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# Physical activity, sedentary behavior and risk of hypertensive disorders of pregnancy in Hispanic women

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## Abstract

**Objective—**Prior studies of the association between physical activity and hypertensive disorders of pregnancy have been conflicting; the majority focused on leisure-time activity only, did not use physical activity questionnaires validated for pregnancy, and were conducted in primarily non-Hispanic white populations.

**Methods—**We prospectively evaluated this association among 1240 Hispanic women in Proyecto Buena Salud. The Pregnancy Physical Activity Questionnaire, validated for use in pregnancy, was used to assess pre- and early pregnancy sports/exercise, household/caregiving, occupational and transportation activity. Diagnoses of hypertensive disorders of pregnancy were based on medical record abstraction and confirmed by the study obstetrician.

**Results—**A total of 49 women (4.0%) were diagnosed with a hypertensive disorder of pregnancy, including 32 women (2.6%) with pre-eclampsia. In age-adjusted analyses, high levels of early pregnancy household/caregiving activity were associated with reduced risk of total hypertensive disorders (OR = 0.4, 95% CI 0.1–0.9) and preeclampsia (OR = 0.3, 95% CI 0.1–0.9) relative to low levels; however, these findings were no longer statistically significant in multivariable models. Pre-pregnancy activity and pattern of activity from pre- to early-pregnancy were not significantly associated with risk. Finally, sedentary behavior was not significantly associated with hypertensive disorders.

**Conclusion—**Findings from this prospective study of Hispanic women were consistent with those of prior prospective cohorts indicating that physical activity prior to and during early pregnancy does not significantly reduce risk of hypertensive disorders of pregnancy.

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**DECLARATION OF INTEREST**

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

**Keywords**

Exercise; Gestational hypertension; Latina; Prospective; Pregnancy

## INTRODUCTION

Hypertensive disorders of pregnancy affect approximately 8% of pregnancies in the United States (1) and include gestational hypertension and pre-eclampsia. Women with gestational hypertension are at risk for pre-eclampsia or eclampsia (2) as well as subsequent hypertension and stroke later in life (3). Hypertensive disorders of pregnancy are one of the leading causes of maternal and perinatal morbidity and mortality worldwide (4) and are associated with an increased risk of preterm delivery, neonatal intensive-care unit admission and fetal death (5).

Findings regarding the impact of physical activity on the risk of pre-eclampsia have been conflicting. Two recent systematic reviews found that a protective effect of physical activity was limited to case–control studies ($n$ = 1194 cases; summary OR 0.77, 95% CI 0.64–0.91) and was only observed among women participating in high-intensity or amounts of leisure time activity (i.e. >4 h per week) either before or during pregnancy (6). In contrast, prior prospective cohort studies have not observed a significant impact of physical activity, regardless of intensity, on pre-eclampsia (summary OR 0.99, 95% CI 0.93–1.05) (6,7).

Randomized trials are sparse. A Cochrane review included two small trials (45 women) comparing moderate-intensity aerobic exercise to normal physical activity and found no statistically significant differences between the groups (8). In another randomized clinical trial, Yeo et al. found a higher incidence of pre-eclampsia among a prenatal walking group (14.6%, 95% CI 5.6–29.2) as compared to a stretching group (2.6%, 95% CI 0.07–13.8) but confidence intervals were wide (9).

The majority of prior studies, however, were restricted to leisure time sports or recreational activities, with few evaluating the impact of occupational and household/caregiving activities, or sedentary behavior. In addition, the prior observational studies had a number of limitations. The majority did not use a validated physical activity questionnaire and only one prior study (10) used a questionnaire validated among pregnant women. Finally, with one exception (10), prior studies were conducted in predominantly non-Hispanic white populations.

Hispanic women have higher rates of risk factors for pre-eclampsia, such as obesity, insulin resistance, type 2 diabetes mellitus and gestational diabetes mellitus compared with non-Hispanic white women, suggesting that Hispanic women might be at increased risk for hypertensive disorders of pregnancy (11). Prevention of pre-eclampsia among Hispanic women is critically important as Hispanics are the largest minority group in the US, with the highest birth (12) and immigration rates of any minority group (13). Hispanics from the Caribbean islands (i.e. Puerto Ricans and Dominicans) are the second largest group of Hispanics living in the US, the fastest growing subgroup and the largest Hispanic subgroup in the northeast US (13). As compared to other Hispanics, Puerto Ricans and Dominicans

experience the greatest health disparities, the highest prevalence of type 2 diabetes (14), and are half as likely as non-Hispanics whites to meet American College of Obstetricians and Gynecologists (ACOG) guidelines for physical activity during pregnancy (15).

Therefore, we prospectively examined the relationship between overall physical activity, as well as activity according to type (i.e. sports/exercise, household/caregiving, occupational, transportation) and intensity (i.e. light, moderate, and vigorous) during pre- and early pregnancy and risk of developing hypertensive disorders of pregnancy among Hispanic women. We also examined the relationship between sedentary behavior and these outcomes. We hypothesized that there would be an inverse relationship between the physical activity variables and a positive relationship between sedentary behavior and risk of hypertensive disorders.

