

**The Effect of Physical Activity during Pregnancy on the Development of Postpartum Depression (PPD): A Literature Review**

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## **Abstract**

**Introduction:** Postpartum depression (PPD) is a condition characterized by major depressive mood disorder following childbirth. The onset of depressive symptoms is most often within four weeks after childbirth, but the diagnosis is often made up until a year postpartum. Current prevention and treatment strategies focus on the use of psychotherapy and anti-depressant medications. The research on alternative interventions such as the effect of exercise on the prevention of PPD is limited and inconclusive.

**Objective:** The purpose of this study is to further understand how efficacious exercise is in the prevention of PPD. There are currently very few recommendations for preventing PPD, thus there are knowledge gaps to fill in this area of research. This study will look at the current literature and determine if there is enough evidence to recommend physical activity during pregnancy for the prevention of PPD.

**Methods:** A literature search was done using PubMed and PsycINFO databases. The search was performed using key terms about physical activity during pregnancy and its relation to the prevention of PPD. Six articles were found that best met the inclusion criteria and were therefore used in the literature review.

**Results:** Four studies selected were randomized controlled trials (RCTs) which used an intervention to investigate how physical activity would impact depression screening in the postpartum period. The other two articles used prospective and retrospective cohorts to analyze if activity levels would influence EPDS scores in the postpartum period.

**Discussion/Conclusion:** The studies selected for review differed in study design and therefore the results of each study had some variation. Two of the RCTs showed no significant impact from exercise during pregnancy on PPD. However, these studies both faced issues with adherence, among other limiting factors. The other two RCTs selected followed similar protocols and both found exercise during pregnancy resulted in less prevalence of depressive symptoms in the postpartum period. Furthermore, both observational studies drew similar conclusions regarding the association between individuals reporting higher levels of activity in pregnancy and lower EPDS scores. No studies reviewed reported adverse effects from exercise during pregnancy on maternal mental health. Nonetheless, more research should be completed to validate the effect of prenatal exercise on the prevention of depression in the postpartum period.

# Introduction

## *Postpartum Depression*

Postpartum depression (PPD) is a condition characterized by a major depressive mood episode following childbirth. The onset of depressive symptoms is most often within four weeks after childbirth, but the diagnosis is often made by clinicians up until a year postpartum (1)(2). The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) states that to meet the diagnostic criteria, an individual must experience a depressed mood or a loss of interest in nearly all activities (3). The individual must also have at least four other symptoms, which may include weight loss, sleep disturbances, fatigue, agitation, feelings of worthlessness or guilt, inability to concentrate, and recurrent thoughts of death or suicide (3). Furthermore, these symptoms must be present the majority of the time for at least two weeks (3). Screening guidelines for PPD vary depending on regional guidelines, but the most widely used formal instrument is the Edinburgh Postnatal Depression Scale (EPDS) (4). The EPDS is a 10-question screening tool that is easy to complete for individuals and gives healthcare professionals a quantifiable score to interpret the probability of PPD (4). A score can range between 0 and 30, with a score of less than 8 suggesting depression is not likely, and a score above 14 indicating a positive screen for depression (5). A score between 9 and 13 should be interpreted with caution as depression could develop, which may be managed by rescreening in 2-4 weeks, offering support, or ensuring close follow-up with a primary care provider.

The burden of PPD is significant, as it is estimated to affect up to 15% of postpartum individuals, making it one of the most common complications following childbirth (4). Untreated maternal depression leads to negative consequences for both the mother and the child. The maternal-infant relationship can suffer due to less engagement from the mother and reduced

ability to bond (6)(7). Less affection from mothers toward their babies has been linked to impairment in the child's physical, cognitive, and emotional development (7)(8). Additionally, PPD may compromise caregiving activities including breastfeeding, sleep routines, well-child visits, vaccinations, and safety practices (7). Furthermore, maternal depression can negatively affect the entire family unit by putting strain on the relationship with a partner or other children (9). Thus, the effect of PPD is complex in how it can manifest in various consequences for the mother, child, and additional family members.

Individuals are particularly susceptible to depression during pregnancy and the postpartum period as they experience many hormonal changes (6). However, the exact pathogenesis of PPD is still not fully understood. It has been suggested that genetic, psychological, and social life stressors, along with hormonal changes each play a role in the development of maternal depression (10). A pathway commonly associated with depression is the hypothalamic-pituitary-adrenal axis (HPA), which releases cortisol in response to stress and trauma (10). During pregnancy and up until 12 weeks postpartum the HPA-releasing hormones are elevated above baseline (10). Other fluctuating hormones in pregnancy such as estradiol, progesterone, oxytocin, and prolactin are all also associated with mood changes (10). Although hormonal changes are intrinsic and non-modifiable, there are other factors which may make some individuals more susceptible to developing depression. High-risk features for PPD include a history of depression, lack of social support, and stressful life events during pregnancy or in the postpartum period (11). Identifying high-risk individuals is essential so that healthcare providers may follow closely during pregnancy or in the immediate postpartum period.

### *Current Prevention and Treatment Strategies*

The first-line option for the prevention and treatment of PPD is psychotherapy such as cognitive-behavioural therapy, and antidepressant medication (12). Clinicians may choose to treat PPD by solely using psychotherapy in mild to moderate cases (10)(13). However, if this is unsuccessful or if the depression is more severe, then often an antidepressant medication is recommended as an adjunct (10). The most common choice of antidepressant medication used is a selective serotonin reuptake inhibitor (SSRI) such as Sertraline (10). If the SSRI chosen is ineffective, then a serotonin-norepinephrine reuptake inhibitor (SNRI) is often considered a reasonable next option (10). The dose can be titrated up to an adequate level for the individual and then is usually continued for 6 to 12 months to prevent relapse of symptoms (10). Other medication options include more novel ones, such as brexanolone, which is a medication specifically approved for postpartum depression (10). The mechanism differs from SSRIs and SNRIs, as brexanolone is an aqueous formulation of a natural neurosteroid produced as a progesterone metabolite (10). Access to brexanolone is challenging as it is currently not approved for use in Canada. Other treatment options include transcranial magnetic stimulation (TMS) or electroconvulsive therapy (ECT), which are both only recommended to individuals with severe depression who do not respond to psychotherapy and antidepressants (10).

