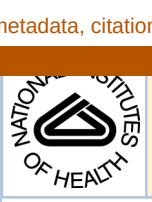

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PHYSICAL ACTIVITY DURING PREGNANCY AND POSTPARTUM DEPRESSIVE SYMPTOMS

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Abstract

Objective—to examine the associations between total and domain-specific moderate-to-vigorous physical activity (MVPA) during pregnancy and postpartum depressive symptoms.

Design—a prospective cohort study.

Participants—data were obtained from 652 women recruited from prenatal clinics at University of North Carolina during 2001–2005 for the Pregnancy, Infection, and Nutrition (PIN) Postpartum Study.

Measurements—MVPA measured at 17–22 and 27–30 weeks' gestation was investigated as a predictor of depressive symptoms assessed with the Edinburgh Postnatal Depression Scale at 3 months postpartum.

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Findings—total MVPA was not associated with depressive symptoms when using either 17–22 weeks' gestation or 27–30 weeks' gestation MVPA measures. In general, there were minimal associations for domain-specific MVPA. The direction of associations between depressive symptoms and work, adult and child care, and outdoor household MVPAs differed by time of measurement.

Key Conclusions—the association between physical activity and postpartum depressive symptoms may differ with the timing of assessment. Additional studies (i.e. with a larger sample of women or a sample of at-risk women) following women throughout pregnancy and postpartum are needed to explore differences in the influence of physical activity on depressive symptoms.

Implications for Practice—assessment of potential risk factors for elevated depressive symptoms, such as participation levels in different types of physical activity, throughout pregnancy may assist in determining who may be susceptible to postpartum depression.

Introduction

Physical activity is a major component to living a healthy life, influencing mortality, disability, physical and mental health, and health behaviors. It is estimated that physical inactivity is responsible for 1.9 million deaths worldwide (World Health Organization [WHO], 2002). Being physically active reduces the risk of premature death (Warburton et al, 2006; WHO, 2003; United States Department of Health and Human Services [US DHHS], 2008) and many chronic diseases (Chen and Millar, 1999; WHO, 2003; Warburton et al., 2006; US DHHS, 2008) and promotes better psychological health (Chen and Millar, 1999; WHO, 2003; Warburton et al., 2006).

The US DHHS recommends that adults perform at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic physical activity a week, or a combination of the two (US DHHS, 2008). It is recommended that pregnant women who are not regularly active or who engage in low intensity activity participate in at least 150 minutes/week of moderate-intensity activity while women who are highly active can continue at their pre-pregnancy activity levels (U.S. DHHS, 2008). Though there is consistent evidence that physical activity during pregnancy benefits the mental and physical health of the mother and fetus with low chance of injury (Pivarnik et al., 2006; US DHHS, 2008; Vladutiu et al., 2010), a national study found that pregnant women are less likely to meet physical activity recommendations than non-pregnant women (Evenson et al., 2004).

Studies have shown there is a positive benefit of physical activity on depression for both patient and non-patient populations, and the benefits may be long-lasting (Biddle, 1995; Craft and Perna, 2004; Teychenne et al., 2008). Women are at increased risk of developing depression during the childbearing years (Burke et al., 1991; Weissman et al., 1993), and the postpartum period is a particularly vulnerable time period (O'Hara et al., 1990; Eberhard-Gran et al., 2003; Munk-Olsen et al., 2006; Dietz et al., 2007; Vesga-Lopez et al., 2008). Postpartum depression negatively impacts the maternal health and behavior, child outcomes, maternal-infant interactions, and the father's mental health (Logsdon et al., 2006; Lee and Chung, 2007; Lusskin et al., 2007; Marcus, 2009).

Only four studies have investigated the association between physical activity during pregnancy and postpartum depressive symptoms, and all but one suggested that physical activity during pregnancy individually is related to lower levels of postpartum depressive symptoms (Abraham et al., 2001; Nordhagen and Sundgot-Borgen, 2002; Symons Downs et al., 2008). Ersek and Brunner Huber (2009) did not find a significant association between physical activity during pregnancy and postpartum depressive symptoms. No studies have investigated the role of physical activity domain in the development of depressive symptoms

among postpartum women. The objective of this investigation was to determine the association between total and domain-specific moderate-to-vigorous physical activity (MVPA) at two time points during pregnancy and postpartum depressive symptoms in a prospective cohort of women followed from pregnancy to postpartum.

Methods

Participants

This investigation reports on participants in the Pregnancy, Infection, and Nutrition (PIN) Postpartum Study, a prospective cohort of postpartum women originally enrolled in the third phase of the PIN (PIN3) Study while they were pregnant. Data from both the prenatal and postpartum components are used in this analysis. The PIN3 study recruited 2006 women from prenatal clinics at University of North Carolina Hospitals in Chapel Hill, North Carolina if they were at less than or equal to 20 weeks' gestation between January 2001 and June 2005. To be eligible for PIN Postpartum recruitment, mothers had to have delivered live-born infants between October 2002 and December 2005 and lived in the study's catchment area (in order to conduct home visits). Out of the 2006 expectant mothers recruited into the PIN3 Study, 1169 women were eligible, 938 women were invited to participate in the study, and 688 women had usable data from a 3-month postpartum home interview. Additional information regarding the PIN3 Study and attrition from PIN3 to the PIN Postpartum Study is available elsewhere (Siega-Riz et al., 2010).