## METHODS

### Setting

Proyecto Buena Salud was based in the ambulatory obstetrical practices of Baystate Medical Center, an integrated health system in Western Massachusetts from 2006 to 2011. Details of the study have been previously published (16). Briefly, the overall goals were to evaluate the association between psychosocial stress, physical activity and risk of gestational diabetes mellitus among Hispanic women. Bilingual interviewers recruited patients at a prenatal care visit early in pregnancy (up to 20 weeks gestation), informed them of the aims and procedures of the study and obtained written informed consent as approved by the Institutional Review Boards of the University of Massachusetts-Amherst and Baystate Health. Interviews were conducted in Spanish or English (based on patient preference) in order to eliminate potential language or literacy barriers.

At the time of enrollment (mean = 12.4 weeks gestation), interviewers collected information on socio-demographic, acculturation and behavioral factors, including physical activity in early pregnancy as well as one year prior to the pregnancy. After delivery, medical records were abstracted for medical and obstetric history and clinical characteristics of the current pregnancy.

### Eligibility

Eligibility was restricted to women of Puerto Rican or Dominican Republic heritage (Caribbean Islanders). Women who: (1) were themselves born in the Caribbean Islands, or (2) had a parent born in the Caribbean Islands or (3) had at least two grandparents born in the Caribbean Islands were included. Additional exclusion criteria included: (1) current medications thought to adversely influence glucose tolerance, (2) multiple gestation, (3) history of diagnosis of diabetes, hypertension, heart disease or chronic renal disease and (4) <16 years of age or over 40 years of age.

A total of 1626 prenatal care patients were enrolled in Proyecto Buena Salud. For the purposes of the current analysis, we excluded 69 (4%) participants who experienced a miscarriage, 168 (10%) participants who did not deliver at Baystate Health, and 13 (0.8%) participants missing pregnancy hypertension information. From the remaining group of 1376

participants, information on key hypertension risk factors (i.e. BMI and parity) and either pre- or early pregnancy physical activity information was available for 1240 (90%) participants. Of this final dataset, pre-pregnancy physical activity data was available for 1212 (98%) participants and early pregnancy activity data were available for 904 (73%). Reasons for missing physical activity information included insufficient time to complete the questionnaire before women were called into their medical appointment and subsequent inability to reach them over the telephone (e.g. due to disconnected telephone).

## Physical Activity

Physical activity during pre-pregnancy (1 year prior) and early pregnancy was assessed using the Pregnancy Physical Activity Questionnaire (PPAQ), a semi-quantitative instrument validated for use during pregnancy (17). The PPAQ evaluates participation in sports/exercise, household/caregiving, occupational and transportation activities. The number of minutes spent on each reported activity on the PPAQ was multiplied by its metabolic equivalent of task (MET) level and summed to arrive at an estimate of average daily energy expenditure (MET-h/day). MET intensity scores were based on the Compendium of Physical Activities (18), with the exception of walking and light housework activities, for which field-based measures among pregnant women were used (19). In addition to total MET-h/day, activity was classified by intensity (i.e. light, moderate and vigorous) and type (i.e. sports/exercise, household/caregiving, occupational and transportation).

Each physical activity variable was then divided into tertiles with the highest (third) tertile reflecting the highest levels of activity. Due to low participation in vigorous activity during pregnancy, this variable was dichotomized as yes/no. In addition, women with >7.5 MET-h/week in sports/exercise activities of moderate-intensity or greater (i.e. 30m per day of activity at ≥3 METs multiplied by 5 days/week) were considered to have met the ACOG exercise guidelines (20).

We also classified women by the joint distribution of total physical activity during the pre- and early pregnancy time periods. Specifically, women in the top tertile of total physical activity were defined as active while women in the bottom two tertiles were defined as inactive. We compared the risk of total hypertensive disorders for women who reported activity only during pre-pregnancy, only during early pregnancy and during both periods to women who reported no activity in either period (referent group).

Sedentary behavior was calculated as the sum of the MET-h/day spent watching TV/videos or sitting/standing at home (e.g. household/caregiving), work, or during transportation. Sedentary behavior was then divided into tertiles with the highest tertile representing the greatest amount of sedentary behavior.

## Hypertensive Disorders of Pregnancy

To ascertain hypertension status and apply standard definitions of pre-eclampsia and gestational hypertension, a trained medical record abstractor conducted detailed reviews of prenatal records including delivery logs. Diagnoses were then confirmed by an obstetrician who reviewed the medical records of each suspected case. Gestational hypertension was

defined using the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy (21) as two blood pressure measurements greater than 140/90 mmHg after 20 weeks gestation in a previously normotensive woman, with no laboratory evidence or symptoms of pre-eclampsia. Pre-eclampsia was defined as blood pressure greater than 140/90 mmHg on two occasions after 20 weeks gestation in a previously normotensive woman, with proteinuria or symptoms consistent with pre-eclampsia, other abnormal laboratory values such as low platelets or elevated liver function tests or the presence of eclampsia (21).

Total hypertensive disorders of pregnancy were defined as both preeclampsia and gestational hypertension combined.

## Covariates

At the time of enrollment, interviewers collected information on age, education, annual household income, marital status, living situation (i.e. with a partner/spouse) and number of children under 18 years and adults in the household. Interviewers also collected information on generation in the Continental US, language preference for speaking/reading (English, Spanish). Acculturation was assessed using the Psychological Acculturation Scale (PAS) (22).