These recommendations can be beneficial for some individuals if available and accessible. However, many individuals are limited by these treatment options as they do not have access to therapy or medication due to financial, social, and cultural barriers. Additionally, there is a stigma associated with a mental health diagnosis such as PPD, which may discourage some people from seeking help. Lastly, there are individualistic differences, which may influence the treatment modality best suited and appropriate for a particular individual. Thus, providing

alternative options for prevention is important to better address the diverse needs of individuals who are at risk of developing PPD.

### ***Major Depressive Disorder & Physical Activity***

Exercise is a suitable recommendation for improving symptoms associated with major depressive disorder (MDD) in the general population (12). The exact mechanism of the antidepressant effect of exercise remains unclear. The most likely explanation is that multiple pathways are involved, including the modulation of neurotransmitter systems such as serotonin and dopamine, the release of  $\beta$ -endorphins, and thermogenesis, which induces relaxation (14). Furthermore, regular physical activity promotes self-esteem, body image, stress reduction, and social interaction (14). Regardless of the mechanism, there have been many trials over the years which have shown the positive effects of exercise on a depressed mood.

One of these studies included the HUNT cohort study, which took a healthy group of 33,908 adults with no mental or physical health conditions and prospectively followed them for eleven years (15). This study found that regular leisure-time exercise was associated with a reduced incidence of future depression (15). The HUNT cohort speaks to the protective effect of exercise on preventing depression. However, many more research studies investigate exercise as a treatment modality for MDD. One recent meta-analysis of 41 randomized trials, including 2264 participants, showed that exercise interventions improved depressive symptoms compared to a cohort of individuals who were not physically active (16). Additionally, they found no difference between aerobic and resistance activity, as both were beneficial (16). This study noted a more significant effect in trials with supervised exercise programs than in trials that were not supervised (16). Another recent meta-analysis of 1039 trials, including 128,119 participants, found similar findings (17). However, they found that trials with higher intensity of physical

activity were associated with greater symptom improvement (17). Overall, the evidence suggests that physical activity is both preventative and therapeutic to at least some degree for depression.

Most guidelines now recommend that exercise can be used as an adjunctive treatment for depression along with antidepressant medication and/or psychotherapy. However, in cases of mild depression, it may be used as a sole therapy with regular monitoring of symptoms (18). The guidelines outlined on UpToDate, recommend individuals to participate in moderate to vigorous aerobic exercise or resistance training for 30-60 minutes per session, three to five times per week (19). Additionally, physical activity should be trialled for at least ten weeks if there are no contraindications (19). The evidence best supports exercise supervised by another person, including participation in exercise classes or group workouts (19).

Many factors can influence the degree of success physical activity can have in relieving depressive symptoms, such as duration and regularity of exercise, level of exertion, and adherence to routine (18). These factors are also common limitations in research on the efficacy of exercise in treating depression. Many early studies found there was no benefit from exercise in the prevention or treatment of depression (18). However, after adjustment of study designs, more research has shown a positive effect of exercise on depression (18). Unfortunately, there have been far fewer studies to investigate the impact of exercise on depression in pregnancy and the postpartum period.

### ***Physical Activity during Pregnancy***

Historically, it was recommended to avoid exercise during pregnancy as there were concerns about the potential risk to the baby. These misconceptions have long been disproven as research has improved over the years (20). Today, most healthcare providers will encourage

individuals in low-risk pregnancies to exercise regularly during the prenatal period. It is important to note that in some cases, it may not be appropriate for individuals to partake in exercise while pregnant. Otherwise, the recommendations follow similar guidelines to non-pregnant individuals, with a goal of 150 minutes of moderate-to-vigorous intensity exercise per week (21). Other critical information to give pregnant individuals about exercising is to avoid overheating, ensure adequate hydration, and avoid dangerous activities that have a high risk of falls or physical contact (21). Another general rule of thumb is that pregnant individuals can continue exercising at a similar intensity as before pregnancy but should decrease to a level as tolerated throughout their pregnancy (21).

Providing advice on what types of exercise are safe, when to begin, and other general suggestions can be helpful to promote individuals to be physically active. Despite the encouragement to exercise, it is estimated that only 40% of individuals during pregnancy do exercise (20). Being physically active during pregnancy can decrease the chance of macrosomia, gestational diabetes, preeclampsia, low back pain, pelvic girdle pain, and urinary incontinence (20). Thus, there are many positive reasons which exist to motivate pregnant individuals to exercise. The benefit of improved maternal mental health could help emphasize the value of having a healthy lifestyle during pregnancy for some individuals. Thus, it is important to assess if prenatal exercise does decrease the risk of postpartum depression.

## **Purpose of the Study**

Many individuals are affected by depression during and following pregnancy. Depression can have severe morbidity and mortality implications for the mother and family unit. PPD causes a significant amount of distress to both psychological well-being and physical health. Moreover, postpartum depression is associated with an increased risk of suicide in mothers which stresses

the importance of intervention, prevention, and treatment (22). Addressing individuals in the prenatal period to discuss depression and provide proactive strategies can help to mitigate the negative outcomes for individuals.