Comparing the 688 women included at 3 months postpartum with the 481 (1169-688) women that were eligible for the PIN Postpartum Study but did not participate, participating women were older (29.4 vs. 28.7 years old, p=0.02), more educated (15.8 vs. 15.2 years, p=0.0002), more affluent (423.4% vs. 390.3% of the poverty level, p=0.02), more likely to be married (χ^2=21.2, p<0.0001), more likely to be of White race (χ^2=20.9, p<0.0001), had lower body mass index (25.4 vs. 26.4 kg/m^2, p=0.01), and had lower depressive symptoms at both <20 weeks (11.1 vs. 12.6 Center for Epidemiologic Studies- Depression [CES-D] score, p=0.02) and 24–29 weeks' gestation (11.2 vs. 12.6 CES-D score, p=0.03). The overall distributions of total MVPA at 17–22 and 27–30 weeks' gestation did not differ between the groups of women. The same above-mentioned comparisons were analyzed between the 688 women included at 3 months postpartum and the 250 (938-688) women who were invited to participate but declined; there were no differences for any of the measures.

Procedures

Potential participants for PIN3 were identified through medical chart reviews of new prenatal patients at the UNC Hospitals and written consent was obtained from each woman by PIN3 study staff. Women were asked to participate in two research clinic visits (at <20 and 24–29 weeks' gestation), two telephone interviews (at 17–22 and 27–30 weeks' gestation), and two self-administered questionnaires which were given at each of the clinic visits and mailed back to study staff. Most psychosocial factors were assessed on the self-administered questionnaires. Telephone interviews were conducted by study staff, and data on general health, additional psychosocial measures, sociodemographics, occupation, physical activity, reproductive history, and health behaviors were assessed. Delivery logs and medical charts were abstracted after delivery to obtain information on pregnancy complications and outcomes. Those eligible for PIN Postpartum who agreed to be contacted after delivery were phoned for recruitment purposes and written consent was obtained from those that participated in the 3-month home interview. Women were asked about demographics, occupation, physical activity, and other measures and anthropometrics were collected. The Institutional Review Board of the UNC School of Medicine reviewed and approved the study protocols.

Physical activity assessment

Women were asked to recall past week physical activity performed during the two telephone interviews at 17–22 and 27–30 weeks' gestation utilizing a structured instrument with documented validity and reliability (Evenson and Wen, 2010). Assessments of five domains of physical activity were performed at each time point: occupational, recreational, household, child and adult care, and transportation. Frequency, duration, and intensity of each activity domain were determined. For each domain of activity, women were asked if they participated in activity that resulted in at least some increase in breathing and heart rate. If so, women were asked to list all the domain-specific activities they performed. Subsequently, they were asked to report the number of sessions, average duration per session, and perceived intensity level of each activity type. Perceived intensity was assessed based on the Borg scale- fairly light, somewhat hard, and hard or very hard (Borg and Linderholm, 1974). Self-reported activities that were "fairly light" corresponded with light activity, "somewhat hard" corresponded to moderate activity, and "hard or very hard" corresponded to vigorous activity (Pollock et al., 1998).

Physical activity for this analysis was characterized in hours/week, calculated by multiplying the number of times a participant reported an activity by the number of hours she reported, focusing only on activities reported as "somewhat hard" or "hard or very hard." Hours per week of activity was then aggregated by intensity and domain. The exposures of interest for this analysis are total (the total of all the domains) and domain-specific MVPAs of perceived intensity at 17–22 and 27–30 weeks' gestation.

Depression assessment at 3 months postpartum

The Edinburgh Postnatal Depression Scale (EPDS) (Cox et al., 1987) was used to assess postpartum depressive symptoms. The EPDS is a 10-item postpartum depression screening questionnaire that has been used extensively in research. The scale assesses the woman's mood during the past week using 4-point response categories. A composite score was calculated by summing across items. Some items required reverse-coding before summation because the questions were framed to ask about negative events rather than positive events. A threshold score of 12 has been shown to indicate depression of various severities and persons needing further assessment (Cox et al., 1987). Therefore, a score of ≥13 was considered as having significant depressive symptoms.

Covariates

Factors found to be associated with both physical activity and depression in previous research and factors adjusted for in previous analyses were considered potential confounders. This includes sociodemographic variables such as age at pregnancy (< 25, 25–29, 30–34, and 35+ years), race (White, Black, or other), marital status during pregnancy (married or unmarried), education (≤12, 13–16, and 17+), employment status at either 17–22 weeks or 27–30 weeks' gestation (yes, no), and poverty status during pregnancy (≤185% or >185% of the poverty line). The cut point of 185% is the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) income guideline cut point (U.S. Department of Agriculture, 2009). Health indicators included were: parity before this birth (0, 1, or 2+), pre-pregnancy body mass index (Institute of Medicine, 1990 categories: <19.8, 19.8–26, >26–29, >29) based on height and weight reported at recruitment, general health status at 17–22 weeks' gestation (poor/fair, good, and very good/excellent), vaginal bleeding (any or none), gestational diabetes (indicated in medical chart or not), and smoking status for the first six months of pregnancy (any smoker or nonsmoker). Sleep quality at 24–29 weeks' gestation (fair/poor, good/excellent) was also investigated as a potential confounder when investigating physical activity at 27–30 weeks' gestation.