Perceived stress was measured using the Cohen's Perceived Stress Scale (PSS-14) which includes 14 items designed to address a person's sense of control over daily life demands (23). Pre-pregnancy body mass index (BMI) and parity were abstracted from medical records. If pre-pregnancy weight was missing from the medical record, it was based upon self-reported pre-pregnancy weight collected at the time of enrollment.

## Data Analysis

Logistic regression was used to model the relation between physical activity in pre- and early pregnancy and risk of total hypertensive disorders and pre-eclampsia, respectively. Due to the low incidence of gestational hypertension ($n$ = 17; 1.4%), we were unable to evaluate this outcome separately. Odds ratios (ORs) and 95% confidence intervals (CI) compared participants in each tertile of activity to those in the lowest tertile. Tests of trend were calculated by modeling physical activity tertiles as ordinal variables (i.e. 1, 2 and 3).

Multivariable logistic regression models included factors associated with hypertensive disorders of pregnancy in the prior literature (i.e. age and pre-pregnancy BMI). Confounding was assessed by evaluating changes in the ORs for physical activity when each covariate was included in the regression model. A change of 10% or greater was used as an indicator of confounding. Based on this technique, only age, pre-pregnancy BMI and parity were confounders of the relationship between physical activity and hypertensive disorders of pregnancy.

Finally, we compared participants who were missing information on physical activity to those not missing information according to covariates. Statistical analysis was conducted using SAS 9.3 software (SAS Institute Inc., SAS Campus Drive, Cary, NC).

## RESULTS

Among the 1240 study participants, a total of 49 women (4.0%) were diagnosed with a hypertensive disorder of pregnancy including 32 women (2.6%) with pre-eclampsia. Overall, the majority of participants (71%) were less than 24 years of age (Table 1) with low levels of education and income. Although 89% of women were not married, approximately 50% were living with a spouse/partner. Approximately one-fifth (22%) of participants preferred Spanish for speaking/reading. Almost half of participants (46%) were overweight or obese and 41% of participants were nulliparous. Parity and pre-pregnancy smoking were inversely associated with hypertensive disorders of pregnancy, while pre-pregnancy alcohol consumption was associated with an increased risk of hypertensive disorders of pregnancy (Table 1).

We first assessed the relationship between pre-pregnancy activity and risk of hypertensive disorders of pregnancy (Table 2). In unadjusted analyses, there were no statistically significant associations between meeting ACOG exercise guidelines and risk of total hypertensive disorders or pre-eclampsia. Similarly, there were no significant associations between total pre-pregnancy physical activity, or intensity or type of activity, and risk of hypertensive disorders. In multivariable analyses adjusting for age, BMI and parity, the findings were essentially unchanged. Sedentary behavior was also not significantly associated with risk of total hypertensive disorders or pre-eclampsia although there was the suggestion of an increased risk for high levels of sedentary behavior (OR= 1.4, 95% CI 0.7–2.9; OR= 1.5, 95% CI 0.6–3.6, respectively) as compared to low levels (Table 2).

We then examined the association between early pregnancy physical activity and risk of hypertensive disorders (Table 3). There were no statistically significant associations between meeting exercise guidelines or total physical activity and risk of hypertensive disorders. However, in age-adjusted analyses, women in the top tertile of household activity had a decreased risk of hypertensive disorders of pregnancy (OR = 0.4, 95% CI 0.1–0.9, $P_{trend}$ = 0.02) as well as pre-eclampsia (OR = 0.3, 95% CI 0.1–0.9, $P_{trend}$ = 0.03) as compared to those in the lowest tertile. However, these findings were attenuated and no longer statistically significant after adjusting for age, pre-pregnancy BMI and parity. We did not observe statistically significant associations between other types or intensities of early pregnancy physical activity and risk of hypertensive disorders. Similarly, sedentary behavior was not associated with risk.

We also classified women by the joint distribution of total physical activity during the pre- and early pregnancy time periods (Table 4). Women who were active only during early pregnancy had a reduction in risk of total hypertensive disorders as compared to women who reported no activity in either pre- or early pregnancy (OR = 0.6, 95% CI 0.1–2.6) however this was not statistically significant.

Finally, when we repeated the above analyses using quartiles of physical activity instead of tertiles, the findings were virtually unchanged. Participants missing physical activity information did not differ statistically from those not missing information in terms of age, education, income, insurance, marital status, number of children in the household,

generation in the US, pre-pregnancy alcohol consumption and cigarette smoking, BMI or parity. However, those missing early pregnancy physical activity data were less likely to have three or more adults in the household (20.49% versus 27.65%, $p = 0.03$), and more likely to prefer to speak/read English (81.85% versus 76.33%, $p = 0.04$). Participants missing pre-pregnancy physical activity data were less likely to be non-smokers prior to pregnancy (31.82% versus 67.83%; $p = 0.0017$).

## DISCUSSION

In this prospective cohort of pregnant Hispanic women, we did not observe statistically significant associations between total physical activity or meeting exercise guidelines during pregnancy and risk of hypertensive disorders of pregnancy or pre-eclampsia. While high levels of household/caregiving activities were inversely associated with hypertensive disorders and pre-eclampsia in age-adjusted analyses, these findings were no longer statistically significant after adjustment for BMI and parity. Other types and intensities of physical activity, as well as sedentary behavior, were also not associated with risk.