Therefore, the purpose of this study is to identify whether exercise during pregnancy has a preventative effect on the development of postpartum depression. The objective of the review is to search through current literature on the topic and determine if there is enough evidence to recommend regular physical activity during pregnancy as a preventative measure for PPD.

## **Methodology**

### ***Inclusion Criteria***

The inclusion criteria are stated below (Table 1). The studies included were primary research articles published from 2003 until 2023 that studied the effect of physical activity in pregnant individuals on the development of PPD. Additionally, the screening for PPD had to be done through a standardized screening tool such as the EPDS or the Center for Epidemiologic Studies Depression Scale (CES-D). The individuals in the study had to be pregnant during the exercise intervention and the depression scores had to be measured in the postpartum period. There were no restrictions in terms of the types of physical activity allowed. The duration of exercise and level of exertion must have been well documented. Six articles were selected for review based on which best fit the criteria due to resource availability and the project timeline.

### ***Search Strategy***

A formal literature search was done using PsycINFO on December 11, 2023. PsycINFO is a database maintained by the American Psychological Association (APA) and is a large resource available for peer-reviewed literature in behavioural science and mental health. The

search terms that were used for the literature search included: (post-partum depression or postpartum depression or post-natal depression or postnatal depression or peripartum depression or ppd) AND (exercise or physically active or physical activity or aerobic activity or running or walking or yoga or swimming or water aerobics). This search yielded 184 results. An additional search was then done on PubMed on December 11, 2023. PubMed is a database by the National Center for Biotechnology Information (NCBI) and is a key resource for literature in the biomedical and health-related disciplines. The search terms that were used for the literature search on PubMed included: (post-partum OR postpartum OR postnatal OR post-natal OR peripartum OR after childbirth) AND (depress\* OR mood OR mental health OR anxiety OR blue) AND (exercis\* OR physical activ\* OR physical exercis\* OR aerobic activity OR walking OR running OR jogging OR swimming OR weightlifting OR yoga). Additionally, a filter option on PubMed was used to select only primary research articles, including randomized controlled trials, clinical trials, and observational studies. This search yielded 166 results. In total, there were 350 articles from the compilation of both searches.

### ***Screening Articles***

The articles from PsycINFO and PubMed searches were then imported into COVIDENCE for screening. 15 articles were automatically removed for being duplicates which were identified by the COVIDENCE software. An additional 10 duplicates were removed after manual screening. After reviewing the titles of the articles there were 207 articles were removed. The abstracts were then screened, and an additional 98 articles were removed. There were 20 articles which met the inclusion criteria following title and abstract screening and underwent full-text screening. After screening these articles, the ones which best fit the research questions of the study were chosen. Six articles were selected to be included in this literature review

(Figure 1). Additionally, all the articles being used within the literature review and others being referenced were imported into the Mendeley desktop reference manager.

## **Results**

### ***Search Results***

A total of 350 articles were found from the initial search. After deduplication 325 articles remained for further screening. Figure 1 displays the process of article exclusion completed in the title and abstract screening stages. 20 articles were selected for full-text screening. There was only one study in which the full text was unavailable and therefore it was excluded. Additionally, 13 of these articles were removed from the literature review as they did not meet the inclusion criteria sufficiently. Subsequently, six articles were included in the final literature review. The six studies included were published between 2012 and 2021. They were conducted in Brazil (n = 1, 16.7%), Sweden (n = 1, 16.7%), Norway (n = 2, 33.3%), and Spain (n = 2, 33.3%). Four of the articles included are randomized controlled trials (RCT) and two of them are retrospective/prospective cohort studies. Table 2 summarizes each study design, location, sample size, duration, intervention, primary outcome, and any other findings.

### ***Study Results***

Each study used a unique approach to determine the effect of exercise on the development of postpartum depression. Coll et al. completed an RCT in 2019, examining a secondary outcome of postpartum depression in the Physical Activity for Mothers Enrolled in Longitudinal Analysis (PAMELA) Study. They aimed to assess the efficacy of a 16-week exercise intervention during pregnancy on the prevention of PPD. The trial was done in Brazil and included 639 pregnant women with the average age of participants being 27.1 years old (23). Women were between 16- and 20-weeks gestation, and the mean gestational age was 16.5

weeks. Exclusion criteria for participants included being less than 18 years old, pre-existing medical conditions, previous preterm birth or miscarriage, persistent bleeding, severe obesity (BMI > 35), heavy smoking, and if individuals were currently active over 150 minutes per week (23). The participants in the exercise group (EG) were to do 60 minutes of supervised moderate-intensity exercise three times per week for a minimum of 16 weeks (23). Physical activity was rated using the Borg rating of perceived exertion scale, and participants were to target moderate intensity. Exercise routines involved aerobic activities, strength training and pregnancy-specific floor exercises (23). PPD was measured three months following childbirth with the EPDS and a score of 12 or higher indicated a positive depression screen according to the guidelines used. At this time frame, they found there was no significant difference in EPDS scores between groups. Thus, the authors concluded that moderate-intensity exercise during pregnancy did not lead to a significant reduction in PPD (23). However, they did note that only 43% of the participants in the EG had adequate compliance which was defined as attendance of > 70% of sessions. At the 5-week mark after initiation of the exercise intervention when adherence was met by close to 70% of participants, they found that EPDS scores were lower in the EG compared to the control group (CG) (23).

Another study which was done by Songøygard et al. in 2012 followed a very similar design and found similar results. The RCT assessed if regular exercise reduces the risk of PPD in a group of 855 individuals living in Norway, with a mean age of 30.6 and who were between 20- and 24 weeks gestation (24). Exclusion criteria included anyone under 18, more than a singleton live fetus, and anyone with pregnancy complications or a disease that could influence participation (24). The participants in the EG were expected to attend one supervised 60-minute group exercise session and complete two comparable exercise sessions at home per week (24).