Psychosocial factors include number of negative life events and social support. Life events were assessed at 17–22 and 24–29 weeks' gestation with the Life Experiences Survey (LES) which examines both acute and chronic life stresses (Sarason et al., 1978). It provides a composite score of life events and the impact of those events. Women are asked if events occurred since the start of pregnancy and, if so, they are asked to report the impact of each item as having a positive (+1 to +3), negative (−1 to −3), or no impact (0). The LES was modified by eliminating the item asking whether the respondent experienced a pregnancy, and combining husband and boyfriend (details of marital status, cohabitation, and relation with the father of the baby are obtained elsewhere), resulting in 39 items from the original 57 in the LES. The composite score of the impact of negative events was examined as a covariate and was categorized as 0- <1, 1-<4, and 4+. Social support was assessed at <20 weeks' gestation with the Medical Outcomes Study Social Support Scale which assesses the availability of perceived social support in four categories (Sherbourne and Stewart, 1991). It uses a five-category Likert response for 19 items. The overall score was used as a covariate and was categorized as 0- <78, 78- <89, and 89+. Partner support (a lot, some, not much/none) was assessed at 27–30 weeks' gestation with a single item about the amount of emotional support the woman receives from the man acting as the child's father and was considered a covariate with physical activity at 27–30 weeks' gestation.

It was determined *a priori* that recent depressive symptoms would be included as a covariate in the final models as antepartum depression is a strong risk factor for postpartum depression (Lusskin et al., 2007) and depressed individuals are less likely to be active (Egede et al., 2009). The Center for Epidemiological Studies-Depression (CES-D) Scale (Radloff, 1977) was used to assess depression during pregnancy at <20 and 24–29 weeks' gestation. The scale measures depressive symptoms, particularly depressed mood in the general population. The CES-D is a 20-item, structured self-administered questionnaire. Each response was given a score of 0 to 3. A composite score is calculated summing responses and the score ranges from 0 to 60. A variety of cutoff scores have shown associations with a clinical diagnosis of depression, with a score of 16+ suggested as an appropriate positive screen for depression (Gaynes et al., 2005; Radloff, 1977). In this analysis, a cutoff of 17 was used as CES-D scores for pregnant women may be higher due to overlap between depressive and pregnancy symptoms (Hoffman and Hatch, 2000; Orr and Miller, 1995; Klein and Essex, 1994/1995). Depressive symptoms at <20 weeks was included as a covariate with 17–22 weeks' gestation physical activity and depressive symptoms at 24–29 weeks was included as a covariate with 27–30 weeks' gestation physical activity.

Data analysis

Analyses were performed using version 9.1 of the SAS statistical software (SAS Institute Inc, Cary, NC) and STATA 11 (StataCorp, College Station, TX). Univariate analysis was conducted among the 652 women that had data on physical activity and depressive symptoms (36 out of the 688 women participating at 3 months postpartum were missing pregnancy physical activity data) to describe sample characteristics of potential covariates and physical activity. A factor was considered a confounder if it was associated with both physical activity and depressive symptoms at 3-month interview (using Chi-square analysis) and changed the estimate of the association by ≥10% in the modeling stage using a backwards approach (Rothman and Greenland, 1998). Fisher's exact test p-values were reported for Chi-square analysis when appropriate. Chi-square analysis and the Fisher's exact test were also used to compare MVPA by depressive symptoms. Exact logistic regression modeling was utilized to calculate odds ratios (ORs) and 95% confidence intervals (CIs). Regression models were calculated using 529 women who had complete data

for exposures, outcome, and covariates (an additional 123 women were missing covariate data). MVPA was dichotomously coded (none, any) for analysis.

Findings

Sample characteristics

Among the 652 mothers participating in the PIN Postpartum Study at 3 months postpartum in this sample, only 43 (7%) reported having elevated depressive symptoms. Scores ranged from 0 to 25 and the median score was 5. Among these women, the majority (78%) were White, 14% were Black, and 9% were of another race. Almost two-thirds (63%) of the women were at least 30 years of age; only 15% were less than 25 years of age. The majority of the women enrolled in this study were highly educated (86% attended college) and married (83%). Approximately half of the women were working at 3 months postpartum (52%), had given birth to their first child (49%), and were of normal BMI at 3 months postpartum (50%). A quarter of the women had incomes that met the WIC eligibility criteria. Only 8% of the women had smoked at least once since giving birth. Overall statistics and differences in postpartum characteristics by depressive symptoms status are found in Table 1. Those with high depressive symptoms were more likely to be younger, Black or of other race, unmarried, less educated, of lower income, and smokers.

