed mechanisms by which PA may alleviate preeclampsia include promoting placental growth and vascular development, reducing oxidative stress, improving endothelial function and suppressing inflammatory response [62]. Placenta, an organ that demands a lot of energy to function properly, benefits from exercise which boosts oxidative metabolism and regulates mediators involved in placental development, including vascularisation [63]. Repeated PA fosters an environment that is adapted to oxidative stress by increasing the number of mitochondria and enhancing enzymatic antioxidant systems [64]. Exercise can prevent or reverse the development of endothelial dysfunction by reducing the concentrations of TNF-α and endothelin, promoting endothelial proliferation and production of antioxidants, and increasing NO bioavailability, thus improving vasodilatatory response. Moreover, regular PA decreases the concentration of proinflammatory cytokines and promotes balanced immune reaction during pregnancy [62].

PA before and during pregnancy seems to mitigate the risk of preeclampsia by addressing its underlying metabolic and pathophysiological components. It reduces blood pressure, improves renal function and lipid profile, and promotes weight loss. Moreover, regular exercise positively affects placental health by promoting vascular development, oxidative stress adaptation, proper endothelial function and regulating inflammatory response. The risk of preeclampsia can be lowered by various forms of PA, ranging from simple

walking to structured aerobic and resistance training with cumulative energy expenditure playing a significant role, which emphasizes the value of consistent exercise.

Physical Activity and Labor Outcomes

A systematic review by Małek et al. investigated the impact of PA on various maternal labor outcomes and perinatal complications. They found that women who regularly participated in PA, especially of moderate intensity, were significantly less likely to require a cesarean section. Additionally, the prevalence of women's pregnancy-related complaints such as nausea, fatigue, leg muscle cramps, dyspnea, haemorrhoids, polyuria, pyrosis and vaginal discharge was significantly reduced [65]. Haakstad et al. in their randomized-controlled trial also concluded that women who regularly exercised during pregnancy showed a lower rate of cesarean section and higher rate of normal vaginal delivery [66]. There are also studies that focused on emergency cesarean sections (EC). In a large population-based cohort study Owe et al. analysed delivery of nulliparous women with uncomplicated pregnancies and concluded that the risk of EC decreases with frequency of exercise up to 5 times a week, after which there was no further decrease [67]. In a cohort study Nielsen et al. came to similar conclusions, that the higher leisure time PA, the less complicated mode of delivery. This included reduced risk of EC as well as instrumental birth compared to spontaneous vaginal delivery [68]. A potential reason for the higher rate of cesarean sections in non-exercising women is that lack of physical activity increases risk of exceeding recommended gestational weight gain, which is a risk factor for EC [69]. Meta-analysis and systematic review by Davenport et al. found that exercise reduced odds of instrumental birth, but did not lower risk of cesarean section [70]. The disparities between results may be due to different types of papers and methodologies used.

In the study conducted by Haakstad et al. the exercise group had lower active labor duration. No differences were found in the induction of labor, use of analgesia, or total labor duration [66]. A randomized controlled trial by Peralez et al. also supports the claim that regular and supervised PA during pregnancy is associated with shorter first stage of labor, but not with mode of delivery, induction, gestational weight gain or neonatal outcomes [71]. Similar conclusions were reached by Watkins et al., who found that PA is related to shorter active labor, but not to the time span of the second stage of labor. Moreover, oxytocin augmentation was less likely to be necessary in a group of physically active women and the rate of spontaneous vaginal delivery was higher. The association between shorter time of active labor and PA may be due to increased uterine contractility during exercise and higher cholesterol levels in sedentary women, which is known to impair spontaneous and oxytocin-induced contractions. Moreover, PA may affect not only skeletal, but also smooth muscles by releasing calcium ions and activating calcium channels leading to increased contractility of the uterus [72]. A systematic review by Chan et al. focused on effectiveness of PA interventions on various pregnancy-related and labor outcomes. The researchers found that supervised PA during pregnancy reduced the levels of pain associated with pregnancy, including lumbopelvic and lower-back pain. Investigated studies also suggested that exercise interventions reduced gestational weight gain, however no definitive conclusions could be drawn. Furthermore, PA interventions correlated with better psychological well-being of pregnant women, mainly with decreased depression and anxiety incidence, although in this case not all considered studies have agreed [73].

Considering reviewed sources, PA during gestation period seems to offer multifaceted benefits. It increases the chances of natural vaginal birth, thus decreasing perinatal complications associated with cesarean section and instrumental deliveries. Women who participated in PA while pregnant reported lower levels of pregnancy-related pain and

experienced reduced incidence of anxiety and depression. They also had lesser gestational weight gain and shorter labor duration.

Conclusions

The studies analysed in this systematic review demonstrate the multifaceted benefits of physical activity before and during pregnancy for maternal labor outcomes. PA appears to be of vital importance as a preventive tool, as it significantly reduces the risk of GDM, preeclampsia, and adverse labor outcomes. Regular exercise, especially of moderate-to-vigorous intensity before and during gestation period, improves glycemic control, reduces insulin resistance, and allows to reduce required insulin dosage in women with GDM. PA also mitigates preeclampsia risk by influencing the metabolic pathways involved in its development. As shown in aforementioned studies, regular PA before and during early pregnancy helps in maintaining proper blood pressure, improves both renal function and lipid profile, and prevents excessive gestational weight gain. Furthermore, PA increases the rates of normal vaginal birth as it significantly decreases the risk of both cesarean section and instrumental birth. Regular exercise seems to shorten the active labor duration, and positively influence levels of reported pregnancy-related pain. Moreover, PA seemingly improves mental well-being of pregnant women by decreasing depression and anxiety incidence. All of these coalesce into improved maternal labor outcomes, and as long as there are no contraindications, regular PA ought to be recommended to all women in reproductive period. Further studies should be conducted in order to find the best exercise patterns and guidelines for women with complicated pregnancies, since as of now the ACOG recommendations focus solely on uncomplicated pregnancies.

Disclosure

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