The intervention was for a total of 12 weeks and adequate adherence was defined as participation in three or more weekly exercise sessions (24). There was no formal measure of perceived or quantified exertion during the provided exercise sessions, however, the exercise sessions were described as being moderate-to-high intensity. PPD was screened for at three months postpartum with the EPDS, with a score above 10 signifying probable minor depression and above 13 signifying probable major depression (24). Ultimately, they did not find a lower prevalence of high EPDS scores in those individuals in the EG compared to those in the CG (24). Once again adherence was a limiting factor as reportedly 57% of participants in the EG adhered to the three weekly exercise sessions. However, they did find a subset of individuals in the EG who did not exercise regularly before pregnancy had lower EPDS scores after the exercise intervention (24).

In contrast, there are other RCTs with suitable differences in design that have shown a positive effect on preventing PPD. One of these studies was completed by Vargas-Terrones et al. (2019) in Spain which included 124 individuals, of which, 70 individuals were randomized into the EG and 54 individuals into the CG. The intervention for the EG was three scheduled 60-minute exercise classes per week which began between 12-16 weeks' gestation and went until the end of the third trimester (25). The adherence to 70% or more of the exercise sessions was met by 65.7% of individuals, 22.8% of participants attended between 30-50% of sessions, and only 11.4% attended less than 30% of sessions (25). The degree of exertion was tracked with heart rate (HR) monitors during activity and individuals were to keep an intensity of 55-60% of their maximal HR (25). Additionally, the Borg Rate of Perceived Exertion scale was used for subjective assessment of the intensity of exercise. PPD was assessed before the intervention, at the end of pregnancy at gestational week 38, and at six weeks postpartum using the Center for Epidemiological Studies-Depression (CES-D) Scale (25). A positive score for depression was 16

or greater on the CES-D scale. The study found that at both 38 weeks gestation and 6 weeks postpartum, there was a smaller percentage of depressed individuals in the EG compared to individuals in the CG (25). At six weeks postpartum only 14.5% of women in the EG scored above 16 on the CES-D scale, compared to 29.8% of the participants in the CG (25).

Another RCT that showed a positive effect of exercise on PPD was done by Aguilar-Cordero et al. (2019) and was also conducted in Spain. Their study included 129 participants with an overall average mean age of 34, who were 20 weeks' gestation when the intervention began (26). The EG participated in three 60-minute aquatic exercise sessions per week for 17 weeks (26). Participants were excluded if they attended less than 80% of the 54 scheduled sessions or if they had any contraindications to continue exercising while pregnant. The exercise was mainly aerobic and strength-focused but also included a stretching and relaxation component (26). Exercise intensity was measured with both heart rate monitoring and the use of the Borg Rate of Perceived Exertion scale (26). Depression was measured using the EPDS between 4-6 weeks postpartum. A score above 10 was considered a moderate risk of PPD and a score above 16 was considered a high risk for PPD (26). The authors found that scores for individuals in the EG were significantly lower compared to individuals in the CG. The average EPDS score for participants in the EG was  $6.41 \pm 3.68$  which falls into the category of "no risk of PPD" (26). A secondary outcome measured in this study was the average weight gain in individuals from the first to third trimester. The average weight gain in the CG was 11.16 kg, which is notably higher than the average amount in the EG which was 8.28 kg (26). Furthermore, the authors found that being overweight or obese is strongly associated with positive screening for PPD. However, if individuals with a higher BMI such as greater than  $30 \text{ kg/m}^2$  were participating in exercise then they were no longer found to be at higher risk of developing PPD (26).

Other studies have chosen to follow a cohort of people by using a prospective or retrospective design. Shakeel et al. (2018) took 643 healthy pregnant individuals from a subset of participants in the STORK Groduddalen in Norway to measure the variability of postpartum depressive symptoms in relation to exercise level during pregnancy. The mean age of the individuals included in the study was 30 years old and 54% were nulliparous (27). Physical activity was measured using a multi-phasic activity monitor, incorporating information from heat flux accelerations, skin temperature and galvanic skin response (27). Participants were to wear the armband in gestational week 28 to monitor their activity for 24 hours a day for 4-7 days and only remove it if performing water activities. Moderate-to-vigorous physical activity (MVPA) in bouts > 10 minutes was recorded and then participants were divided into four categories based on their amount of MVPA (27). Individuals in the category of 150 minutes or greater of MVPA per week were considered to meet the recommended level. Depression was measured at gestational week 28 and at 3 months postpartum with the EPDS (27). A positive score for depression on screening with the EPDS was 10 or higher (27). The study found that the participants who had accumulated 150 minutes or greater of exercise per week had a significantly lower risk of PPD compared to those who had accumulated less or none (27). Moreover, they found meeting exercise recommendations lowered the risk of PPD even in a subgroup of participants who are of ethnic minority and are considered at higher risk for depression (27).

Another example of an observational study with a focus on determining the effect of physical activity prior to, during, and following pregnancy on PPD was done by Ekelöf et al. (2021). They completed a retrospective study with a group of 532 individuals in Sweden and investigated their level of activity using the Saltin Grimby Physical Activity Level (SGPAL) at

the 8-week postpartum mark (28). The participants were asked to evaluate based on their level of physical activity over the past year. The SGPAL was then used to categorize individuals as physically inactive/sedentary (I), light physical activity (LPA), moderate physical activity (MPA) and vigorous physical activity (VPA) (28). Additionally, a 10-point Likert scale was used to estimate activity levels at different periods such as before pregnancy, during the first trimester, second trimester, third trimester and postpartum period (28). The EPDS was the scale used to measure PPD at the 8-week postpartum mark and a score of 12 or greater was used as a cut-off for a higher risk of depression (28). The results suggested that a higher level of physical activity during pregnancy was associated with a lower level of depressive symptoms postpartum (28). However, almost two-thirds of the participants reported they were inactive or only performing light physical activity in the year before giving birth (28).