About one-third (31%) of the mothers in this sample did not participate in any MVPA at 17–22 weeks' gestation according to their perceived intensities. The median of total MVPA in hours/week was 1 (with an interquartile range [IQR] of 0–1). The median value for all domain-specific values of MVPA was 0. Women were most likely to participate in recreational activity, which represented 53% of their activity on average, and least likely to participate in outdoor household activity (3%). At 27–30 weeks' gestation, 37% of the mothers did not participate in any MVPA and the median and IQR values were the same. At this time, women were still spending most of their MVPA time doing recreational activities (43%) and were spending the least amount of time in transportation (6%).

Physical activity levels during pregnancy differed by postpartum depressive symptoms status. At 17–22 weeks' gestation, women with high depressive symptoms spent a lower mean proportion of their total MVPA at work (1% vs. 8%, $p<0.001$) and in transportation (1% vs. 7% $p<0.001$) and greater mean proportions of time in the indoor household (30% vs. 15%, $p=0.01$) and outdoor household (1% vs. 3%, $p=0.01$) domains than women with low levels of depressive symptoms. At 27–30 weeks' gestation, women with high depressive symptoms spent less time doing recreational (25% vs. 44%, $p=0.03$) and outdoor household (2% vs. 6%, $p=0.03$) activities than women with low levels of depressive symptoms. A full graphical comparison of mean proportions of time spent in each domain by depressive symptoms status is presented in Figure 1 for both time points. Results of Chi-square analysis of dichotomous MVPA by depressive symptoms status is presented in Table 2. There were differences by depressive symptoms in indoor household MVPA at 17–22 weeks' gestation and adult and child care MVPA at 27–30 weeks' gestation.

Physical activity associations with depressive symptoms

Results from crude and adjusted regression models of the associations between MVPA, measured in hours/week, at 17–22 weeks' gestation and depressive symptoms at 3 months postpartum are presented in Table 3. Most of the associations produced estimates close to the null: total, adult and child care, indoor household, and transportation MVPAs. Women participating in recreational MVPA had a small decrease in the odds of having depressive symptoms at 3 months postpartum and women participating in outdoor household MVPA had a small increase in the odds of being depressed at 3 months postpartum. The strongest

association with 3-month depressive symptoms was work MVPA which conferred an 86% reduction in the odds (OR=0.14, 95% CI=0.02, 1.17).

Results from crude and adjusted regression models of the associations between MVPA, measured in hours/week, at 27–30 weeks' gestation and depressive symptoms at 3 months postpartum are presented in Table 4. Most of the associations were similar to those found for 17–22 weeks' gestation MVPA. However, reverse directions of associations were found for work, adult and child care, and outdoor household MVPAs. Participation in work and adult and child care MVPA was associated with an increase in the odds of having high depressive symptoms at 3 months postpartum. Women participating in outdoor household MVPA had lower odds of having elevated 3-month postpartum symptoms. The biggest variation between the assessments was for work MVPA which, at 27–30 weeks' gestation, was associated with a 1.47 (95% CI= 0.50, 4.33) increase in the odds of postpartum depressive symptoms.

The interpretation of the results from both time points did not differ substantially upon adjusting additionally for all other domains of physical activity. The OR for outdoor household MVPA at 17–22 weeks' gestation did change by more than 20%, but was at the null (OR=1.00, 95% CI=0.24, 4.10).

As the group of women classified as having no work MVPA consists of both women working but having no work MVPA and women who do not work at all (and therefore do not have the chance of participating in work MVPA), we also examined the physical activity-depression associations among women who were working at both time points during pregnancy. A total of 346 women were eligible for analysis. The results for the final adjusted models were similar to those presented in Tables 3 and 4, with one exception. The OR for adult and child care MVPA at 27–30 weeks' gestation was 0.70 (0.07, 3.72) among working women as compared to 1.33 (0.53, 3.34) among all women.

Discussion

In this sample of 529 women followed prospectively from pregnancy to postpartum, no significant associations were found between total or domain-specific MVPA at either 17–22 weeks or 27–30 weeks' gestation and postpartum depressive symptoms. Most estimates of the associations were similar across the two physical activity assessments, but differences across time existed for work, adult and child care, and outdoor household MVPA.

We found no significant associations between physical activity and depressive symptoms while the four previously conducted cohort studies have each suggested that physical activity during pregnancy may have some benefit for depressive symptoms (Abraham et al., 2001; Nordhagen and Sundgot-Borgen, 2002; Symons Downs et al., 2008; Ersek and Brunner Huber, 2009). All the studies examined the association between third trimester physical activity and postpartum depressive symptoms and only Nordhagen and Sundgot-Borgen (2002) found significant associations with either exercise or total physical activity. Abraham et al. (2001) found less depressive symptoms among women who exercised during months 3–4 of pregnancy, but not during months 6–7. Symons Downs et al. (2008) found that a cumulative index of pregnancy exercise (combining behavior from all three trimesters) indicated that women participating in more activity experienced lower depressive symptoms at 6 weeks postpartum than less active women, but no association with third trimester activity alone. Ersek and Brunner Huber (2009) did not find a significant association between physical activity during the last trimester of pregnancy and postpartum depressive symptoms among women who had given birth in the last 2 to 6 months, but found that being active both before and during pregnancy was associated with reduced odds

of feeling depressed. The latter three studies correspond with our findings of no association between MVPA at 27–30 weeks' gestation and 3-month depressive symptoms.