Our findings for pre- and early pregnancy activity are consistent with prior large prospective cohort studies which, with few exceptions, did not observe statistically significant relationships between physical activity and risk of hypertensive disorders (6,7). The protective association observed in case–control studies has been limited to women participating in high-intensity leisure time physical activity or high amounts of activity (i.e. >4 h/week or >24 MET-h/week) either before or during pregnancy. In comparison, in the current study, the mean level of early pregnancy vigorous activity was 19.8 MET-h/week suggesting that our population of Hispanic women may not reach the threshold for a protective effect. On the other hand, one case–control study found that high amounts of leisure time physical activity in early pregnancy (≥4.5 h/week) was associated with an increased risk of pre-eclampsia (24).

In the only prior study limited to Hispanic women, Fortner et al. evaluated the association between physical activity and risk of hypertensive disorders of pregnancy among 1043 women (50 cases) in the prospective Latina Gestational Diabetes Mellitus Study. The authors observed the suggestion of an inverse association between high levels of total physical activity (OR: 0.3, 95% CI 0.1– 1.0, $P_{trend} = 0.06$) and household/caregiving activity (OR: 0.4, 95% CI 0.1–1.3, $P_{trend} = 0.07$) and risk of total hypertensive disorders. However, these associations were not statistically significant. In addition, physical activity was assessed via the Kaiser Physical Activity Survey (KPAS) (25) which uses a Likert-scale type measure of physical activity (ranging from 1 to 5) making it difficult to identify the actual amount of activity necessary to reduce risk.

To the best of our knowledge, the study by Fortner et al. was the only prior study to evaluate household/caregiving activity. Similarly, few prior studies have evaluated the impact of occupational activity. Findings have been conflicting with prospective studies finding no association or a suggestion of a decreased risk between occupational activity and pre-eclampsia or gestational hypertension (10,26–28). In contrast, several case–control studies have found that physically demanding and stressful occupational conditions at the onset of

pregnancy increased the risk of pre-eclampsia (29–31). Differences in findings are likely due to differences in study design and the wide variation in the methods used to classify the type and intensity of occupational activities. In addition, the increase in risk for occupational activities may be due, in part, to a corresponding increase in psychosocial stress associated with workplace activity (28). Unlike the majority of prior studies of physical activity and hypertensive disorders, we had detailed information on psychosocial stress. However, in the current analysis, we found that psychosocial stress was not a confounder of the association between occupational activity and hypertensive disorders.

Recent review articles have concluded that differences between studies in physical activity assessment tools and cutpoints, study demographics, as well as differences in diagnostic criteria for hypertensive disorders of pregnancy, preclude firm conclusions (7). In addition, case-control studies are particularly susceptible to recall bias in that women with healthy pregnancy outcomes tend to over-report their history of healthy behaviors (e.g. physical activity) during pregnancy. In the current study, physical activity was collected prospectively prior to pregnancy outcomes, using a questionnaire validated for use in pregnancy. We also collected information on activity of any type (i.e. household/caregiving, sports/exercise, occupational activity and transportation).

However, our study has several limitations. While the incidence of overall hypertension in pregnancy was 4%, we observed a fairly low incidence of pre-eclampsia (2.6%) which limited our ability to detect associations for this outcome. However, the rates of hypertensive disorders in our cohort of predominantly Puerto Rican women were comparable to those observed among similar Hispanic subgroups. For example, in the Massachusetts General Hospital Obstetric Maternal Study (MOMS), Wolf et al. observed rates of preeclampsia and gestational hypertension of 3.8 and 1.6%, respectively, among Hispanic cohort participants (predominantly Central and South American) (32). Tanaka et al. observed rates of pre-eclampsia and gestational hypertension of 3.0 and 1.2%, respectively, in New York State (predominantly Puerto Ricans) (33). Our combined variable of total hypertensive disorders of pregnancy is based on findings that pre-eclampsia and gestational hypertension share common risk factors; however, it remains unclear whether pre-eclampsia and gestational hypertension represent ends of a single pathophysiological spectrum of pregnancy induced hypertension or distinct disorders with unique biological pathways (32).

Our study was also limited by the fact that Hispanic women are less likely to engage in vigorous-intensity activities and sports/exercise as compared to non-Hispanic white populations (15). In the current study, 11% of women reported any vigorous intensity activity in early pregnancy, including only four cases of hypertensive disorders of pregnancy and two cases of pre-eclampsia. This small number of cases may explain, in part, the lack of statistically significant associations. However, while the majority of confidence intervals do not provide statistically significant evidence, they do not rule out a reduction in risk for more active women.

In summary, in this prospective cohort study of Hispanic women, after controlling for important risk factors, higher levels of physical activity prior to and during early pregnancy

were not associated with significant reductions in risk of hypertensive disorders of pregnancy. While high levels of household/caregiving activities were inversely associated with hypertensive disorders and pre-eclampsia in age-adjusted analyses, these findings were no longer statistically significant after adjustment for hypertension risk factors. Although there was a suggestion of an increased risk of hypertensive disorders with increasing sedentary behavior, these findings were not statistically significant. Our observed associations are consistent with the findings of prior prospective studies conducted among predominantly non-Hispanic white populations and extend these findings to a Hispanic population.