## **Discussion**

The primary goal of this literature search was to better understand the impact of physical activity during pregnancy on the development of depression. Furthermore, to determine if there is enough prior research completed which shows a therapeutic effect of exercise on the prevention of PPD. The results varied in terms of the influence that exercise has on PPD, which may be attributed to multiple factors. Some studies demonstrated a positive association between exercise during pregnancy and reduced postpartum depressive symptoms, but others did not find any significant effect. However, there were no findings which suggested any adverse impact on maternal mental health postpartum by exercising during pregnancy. Overall, this literature review supports much of the current research that physical activity is protective against depression, which likely can be extrapolated to the pregnant and postpartum populations.

Moreover, as mentioned previously, there are many other positive effects of exercising during the prenatal period, among being beneficial for mental health.

### ***Exercise During Pregnancy on the Development of PPD***

Depression is a notable complication of pregnancy and affects many individuals in the prenatal and postpartum period. There are a few recommendations for the prevention of depression following childbirth, but these methods are not always accessible or suitable for all individuals. Having options aside from psychotherapy and medications that healthcare providers can recommend may encourage the utilization of proactive interventions by a broader scope of individuals. The use of exercise as an aid to prevent PPD has been proposed and studied by a variety of researchers in recent years. This review selected six studies to complete an in-depth assessment and comparison to draw a reasonable conclusion about the effect of exercise during pregnancy on postpartum depression.

Studies by Songøygard et al. (2012) and Coll et al. (2019) showed no significant effects on the prevention of postpartum depression when exercise was implemented in pregnancy. The study by Coll et al. (2019) was a large trial but it faced an issue with adherence to exercise protocol, which could very likely impact the results obtained. Studies may have poor participant compliance with exercise regimens for many reasons, including personal or family conflicts, transportation issues, low interest, perceived lack of benefit, or physical limitations. The researchers attempted to mitigate the low adherence to exercise sessions by providing transportation, flexible schedules, and exercise clothing. The results found that noncompliance was more common among younger and less educated women (23). Unfortunately, these participants may represent some of the individuals who may be at higher risk of developing PPD. A secondary analysis of the results from the study suggested that due to the high dropout rates,

there could be a significant underestimation of the effect of exercise exhibits on depressive symptoms (23). Thus, it's crucial to consider this major limitation when interpreting the study results as insignificant.

The study by Songøygard et al. (2012) also exhibited moderately low adherence to the proposed exercise protocol. Moreover, the design relied on participants completing at least two 45-minute unsupervised exercise sessions at home per week (24). The exercise data's accuracy may have been influenced by participants' social desirability and recall biases when providing information. Another issue with the design chosen by Songøygard et al. (2012) was the lack of objective and subjective measures of exercise intensity. Research in the general population has shown that the intensity, along with the type and duration, likely plays a role in the effectiveness of the intervention. Therefore, the general suggestion for using exercise for depression treatment is to participate in some form of supervised exercise, such as group workouts. Lastly, another explanation which may result in a discrepancy between the results found by Songøygard et al. (2012) could be the low prevalence of EPDS scores across the study population. They found from the study population that 72.9% of women reported regular exercise before pregnancy, which was a reason provided for the low yield of depressive scoring among the whole sample (24). However, this would make it challenging to determine if those women who were previously active and then placed in the control group indeed had reduced activity compared to the exercise group. Moreover, they found that a subgroup of women in the EG who did not exercise regularly before pregnancy did have a significant reduction in EPDS scores greater than 10 in the postpartum period. These findings in the subgroup support the thought that the insignificance in the results may be attributed to the lack of difference between participants in exercise and control groups.

As mentioned previously, both RCTs by Vargas-Terrones et al. (2019) and Aguilar-Cordero et al. (2019) found evidence supporting the positive impact of physical activity during pregnancy on reducing PPD. Both studies used quite similar populations and took place in Southwestern Europe, which may potentially make the results less generalizable. Nonetheless, both study designs had several positive features, which resulted in much better adherence to exercise regimens and more subjective measures of exercise exertion. The study by Vargas-Terrones et al. (2019) was a lengthy intervention, and depressive symptoms were measured at multiple time points. The findings showed lower depression scores at both the end of pregnancy and at six weeks postpartum in women who participated in exercise (25). One subtle difference in their study design was using the CES-D scale instead of the more commonly used EPDS. The CES-D scale is also a self-rating scale comprising 20 questions, and the scores range from 0 to 60 (29). Typically, scores of 16 or greater indicate depression, which are the guidelines that Vargas-Terrones et al. (2019) followed in the study (25)(29). In contrast, Aguilar-Cordero et al. (2019) used the EPDS, but they also decided to screen for PPD around the six-week postpartum mark. The previously mentioned studies by Songøygard et al. (2012) and Coll et al. (2019) chose to measure at the three-month postpartum mark. Although there are some discrepancies in when to screen for depression following childbirth, the recommendation from the DSM-5 is between 4-6 weeks postpartum (5). An additional difference is that each study used a different score on the EPDS for what they considered a positive for PPD. According to most literature, a positive score for PPD on the EPDS would typically be considered a score of 14 or above (5). As most studies did not follow this as a set guideline, it does help provide a reason for differences in results and prevalence of PPD between studies.