The variation in physical activity and depression assessments makes it somewhat difficult to compare results across studies. Abraham et al. (2001) assessed if participants participated in low-intensity exercise as a means of controlling weight or shape. They included exercise measurements at pre-pregnancy, 3–4 months in pregnancy, and 6–7 months in pregnancy simultaneously in a model predicting postpartum depressive symptoms at 1 week postpartum; only the 3–4 month measure was associated with symptoms. Ersek and Brunner Huber (2009) found a benefit of physical activity performed pre-pregnancy and during last 3 months of pregnancy on depressive symptoms over 2–6 months postpartum. Both Nordhagen and Sundgot-Borgen (2002) and Symons Downs et al. (2008) looked at the association between third trimester physical activity and depressive symptoms at 6 weeks postpartum. The former found an association with total physical activity, while the latter did not with exercise. Perhaps the reason why we found no association between physical activity and postpartum depressive symptoms is because we assessed depressive symptoms at 3 months postpartum or because it is important to assess levels of physical activity over the entire length of the pregnancy and perhaps even from pre-pregnancy.

Limitations and Strengths

The results of this study must be considered along with its limitations. First, the EPDS is a self-report scale that assesses depressed mood and symptoms, not a diagnosis of depression; depression can only be diagnosed through clinical assessment. However, performing clinical assessments on participants in population studies is costly and time-consuming; therefore, depression screening tools are frequently used in research studies. The EPDS has been determined to have satisfactory sensitivity, specificity, and positive predictive value (PPV) (Cox et al., 1987; Gaynes et al., 2005). The EPDS was designed with the purpose of identifying women who are depressed after childbirth and it is a widely utilized screening tool for assessing postpartum depressive symptoms (Cox et al., 1987; Gaynes et al., 2005; Pogany and Petersen 2007).

Physical activity measurement also relied on a self-report tool which can result in recall issues. However, since the assessment asked about the past week, recall issues may be limited. The questionnaire asked women to consider the frequency, duration, and intensity of all forms of physical activity by domain. This framework may contribute to better recall. Self-report methods are frequently used to assess physical activity and have been determined to be an acceptable method to assess physical activity with a number of advantages (Dale et al., 2002). Another concern is that physical activity was only assessed during the past week. Physical activity behavior can change from week to week and the reported values may not be representative of usual behavior. This may be an important consideration for the early postpartum since women are likely developing new daily routines.

Precision was of concern in this study. The reporting of elevated depressive symptoms was low in this sample (7%). Many women also reported no MVPA overall (34% at 17–22 weeks and 37% at 27–30 weeks' gestation) and by the different domains, and the variation in levels of activity was low. This resulted in wide confidence intervals for the regression analysis. The confidence limit ratios for the adjusted odds ratios ranged from 4.72 (recreational MVPA at 17–22 weeks' gestation) to 83 (outdoor household MVPA at 27–30 weeks' gestation).

Generalizability of the results should be considered. One possible mechanism of physical activity's effect on depression is that it serves as a distraction from life stressors (North et al., 1990; Craft and Perna, 2004). It is possible that the contribution of physical activity to

the development of depressive symptoms may differ among women of different profiles, such as disadvantaged women with different or elevated amount of stressors. The association may also differ for women from different cultures, as the benefits and burdens of physical activity may be perceived differently. These are concerns given that this is a self-selecting sample of women that is not representative of the source population. When comparing the women who participated in the PIN Postpartum Study to the women considered eligible who were invited to participate in the study and declined, the women did not differ in regards to any socio-demographic variables or MVPA levels at either 17–22 or 27–30 weeks' gestation. Heckman modeling (Heckman, 1978; Heckman, 1979) was used to determine if there was selection bias in our final model sample as compared to the women eligible for the PIN Postpartum Study. No substantial bias was found.

Despite the limitations discussed, there are also several strengths to this investigation. The prospective cohort design of the PIN Postpartum Study provided us with the opportunity to examine if the timing of physical activity assessment used in analysis resulted in different associations between physical activity during pregnancy and postpartum depressive symptoms; where were found in this investigation. The length of time between exposure and outcome is over 3 months. This is beneficial for an investigation of depression since it is a chronic condition and length of exposure might need to be considerable to have an impact. Data collection was extensive; a variety of factors related to the health of new mothers were assessed. This enabled us to control for a number of potential confounders, however, there is still the possibility of residual confounding. Another strength is that both physical activity and depressive symptoms were assessed using reliable and valid assessment tools (Cox et al., 1987; Gaynes et al., 2005; Evenson and Wen, 2010). The physical activity assessment was comprehensive- collecting data on duration, frequency, intensity, and domain. Previous studies of the association between physical activity during pregnancy and postpartum depressive symptoms have either only assessed total activity or exercise.