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**Table 1**

Distribution of hypertensive disorders of pregnancy according to participant characteristics ($n$ = 1240); Proyecto Buena Salud, Western Massachusetts, 2006–2011.

| | Total population | | Total hypertensive disorders | | | |
|---|---|---|---|---|---|---|
| | | | Cases | | Age adjusted | |
| | N[b] | % | N | % | OR | 95% CI |
| Total | 1240 | 100.0 | 49 | 4.0 | | |
| *Demographic variables* | | | | | | |
| Age (years) | | | | | | |
| Less than 19 | 390 | 31.5 | 19 | 4.9 | 1.6 | (0.8, 3.2) |
| 19–23 | 484 | 39.0 | 15 | 3.1 | 1.0 | Referent |
| 24–29 | 221 | 17.8 | 6 | 2.7 | 0.9 | (0.3, 2.3) |
| 30 and above | 145 | 11.7 | 9 | 6.2 | 2.1 | (0.9. 4.8) |
| Educational status | | | | | | |
| Less than high school | 564 | 48.0 | 19 | 3.4 | 1.0 | Referent |
| High school graduate | 390 | 33.2 | 18 | 4.6 | 1.5 | (0.8, 2.9) |
| Some college/graduate | 222 | 18.9 | 10 | 4.5 | 1.6 | (0.7, 3.5) |
| Annual Household Income | | | | | | |
| ≤$15 000 | 356 | 28.7 | 19 | 5.3 | 1.0 | Referent |
| >$15 000–$30 000 | 176 | 14.2 | 6 | 3.4 | 0.6 | (0.2, 1.5) |
| >$30 000 | 75 | 6.1 | 3 | 4.0 | 0.7 | (0.2, 2.4) |
| Don’t know/refused/missing | 633 | 51.1 | 21 | 3.3 | 0.5 | (0.3, 1.0) |
| Marital status | | | | | | |
| Single/divorced/separated/widowed | 1019 | 89.2 | 41 | 4.0 | 1.0 | Referent |
| Married | 123 | 10.8 | 6 | 4.9 | 1.2 | (0.5, 3.0) |
| Live with spouse/partner | | | | | | |
| No | 571 | 49.1 | 18 | 3.2 | 1.0 | Referent |
| Yes | 591 | 50.9 | 29 | 4.9 | 1.7 | (0.9, 3.0) |
| Children (<18 years) in household[a] | | | | | | |
| 0 | 223 | 19.4 | 13 | 5.8 | 1.0 | Referent |

| | Total population | | Total hypertensive disorders | | | |
|---|---|---|---|---|---|---|
| | | | Cases | | Age adjusted | |
| | N[b] | % | N | % | OR | 95% CI |
| 1 | 418 | 36.4 | 14 | 3.4 | 0.6 | (0.3, 1.2) |
| 2 | 506 | 44.1 | 17 | 3.4 | 0.5 | (0.3, 1.1) |
| Adults (≥18 years) in household[a] | | | | | | |
| 1 | 304 | 26.0 | 8 | 2.6 | 1.0 | Referent |
| 2 | 561 | 48.1 | 24 | 4.3 | 1.7 | (0.7, 3.8) |
| 3+ | 302 | 25.9 | 15 | 5.0 | 1.9 | (0.8, 4.6) |
| Language preference for speaking/reading | | | | | | |
| English | 965 | 77.8 | 34 | 3.5 | 1.0 | Referent |
| Spanish | 275 | 22.2 | 15 | 5.5 | 1.6 | (0.8, 3.0) |
| *Medical record variables* | | | | | | |
| Pre-pregnancy BMI | | | | | | |
| Underweight (Less than 18.5) | 75 | 6.0 | 2 | 2.7 | 0.7 | (0.2, 3.1) |
| Normal (18.5 to <25) | 592 | 47.7 | 22 | 3.7 | 1.0 | Referent |
| Overweight (25 to <30) | 295 | 23.8 | 11 | 3.7 | 1.0 | (0.5, 2.2) |
| Obese (30 or greater) | 278 | 22.4 | 14 | 5.0 | 1.4 | (0.7, 2.8) |
| Parity | | | | | | |
| 0 | 513 | 41.4 | 32 | 6.2 | 1.0 | Referent |
| 1 | 381 | 30.7 | 10 | 2.6 | 0.3 | (0.2, 0.7) |
| ≥2 | 346 | 27.9 | 7 | 2.0 | 0.2 | (0.1, 0.5) |
| *Behavioral variables* | | | | | | |
| Pre-pregnancy alcohol consumption | | | | | | |
| No | 703 | 60.0 | 23 | 3.3 | 1.0 | Referent |
| Yes | 469 | 40.0 | 24 | 5.1 | 1.7 | (1.0, 3.2) |
| Pre-pregnancy cigarette smoking | | | | | | |
| No | 787 | 67.2 | 39 | 5.0 | 1.0 | Referent |
| Yes | 385 | 32.8 | 8 | 2.1 | 0.4 | (0.2, 0.9) |
| Early pregnancy cigarette smoking | | | | | | |
| No | 736 | 86.4 | 36 | 4.9 | 1.0 | Referent |

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| | Total population | | Total hypertensive disorders | | | |
|---|---|---|---|---|---|---|
| | | | Cases | | Age adjusted | |
| | *N*[b] | % | *N* | % | OR | 95% CI |
| Yes | 116 | 13.6 | 4 | 3.4 | 0.7 | (0.2, 2.0) |

[a] Including the participant as appropriate: if518 years, included as a child; if >18 years, included as an adult.