Many factors can influence what individuals are at risk for the development of postpartum depression, which includes biological, psychological, and environmental factors. A secondary goal of the study by Aguilar-Cordero et al. (2019) was to determine if body mass index (BMI) influenced the development of PPD. In this study, those with a BMI categorized as overweight or obese were at higher risk of PPD (26). However, if those individuals participated in physical activity, such as those in the EG, they were no longer at risk (26). This finding suggests that exercise is a protective factor for individuals with a higher BMI. Previous studies have indicated that a higher BMI or more weight gain during pregnancy could increase the likelihood of PPD. The etiology could be attributed to biological mechanisms and psychosocial factors such as lower self-esteem and body image issues. More research is likely needed to clarify and further understand this relationship. Regardless, exercise can be used as a tool to prevent excessive weight gain during pregnancy, which is associated with complications such as gestational diabetes and hypertension.

The last two articles reviewed were observation studies, meaning no conclusions can be drawn from the results but only associations. However, these studies offer several other benefits, such as obtaining information from a more realistic environment, likely less participant bias, and often providing more generalizable data. The prospective cohort study by Shakeel et al. (2018) used a multiethnic group of individuals and adjusted for multiple confounders such as age, education, parity, and pre-pregnancy BMI. They found that engaging in regular physical activity both before and during pregnancy reduced the risk of developing PPD, even after adjusting for the confounding variables (27). This study contributes to the growing research evidence highlighting the protective effect of exercise for PPD. Moreover, the retrospective study by Ekelöf et al. (2021) also showed similar findings in that women with higher levels of physical

activity in the year prior to birth had fewer postpartum depressive symptoms (28). Moreover, they found that with every increase in physical activity level, individuals were at 13% less of a risk of developing depressive symptoms, resulting in EPDS scores above 12 (28). Thus, an association between the amount of physical activity performed and the efficacy of the results was shown.

### ***Study Limitations***

One of the limitations of this study is the large degree of heterogeneity between the studies selected. Choosing research with different designs helps better understand which methods yield specific results, but it makes a meaningful analysis difficult. Ideally, more research will be replicated using the same study designs to help make the conclusions drawn more valid. Another limitation is that regardless of the methods used, each study has a degree of subjectivity and biases. All the studies rely on at least one type of self-reported measure, whether that's the degree of exertion during exercise or depressive feelings in the postpartum period. For example, participants may provide biased answers involving reports of higher or lower levels of exercise and physical exertion based on what is expected of them as participants. Furthermore, if an individual in an intervention group were to expect that exercise should be beneficial to improve mental health, then they may report lower depressive symptoms. Alternatively, individuals may hide or diminish feelings of depression on self-assessment for other reasons, including the stigma associated with mental health disorders. One other prominent drawback to these self-reported measurements is that they often rely on participants' recall of information, which can be inaccurate and misleading. Another potential bias encountered in these studies is selection bias, as participant selection depends on individuals attending clinics or healthcare during the prenatal and postpartum periods. These study populations are likely not accurately depicting the general

population as they represent more motivated and privileged individuals on average. The last notable limitation is that all of the research studies selected for this literature review were done in countries outside of North America. Thus, extrapolating data into other populations, such as Canada, may be inappropriate. Culture and ethnicity play a significant role in both the development of postpartum depression and how individuals respond to treatment. The development of PPD may be greater or lesser depending on an individual's cultural perceptions and expectations of motherhood. Moreover, cultural norms may influence the level of support available to mothers. In cultures with high levels of family and social support, this can decrease feelings of isolation and vulnerability to developing depressive feelings.

## **Conclusion**

Physical activity is essential in any stage of life, including the prenatal period. However, exercise remains to be neglected during this vulnerable period. Encouragement to maintain physical activity during pregnancy should be recommended to support maternal physical and mental health. Viewing exercise as a modality to prevent PPD may encourage some individuals to participate in exercise during pregnancy who otherwise would choose not to. Additionally, it is crucial to have a wide assortment of preventative and treatment options available for individuals who are at risk of PPD to utilize. Healthcare providers should feel comfortable addressing physical activity as a topic of discussion during routine prenatal care. Overall, this study underscores the importance of promoting regular exercise during the prenatal period, as much of the evidence supports maternal mental health benefits. Future research may be warranted to help validate current research and further investigate the underlying mechanisms between the association of physical activity and postpartum depression.