Conclusion

We investigated the associations between total and domain-specific MVPA at two times during pregnancy and 3-month postpartum depressive symptoms. No significant associations were found for either time point, but a substantial decrease in the odds was found for work MVPA at 17–22 weeks' gestation and postpartum depressive symptoms. Most of the associations were similar across time, but the direction of associations reversed between time points for work, adult and child care, and outdoor household MVPAs. Previous research has produced mixed results of the association between pregnancy physical activity and postpartum depressive symptoms depending on both the physical activity and depressive symptom assessment used. Research in this area is still in its infancy. More research is needed to examine the impact of physical activity before and throughout pregnancy on depressive symptoms at different times in the postpartum period so that results can be better compared and contrasted. Future studies examining associations between physical activity and postpartum depression should not only report on total and recreational physical activity, but explore the impact of being active in other domains.

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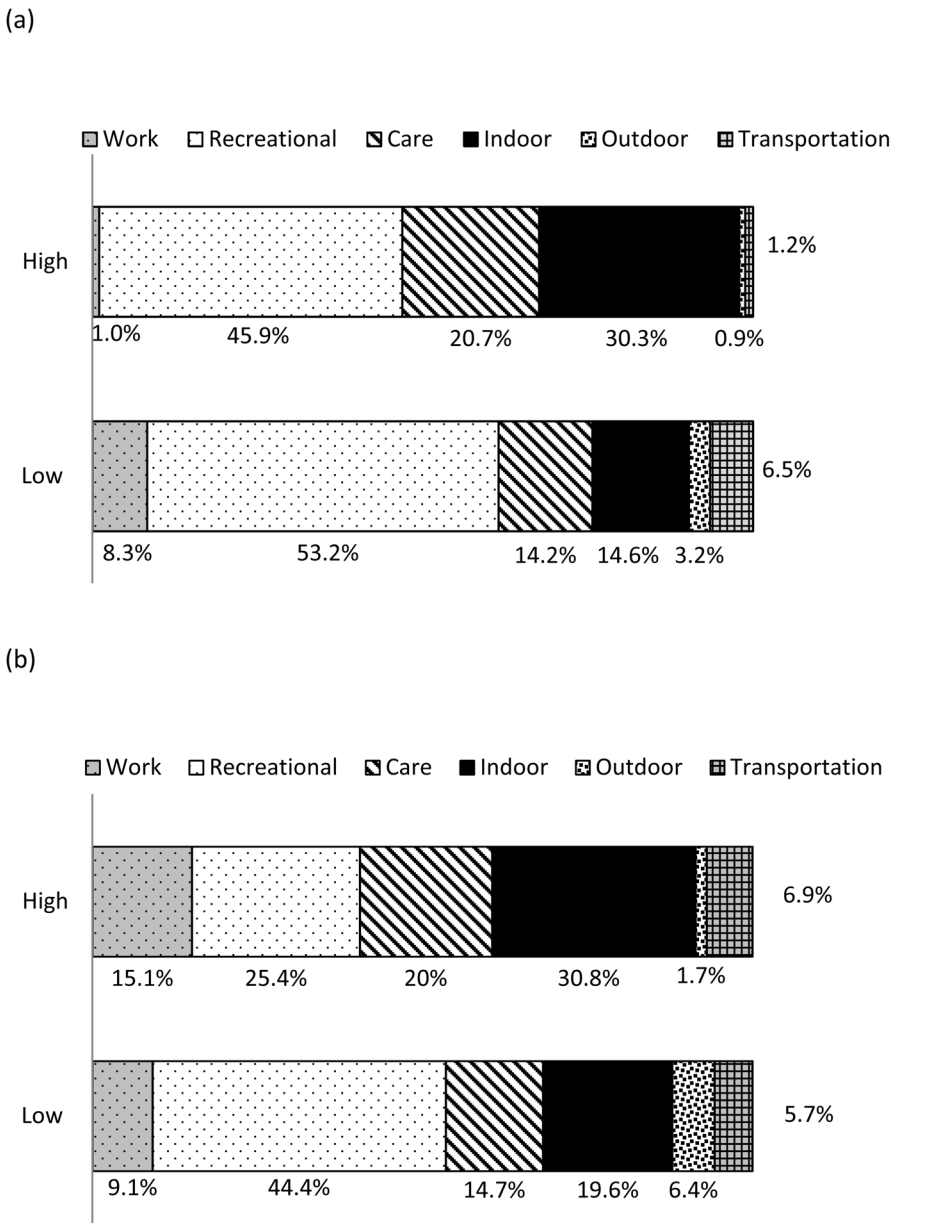

FIGURE 1.