[b] Numbers may not total to 1240 due to missing data.

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**Table 2**

Multivariable odds ratios of hypertensive disorders of pregnancy according to pre-pregnancy physical activity ($n$ = 1240); Proyecto Buena Salud, Western Massachusetts, 2006–2011.

| | Total hypertensive disorders | | | | | | | | Pre-eclampsia | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Cases | | Age adjusted | | | Multivariable adjusted[b] | | Cases | | Age adjusted | | | Multivariable adjusted[b] | | |
| | N | N | % | OR | 95% CI | | OR | 95% CI | N | % | OR | 95% CI | | OR | 95% CI | |
| Met exercise guidelines[a] | | | | | | | | | | | | | | | | |
| Yes | 731 | 28 | 3.8 | 1.0 | Referent | | 1.0 | Referent | 18 | 2.5 | 1.0 | Referent | | 1.0 | Referent | |
| No | 440 | 17 | 3.9 | 1.0 | 0.6 | 1.9 | 1.1 | 0.6 2.0 | 11 | 2.5 | 1.0 | 0.5 | 2.2 | 1.1 | 0.5 | 2.3 |
| Total physical activity | | | | | | | | | | | | | | | | |
| 1st tertile | 365 | 16 | 4.4 | 1.0 | Referent | | 1.0 | Referent | 10 | 2.7 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 364 | 11 | 3.0 | 0.7 | 0.3 | 1.5 | 0.8 | 0.4 1.7 | 8 | 2.2 | 0.8 | 0.3 | 2.1 | 0.9 | 0.4 | 2.5 |
| 3rd tertile | 364 | 16 | 4.4 | 1.1 | 0.5 | 2.1 | 1.1 | 0.6 2.4 | 10 | 2.7 | 1.0 | 0.4 | 2.5 | 1.2 | 0.5 | 2.8 |
| *p*-trend | | | | 0.90 | | | 0.73 | | | | 0.93 | | | 0.76 | | |
| *Physical activity by intensity* | | | | | | | | | | | | | | | | |
| Light | | | | | | | | | | | | | | | | |
| 1st tertile | 374 | 15 | 4.0 | 1.0 | Referent | | 1.0 | Referent | 8 | 2.1 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 376 | 13 | 3.5 | 0.9 | 0.4 | 1.9 | 0.9 | 0.4 1.9 | 9 | 2.4 | 1.2 | 0.4 | 3.0 | 1.1 | 0.4 | 3.0 |
| 3rd tertile | 368 | 15 | 4.1 | 1.1 | 0.5 | 2.3 | 1.2 | 0.6 2.5 | 11 | 3.0 | 1.5 | 0.6 | 3.8 | 1.7 | 0.7 | 4.4 |
| *p*-trend | | | | 0.82 | | | 0.64 | | | | 0.39 | | | 0.27 | | |
| Moderate | | | | | | | | | | | | | | | | |
| 1st tertile | 374 | 14 | 3.7 | 1.0 | Referent | | 1.0 | Referent | 9 | 2.4 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 380 | 19 | 5.0 | 1.4 | 0.7 | 2.8 | 1.6 | 0.8 3.3 | 12 | 3.2 | 1.3 | 0.6 | 0.6 | 1.6 | 0.7 | 4.0 |
| 3rd tertile | 377 | 12 | 3.2 | 0.9 | 0.4 | 1.9 | 1.0 | 0.4 2.2 | 8 | 2.1 | 0.9 | 0.3 | 0.3 | 1.0 | 0.4 | 2.8 |
| *p*-trend | | | | 0.77 | | | 0.98 | | | | 0.85 | | | 0.92 | | |
| Vigorous | | | | | | | | | | | | | | | | |
| No | 806 | 33 | 4.1 | 1.0 | Referent | | 1.0 | Referent | 20 | 2.5 | 1.0 | Referent | | 1.0 | Referent | |
| Yes | 375 | 12 | 3.2 | 0.8 | 0.4 | 1.5 | 0.8 | 0.4 1.5 | 9 | 2.4 | 1.0 | 0.4 | 2.1 | 0.9 | 0.4 | 2.1 |
| *Physical activity by type* | | | | | | | | | | | | | | | | |
| Household/caregiving | | | | | | | | | | | | | | | | |