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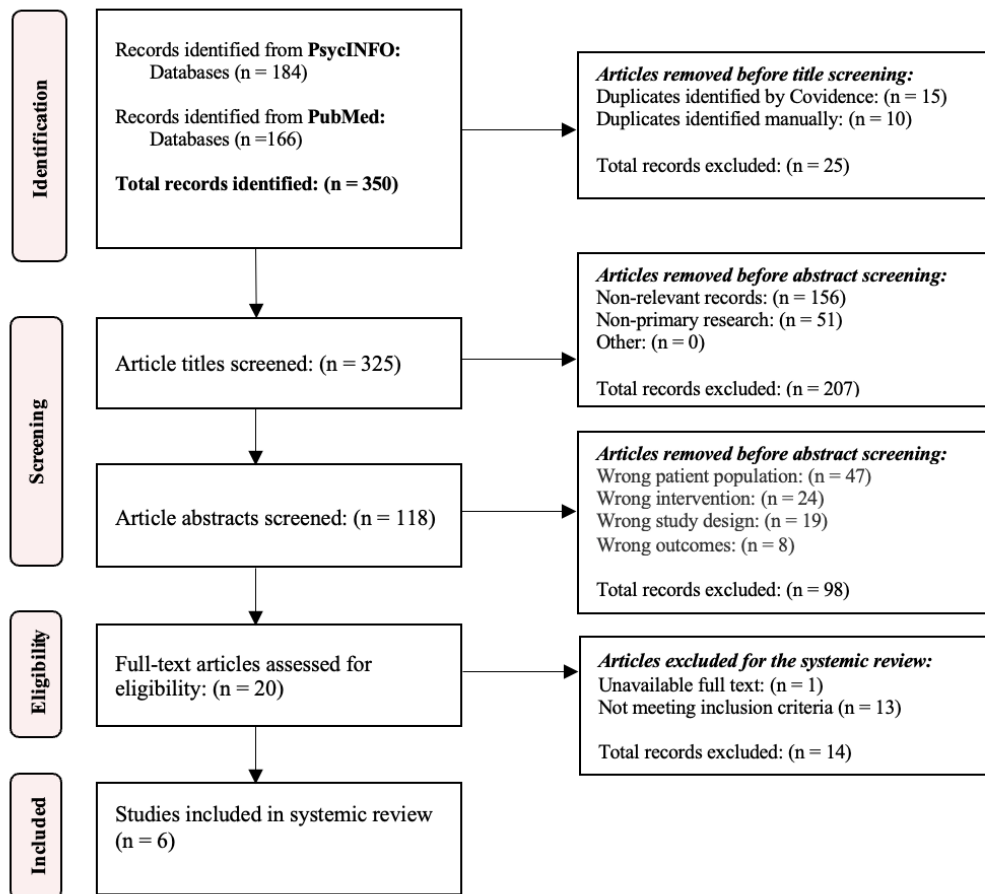
In conclusion, I am thankful to everyone who has played a role in my academic and professional development during my time in the MPAS program.

# Figures & Tables

Table 1: Inclusion Criteria

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	Inclusion
<b>Date</b>	Published between 2003-2023
<b>Geographic</b>	Worldwide
<b>Peer Review</b>	Peer reviewed articles
<b>Study Design</b>	All forms of primary research (randomized controlled trials, prospective/retrospective studies, cohort studies)
<b>PPD Screening Methods</b>	Must have screening with a standardized screening tool such as the EPDS, CES-D, PHQ-9
<b>Participates</b>	Pregnant and postpartum individuals
<b>Physical Activity Requirements</b>	Engaged in regular physical activity during pregnancy including activities such as walking, swimming, yoga, or other types of moderate-intensity exercises

Figure 1: PRISMA Flow Diagram



Identified – Search on December 11<sup>th</sup>, 2023

Figure 2: EPDS

## Edinburgh Postnatal Depression Scale<sup>1</sup> (EPDS)

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Your Date of Birth: \_\_\_\_\_

Baby's Date of Birth: \_\_\_\_\_

Phone: \_\_\_\_\_

As you are pregnant or have recently had a baby, we would like to know how you are feeling. Please check the answer that comes closest to how you have felt **IN THE PAST 7 DAYS**, not just how you feel today.

Here is an example, already completed.

I have felt happy:

- Yes, all the time
- Yes, most of the time      This would mean: "I have felt happy most of the time" during the past week.
- No, not very often      Please complete the other questions in the same way.
- No, not at all

In the past 7 days:

- |  |  |
|--|--|
| <p>1. I have been able to laugh and see the funny side of things</p> <ul style="list-style-type: none"><li><input type="checkbox"/> As much as I always could</li><li><input type="checkbox"/> Not quite so much now</li><li><input type="checkbox"/> Definitely not so much now</li><li><input type="checkbox"/> Not at all</li></ul> <p>2. I have looked forward with enjoyment to things</p> <ul style="list-style-type: none"><li><input type="checkbox"/> As much as I ever did</li><li><input type="checkbox"/> Rather less than I used to</li><li><input type="checkbox"/> Definitely less than I used to</li><li><input type="checkbox"/> Hardly at all</li></ul> <p>*3. I have blamed myself unnecessarily when things went wrong</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, most of the time</li><li><input type="checkbox"/> Yes, some of the time</li><li><input type="checkbox"/> Not very often</li><li><input type="checkbox"/> No, never</li></ul> <p>4. I have been anxious or worried for no good reason</p> <ul style="list-style-type: none"><li><input type="checkbox"/> No, not at all</li><li><input type="checkbox"/> Hardly ever</li><li><input type="checkbox"/> Yes, sometimes</li><li><input type="checkbox"/> Yes, very often</li></ul> <p>*5. I have felt scared or panicky for no very good reason</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, quite a lot</li><li><input type="checkbox"/> Yes, sometimes</li><li><input type="checkbox"/> No, not much</li><li><input type="checkbox"/> No, not at all</li></ul> | <p>*6. Things have been getting on top of me</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, most of the time I haven't been able to cope at all</li><li><input type="checkbox"/> Yes, sometimes I haven't been coping as well as usual</li><li><input type="checkbox"/> No, most of the time I have coped quite well</li><li><input type="checkbox"/> No, I have been coping as well as ever</li></ul> <p>*7. I have been so unhappy that I have had difficulty sleeping</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, most of the time</li><li><input type="checkbox"/> Yes, sometimes</li><li><input type="checkbox"/> Not very often</li><li><input type="checkbox"/> No, not at all</li></ul> <p>*8. I have felt sad or miserable</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, most of the time</li><li><input type="checkbox"/> Yes, quite often</li><li><input type="checkbox"/> Not very often</li><li><input type="checkbox"/> No, not at all</li></ul> <p>*9. I have been so unhappy that I have been crying</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, most of the time</li><li><input type="checkbox"/> Yes, quite often</li><li><input type="checkbox"/> Only occasionally</li><li><input type="checkbox"/> No, never</li></ul> <p>*10. The thought of harming myself has occurred to me</p> <ul style="list-style-type: none"><li><input type="checkbox"/> Yes, quite often</li><li><input type="checkbox"/> Sometimes</li><li><input type="checkbox"/> Hardly ever</li><li><input type="checkbox"/> Never</li></ul> |
|--|--|

Administered/Reviewed by \_\_\_\_\_ Date \_\_\_\_\_

<sup>1</sup>Source: Cox, J.L., Holden, J.M., and Sagovsky, R. 1987. Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry* 150:782-786 .