The mean proportions of total moderate-to-vigorous physical activity (MVPA) in hours/ week spent in each domain by Edinburgh Postnatal Depression Scale (EPDS) symptoms status (low= EPDS < 13, high= ≥ 13) among women enrolled in the postpartum phase of the Pregnancy, Infection, and Nutrition Study with complete data on physical activity and depressive symptoms at 3 months postpartum (n=652): (a) 17–22 weeks' gestation and (b) 27–30 weeks' gestation.

Table 1

Postpartum characteristics of women enrolled in the postpartum phase of the Pregnancy, Infection, and Nutrition Study with physical activity data from pregnancy and the 3-month home interview depressive symptoms status (<13 score on the Edinburgh Postnatal Depression Scale [EPDS] scale versus ≥ 13 score on the EPDS) (n=652).

		EPDS		
	Total	< 13 (n=609)	≥ 13 (n=43)	
	n (%)	n (%)	n (%)	χ^2 (p-value)
Age (years)				17.26 (.0006)
< 25	95 (15)	80 (13)	15 (35)	
25–29	149 (23)	138 (23)	11 (26)	
30–34	240 (37)	229 (38)	11 (26)	
35+	168 (26)	162 (27)	6 (7)	
Race				11.04 (.0040)
White	507 (78)	480 (79)	27 (63)	
Black	88 (14)	75 (12)	13 (30)	
Other	57 (9)	54 (9)	3 (7)	
Marital status				8.30 (.0040)
Married	543 (83)	514 (84)	29 (67)	
Unmarried	109 (17)	95 (16)	14 (33)	
Education (years)				
≤12	95 (15)	78 (13)	17 (40)	23.78 (<.0001)
13–16	311 (48)	294 (48)	17 (40)	
17+	246 (38)	237 (39)	9 (21)	
Working[a]				0.24 (.6390)
Yes	342 (52)	321 (53)	21 (49)	
No	310 (48)	288 (47)	22 (51)	
Income (percent of the poverty line)[a,b]				9.37 (.0052)
≤ 185	160 (25)	141 (23)	19 (44)	
>185	487 (75)	463 (77)	24 (56)	
Parity				0.85 (.6530)
1	321 (49)	301 (49)	20 (47)	
2	227 (35)	213 (35)	14 (33)	
3+	104 (16)	95 (16)	9 (21)	
Body mass index (kg/m^2)[c]				3.49 (.3220)
<19.8	28 (4)	28 (5)	0 (0)	
19.8–26	328 (50)	307 (51)	21 (49)	
>26–29	110 (17)	104 (17)	6 (14)	
>29	185 (28)	169 (28)	16 (37)	
Smoking[a]				14.11 (.0013)
Yes	53 (8)	43 (7)	10 (23)	

	Total	EPDS		
		< 13 (n=609)	≥ 13 (n=43)	
	n (%)	n (%)	n (%)	χ^2 (p-value)
No	599 (92)	566 (93)	33 (77)	

[a] Fisher's Exact Test p-value reported

[b] Missing data on 5 women

[c] Missing data on 1 woman

Table 2

Frequencies and Chi-square statistics (with Fisher's Exact p-values) of moderate-to-vigorous physical activity (MVPA) during pregnancy by depressive symptoms status (<13 score on the Edinburgh Postnatal Depression Scale [EPDS] scale versus ≥ 13 score on the EPDS) among women enrolled in the postpartum phase of the Pregnancy, Infection, and Nutrition Study (n=652).

		EPDS		
	Total	< 13 (n=609)	≥ 13 (n=43)	
	n (%)	n (%)	n (%)	χ^2 (p-value)
17–22 weeks' gestation				
Total MVPA				0.25 (.6197)
None	220 (34)	204 (33)	16 (37)	
Any	432 (66)	405 (67)	27 (63)	
Work MVPA				3.48 (.0734)
None	581 (89)	539 (89)	42 (98)	
Any	71 (11)	70 (11)	1 (2)	
Recreational MVPA				1.41 (.2674)
None	368 (56)	340 (56)	28 (65)	
Any	284 (44)	269 (44)	15 (35)	
Adult and Child Care MVPA				1.57 (.2049)
None	545 (84)	512 (84)	33 (77)	
Any	107 (16)	97 (16)	10 (23)	
Indoor Household MVPA				4.86 (.0443)
None	524 (80)	495 (81)	29 (67)	
Any	128 (20)	114 (19)	14 (33)	
Outdoor Household MVPA				1.13 (.2958)
None	615 (94)	576 (95)	39 (91)	
Any	37 (6)	33 (5)	4 (9)	
Transportation MVPA				0.06 (1.0000)
None	600 (92)	560 (92)	40 (93)	
Any	52 (8)	49 (8)	3 (7)	
27–30 weeks' gestation				
Total MVPA				0.11 (.8706)
None	243 (37)	228 (37)	15 (35)	
Any	409 (63)	381 (63)	28 (65)	
Work MVPA				0.55 (.4412)
None	583 (89)	546 (90)	37 (86)	
Any	69 (11)	63 (10)	6 (14)	
Recreational MVPA				1.37 (.3244)
None	416 (64)	385 (63)	31 (72)	
Any	236 (36)	224 (37)	12 (28)	
Adult and Child Care MVPA				4.48 (.0434)
None	557 (85)	525 (86)	32 (74)	