| | Total hypertensive disorders | | | | | | | | Pre-eclampsia | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Cases | | Age adjusted | | | Multivariable adjusted[b] | | Cases | | Age adjusted | | | Multivariable adjusted[b] | | |
| | N | N | % | OR | 95% CI | | OR | 95% CI | N | % | OR | 95% CI | | OR | 95% CI | |
| 1st tertile | 391 | 16 | 4.1 | 1.0 | Referent | | 1.0 | Referent | 12 | 3.1 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 390 | 16 | 4.1 | 1.0 | 0.5 | 2.1 | 1.3 | 0.6 2.7 | 8 | 2.1 | 0.7 | 0.3 | 1.7 | 0.9 | 0.4 | 2.2 |
| 3rd tertile | 388 | 14 | 3.6 | 1.0 | 0.5 | 2.0 | 1.4 | 0.6 3.0 | 10 | 2.6 | 0.9 | 0.4 | 2.2 | 1.4 | 0.6 | 3.4 |
| *p*-trend | | | | 0.94 | | | 0.42 | | | | 0.83 | | | 0.53 | | |
| Occupational | | | | | | | | | | | | | | | | |
| 1st tertile | 383 | 13 | 3.4 | 1.0 | Referent | | 1.0 | Referent | 7 | 1.8 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 382 | 16 | 4.2 | 1.2 | 0.6 | 2.6 | 1.0 | 0.5 2.3 | 10 | 2.6 | 1.4 | 0.5 | 3.7 | 1.2 | 0.4 | 3.2 |
| 3rd tertile | 385 | 17 | 4.4 | 1.3 | 0.6 | 2.8 | 1.1 | 0.5 2.3 | 12 | 3.1 | 1.7 | 0.7 | 4.5 | 1.4 | 0.5 | 3.6 |
| *p*-trend | | | | 0.46 | | | 0.87 | | | | 0.25 | | | 0.52 | | |
| Transportation | | | | | | | | | | | | | | | | |
| 1st tertile | 385 | 14 | 3.6 | 1.0 | Referent | | 1.0 | Referent | 10 | 2.6 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 410 | 18 | 4.4 | 1.2 | 0.6 | 2.4 | 1.1 | 0.5 2.3 | 10 | 2.4 | 0.9 | 0.4 | 2.2 | 0.9 | 0.3 | 2.1 |
| 3rd tertile | 398 | 15 | 3.8 | 1.1 | 0.5 | 2.2 | 1.0 | 0.5 2.1 | 10 | 2.5 | 1.0 | 0.4 | 2.4 | 0.9 | 0.4 | 2.2 |
| *p*-trend | | | | 0.87 | | | 0.95 | | | | 0.97 | | | 0.83 | | |
| Sports/exercise | | | | | | | | | | | | | | | | |
| 1st tertile | 392 | 13 | 3.3 | 1.0 | Referent | | 1.0 | Referent | 8 | 2.0 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 392 | 14 | 3.6 | 1.1 | 0.5 | 2.3 | 1.1 | 0.5 2.3 | 8 | 2.0 | 1.0 | 0.4 | 2.7 | 1.0 | 0.4 | 2.7 |
| 3rd tertile | 387 | 18 | 4.7 | 1.4 | 0.7 | 2.9 | 1.3 | 0.6 2.8 | 13 | 3.4 | 1.6 | 0.7 | 4.0 | 1.5 | 0.6 | 3.8 |
| *p*-trend | | | | 0.37 | | | 0.45 | | | | 0.26 | | | 0.32 | | |
| Sedentary behavior | | | | | | | | | | | | | | | | |
| 1st tertile | 431 | 13 | 3.0 | 1.0 | Referent | | 1.0 | Referent | 8 | 1.9 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 371 | 16 | 4.3 | 1.4 | 0.7 | 3.0 | 1.4 | 0.6 2.9 | 11 | 3.0 | 1.6 | 0.6 | 4.0 | 1.5 | 0.6 | 3.9 |
| 3rd tertile | 410 | 20 | 4.9 | 1.7 | 0.8 | 3.4 | 1.4 | 0.7 2.9 | 13 | 3.2 | 1.7 | 0.7 | 4.2 | 1.5 | 0.6 | 3.6 |
| *p*-trend | | | | 0.17 | | | 0.36 | | | | 0.25 | | | 0.44 | | |

[a] Met American College of Obstetricians and Gynecologists guidelines of >7.5 MET hrs/week in sports/exercise activities of moderate intensity or greater.

[b] Adjusted for age, BMI, and parity.

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**Table 3**

Multivariable odds ratios of hypertensive disorders of pregnancy according to early pregnancy physical activity (n = 1240); Proyecto Buena Salud, Western Massachusetts, 2006–2011.