<sup>2</sup>Source: K. L. Wisner, B. L. Parry, C. M. Piontek, Postpartum Depression N Engl J Med vol. 347, No 3, July 18, 2002, 194-199

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Figure 3: CES-D

## Center for Epidemiologic Studies Depression Scale (CES-D), NIMH

Below is a list of the ways you might have felt or behaved. Please tell me how often you have felt this way during the **past week**. Circle **one** number on each line.

	<b>During the Past Week</b>			
	Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	All of the time (5-7 days)
1. I was bothered by things that usually don't bother me	0	1	2	3
2. I did not feel like eating; my appetite was poor	0	1	2	3
3. I felt that I could not shake off the blues even with help from my family or friends	0	1	2	3
4. I felt I was just as good as other people	0	1	2	3
5. I had trouble keeping my mind on what I was doing	0	1	2	3
6. I felt depressed	0	1	2	3
7. I felt that everything I did was an effort	0	1	2	3
8. I felt hopeful about the future	0	1	2	3
9. I thought my life had been a failure	0	1	2	3
10. I felt fearful	0	1	2	3
11. My sleep was restless	0	1	2	3
12. I was happy	0	1	2	3
13. I talked less than usual	0	1	2	3
14. I felt lonely	0	1	2	3
15. People were unfriendly	0	1	2	3
16. I enjoyed life	0	1	2	3
17. I had crying spells	0	1	2	3
18. I felt sad	0	1	2	3
19. I felt that people dislike me	0	1	2	3
20. I could not get "going"	0	1	2	3

Table 2: Result Summary

<b>Study</b>	<i>Coll et al. (2019)</i>	<i>Ekelöf et al. (2021)</i>	<i>Aguilar-Cordero et al. (2019)</i>	<i>Songoygard et al. (2012)</i>	<i>Shakeel et al. (2018)</i>	<i>Vargas-Terrones et al. (2019)</i>
<b>Location</b>	Brazil	Sweden	Spain	Norway	Norway	Spain
<b>Study Design</b>	Randomized controlled trial	Retrospective observational study	Randomized controlled trial	Randomized controlled trial	Prospective observational study	Randomized controlled trial
<b>Sample Size</b>	639	532	129	855	643	124
<b>Study Duration</b>	16 weeks (beginning the intervention at GW 16-20)	N/A	17 weeks (beginning the intervention at GW 20)	12 weeks (beginning the intervention at GW 20-24)	N/A	22-28 weeks (beginning the intervention at GW 12-16)
<b>Intervention</b>	Three 60-minute moderate intensity supervised exercise sessions per week	Separated individuals into activity level categories based on self-report of physical activity during leisure time in the past year (Saltin Grimby Physical Activity Level)	Three 60-minute moderate intensity aquatic environment exercise sessions per week	One supervised 60-minute and two home 45-minute moderate-to-high intensity exercise sessions per week	Separated individuals into activity level categories based on recorded moderate-to-vigorous intensity physical activity accumulated in bouts $\geq 10$ min in GW 28	Three 60-minute moderate intensity group exercise sessions per week
<b>Exercise rating</b>	Borg Rating of Perceived Exertion scale	Not specified	Heart rate monitor – Quirumed OXYM2000 & Borg Rating of Perceived Exertion scale	Not specified	Armband – Sense Wear Pro 3 (heat flux, skin temperature, galvanic skin response)	Heart rate monitor – Polar FT7 & Borg Rating of Perceived Exertion scale
<b>PPD rating</b>	EPDS – at 3 months postpartum (positive score for PPD > 12)	EPDS – at 8 weeks postpartum (positive score for PPD > 12)	EPDS – at 4-6 weeks postpartum (positive score for minor risk of PPD > 10 and major risk of PPD > 16)	EPDS – at 3 months postpartum (positive score for minor risk of PPD > 10 and major risk of PPD > 13)	EPDS – at 3 months postpartum (positive score for PPD > 10)	CES-D – at 6 weeks postpartum (positive score for PPD > 16)

<b>Primary Outcome</b>	Regular exercise during pregnancy showed no difference in rates of PPD based on EPDS scores at the 3 months postpartum	Women with higher physical activity levels the year prior to giving birth were associated with lower depressive symptoms postpartum at 8 weeks postpartum	Regular exercise in an aquatic environment during pregnancy resulted in a lower risk of PPD based on EPDS scores at 4-6 weeks postpartum	Regular exercise during pregnancy showed no difference in rates of PPD based on EPDS scores at the 3 months postpartum	Women who accumulated $\geq$ 150 MVPA minutes/week had significantly lower risk for PPD at 3 months postpartum compared to those who did not accumulate any minutes/week of MVPA	Regular exercise during pregnancy resulted in a lower risk of PPD based on EPDS scores at 6 weeks postpartum
<b>Other Findings</b>	N/A	N/A	In a subgroup of women were overweight (BMI 25-29.99) those who did not exercise were at risk of PPD, while those who did were not	In a subgroup of women in the intervention group who did not exercise regularly prior to pregnancy had a reduced risk of PPD	In a subgroup of women of ethnic minority, those who accumulated $>$ 150 MVPA minutes/week had lower risk of PPD based on EPDS scores	N/A

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