	Total	EPDS		
		< 13 (n=609)	≥ 13 (n=43)	
	n (%)	n (%)	n (%)	χ^2 (p-value)
Any	95 (15)	84 (14)	11 (26)	
Indoor Household MVPA				3.45 (.0907)
None	500 (77)	472 (78)	28 (65)	
Any	152 (23)	137 (23)	15 (35)	
Outdoor Household MVPA				1.64 (.3540)
None	605 (93)	563 (92)	42 (98)	
Any	47 (7)	46 (8)	1 (2)	
Transportation MVPA				0.14 (.7661)
None	601 (92)	562 (92)	39 (91)	
Any	51 (8)	47 (8)	4 (9)	

Table 3

Odds ratios (OR) and 95% confidence intervals (CI) from logistic regression analysis of the association between total and domain-specific physical activity of somewhat hard and hard/very hard perceived intensity (hours/week) at 17 to 22 weeks' gestation and depressive symptoms at 3 months postpartum among women enrolled in the PIN Postpartum Study (n=529).

		Crude Model		Final Adjusted Model	
	n	OR	95% CI	OR	95% CI
Total Activity (hrs/wk)[a]					
None	164	1.00	--	1.00	--
Any	365	1.46	0.50, 2.90	1.07	0.46, 2.46
Work Activity (hrs/wk)[b]					
None	478	1.00	--	1.00	--
Any	51	0.29	0.01, 1.82	0.14	0.02, 1.17
Recreational Activity (hrs/wk)[a]					
None	280	1.00	--	1.00	--
Any	249	0.66	0.30, 1.46	0.84	0.39,1.84
Adult and Child Care Activity (hrs/wk)[c]					
None	437	1.00	--	1.00	--
Any	92	2.32	0.95, 5.85	0.90	0.36, 2.26
Indoor Household Activity (hrs/wk)[d]					
None	428	1.00	--	1.00	--
Any	101	2.35	0.99, 5.81	1.19	0.49, 2.88
Outdoor Household Activity (hrs/wk)[e]					
None	494	1.00	--	1.00	--
Any	35	2.12	0.52, 7.05	1.25	0.34, 4.58
Transportation Activity (hrs/wk)[f]					
None	483	1.00	--	1.00	--
Any	46	1.09	0.21, 4.07	0.95	0.26, 3.51

[a] Adjusted for depressive symptoms at <20 weeks' gestation.

[b] Adjusted for depressive symptoms at <20 weeks' gestation, smoking.

[c] Adjusted for depressive symptoms at <20 weeks' gestation, education, life events at 17–22 weeks' gestation.

[d] Adjusted for depressive symptoms at <20 weeks' gestation, education, marital status, health status at 17–22 weeks' gestation.

[e] Adjusted for depressive symptoms at <20 weeks' gestation, education, poverty.

[f] Adjusted for depressive symptoms at <20 weeks' gestation, life events at 17–22 weeks' gestation.

Table 4

Odds ratios (OR) and 95% confidence intervals (CI) from logistic regression analysis of the association between total and domain-specific physical activity of somewhat hard and hard/very hard perceived intensity (hours/week) at 27 to 30 weeks' gestation and depressive symptoms at 3 months postpartum among women enrolled in the PIN Postpartum Study (n=529).

		Crude Model		Final Adjusted Model	
	n	OR	95% CI	OR	95% CI
Total Activity (hrs/wk)[a]					
None	195	1.00	--	1.00	--
Any	334	1.31	0.58, 3.31	1.02	0.45, 2.32
Work Activity (hrs/wk)[b]					
None	475	1.00	--	1.00	--
Any	54	1.67	0.48, 4.52	1.47	0.50, 4.33
Recreational Activity (hrs/wk)[b]					
None	326	1.00	--	1.00	--
Any	203	0.72	0.29, 1.62	0.91	0.40,2.07
Adult and Child Care Activity (hrs/wk)[b]					
None	452	1.00	--	1.00	--
Any	77	2.18	0.77, 6.49	1.33	0.53, 3.34
Indoor Household Activity (hrs/wk)[c]					
None	411	1.00	--	1.00	--
Any	118	1.91	1.91, 4.55	0.93	0.39, 2.25
Outdoor Household Activity (hrs/wk)[d]					
None	488	1.00	--	1.00	--
Any	41	0.38	0.01, 2.34	0.44	0.05, 4.15
Transportation Activity (hrs/wk)[e]					
None	487	1.00	--	1.00	--
Any	42	1.22	0.23, 4.75	0.94	0.26, 3.43

[a] Adjusted for depressive symptoms at 24–29 weeks' gestation, smoking.

[b] Adjusted for depressive symptoms at 24–29 weeks' gestation, education.

[c] Adjusted for depressive symptoms at 24–29 weeks' gestation, education, health status at 17–22 weeks' gestation.

[d] Adjusted for depressive symptoms at 24–29 weeks' gestation, health status.

[e] Adjusted for depressive symptoms at 24–29 weeks' gestation.