| | Total hypertensive disorders | | | | | | | | Pre-eclampsia | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Cases | | Age adjusted | | | Multivariable adjusted[b] | | Cases | | Age adjusted | | | Multivariable adjusted[b] | | |
| | N | N | % | OR | 95% CI | | OR | 95% CI | N | % | OR | 95% CI | | OR | 95% CI | |
| Met exercise guidelines[a] | | | | | | | | | | | | | | | | |
| Yes | 281 | 13 | 4.6 | 1.0 | Referent | | 1.0 | Referent | 10 | 3.6 | 1.0 | Referent | | 1.0 | Referent | |
| No | 607 | 27 | 4.4 | 0.9 | 0.5 | 1.9 | 0.9 | 0.5 1.9 | 17 | 2.8 | 0.8 | 0.3 | 1.7 | 0.8 | 0.3 | 1.7 |
| Total physical activity | | | | | | | | | | | | | | | | |
| 1st tertile | 281 | 17 | 6.0 | 1.0 | Referent | | 1.0 | Referent | 10 | 3.6 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 280 | 12 | 4.3 | 0.7 | 0.3 | 1.6 | 0.8 | 0.4 1.7 | 10 | 3.6 | 1.1 | 0.4 | 2.7 | 1.2 | 0.5 | 2.9 |
| 3rd tertile | 278 | 8 | 2.9 | 0.5 | 0.2 | 1.2 | 0.6 | 0.3 1.5 | 4 | 1.4 | 0.4 | 0.1 | 1.5 | 0.6 | 0.2 | 1.9 |
| *p*-trend | | | | 0.12 | | | 0.28 | | | | 0.22 | | | 0.42 | | |
| *Physical activity by intensity* | | | | | | | | | | | | | | | | |
| Light | | | | | | | | | | | | | | | | |
| 1st tertile | 287 | 16 | 5.6 | 1.0 | Referent | | 1.0 | Referent | 11 | 3.8 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 284 | 12 | 4.2 | 0.8 | 0.4 | 1.6 | 0.8 | 0.4 1.7 | 8 | 2.8 | 0.7 | 0.3 | 1.9 | 0.7 | 0.3 | 1.9 |
| 3rd tertile | 282 | 10 | 3.5 | 0.7 | 0.3 | 1.5 | 0.8 | 0.3 1.7 | 6 | 2.1 | 0.6 | 0.2 | 1.6 | 0.7 | 0.2 | 1.9 |
| *p*-trend | | | | 0.33 | | | 0.48 | | | | 0.31 | | | 0.43 | | |
| Moderate | | | | | | | | | | | | | | | | |
| 1st tertile | 292 | 17 | 5.8 | 1.0 | Referent | | 1.0 | Referent | 10 | 3.4 | 1.0 | Referent | | 1.0 | Referent | |
| 2nd tertile | 285 | 12 | 4.2 | 0.7 | 0.3 | 1.6 | 0.9 | 0.4 1.9 | 10 | 3.5 | 1.1 | 0.4 | 2.7 | 1.3 | 0.5 | 3.2 |
| 3rd tertile | 286 | 10 | 3.5 | 0.6 | 0.3 | 1.4 | 0.8 | 0.3 1.8 | 6 | 2.1 | 0.6 | 0.2 | 1.8 | 0.8 | 0.3 | 2.4 |
| *p*-trend | | | | 0.23 | | | 0.55 | | | | 0.42 | | | 0.80 | | |
| Vigorous | | | | | | | | | | | | | | | | |
| No | 791 | 36 | 4.6 | 1.0 | Referent | | 1.0 | Referent | 25 | 3.2 | 1.0 | Referent | | 1.0 | Referent | |
| Yes | 101 | 4 | 4.0 | 0.9 | 0.3 | 2.5 | 0.9 | 0.3 2.7 | 2 | 2.0 | 0.6 | 0.1 | 2.7 | 0.7 | 0.2 | 2.9 |
| *Physical activity by type* | | | | | | | | | | | | | | | | |
| Household/caregiving | | | | | | | | | | | | | | | | |

| | Total hypertensive disorders | | | | | | | | | Pre-eclampsia | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Cases | | Age adjusted | | | Multivariable adjusted[b] | | | Cases | | Age adjusted | | | Multivariable adjusted[b] | | | |
| | N | N | % | OR | 95% CI | | OR | 95% CI | | N | % | OR | 95% CI | | OR | 95% CI | | |
| 1st tertile | 289 | 20 | 6.9 | 1.0 | Referent | | 1.0 | Referent | | 14 | 4.8 | 1.0 | Referent | | 1.0 | Referent | | |
| 2nd tertile | 289 | 13 | 4.5 | 0.7 | 0.3 | 1.4 | 0.8 | 0.4 | 1.7 | 9 | 3.1 | 0.7 | 0.3 | 1.6 | 0.8 | 0.3 | 2.0 |
| 3rd tertile | 287 | 7 | 2.4 | 0.4 | 0.1 | 0.9 | 0.5 | 0.2 | 1.3 | 4 | 1.4 | 0.3 | 0.1 | 0.9 | 0.4 | 0.1 | 1.3 |
| *p*-trend | | | | 0.02 | | | 0.15 | | | | | 0.04 | | | 0.15 | | | |
| Occupational | | | | | | | | | | | | | | | | | | |
| 1st tertile | 429 | 19 | 4.4 | 1.0 | Referent | | 1.0 | Referent | | 13 | 3.0 | 1.0 | Referent | | 1.0 | Referent | | |
| 2nd tertile | 159 | 8 | 5.0 | 1.1 | 0.5 | 2.5 | 1.0 | 0.4 | 2.4 | 6 | 3.8 | 1.2 | 0.4 | 3.1 | 1.1 | 0.4 | 3.1 |
| 3rd tertile | 295 | 12 | 4.1 | 0.9 | 0.4 | 2.0 | 0.8 | 0.4 | 1.7 | 7 | 2.4 | 0.8 | 0.3 | 2.0 | 0.7 | 0.3 | 1.8 |
| *p*-trend | | | | 0.87 | | | 0.58 | | | | | 0.68 | | | 0.45 | | | |
| Transportation | | | | | | | | | | | | | | | | | | |
| 1st tertile | 299 | 16 | 5.4 | 1.0 | Referent | | 1.0 | Referent | | 11 | 3.7 | 1.0 | Referent | | 1.0 | Referent | | |
| 2nd tertile | 313 | 16 | 5.1 | 0.9 | 0.5 | 1.9 | 0.9 | 0.4 | 1.8 | 12 | 3.8 | 1.0 | 0.4 | 2.4 | 0.9 | 0.4 | 2.2 |
| 3rd tertile | 281 | 10 | 3.6 | 0.7 | 0.3 | 1.5 | 0.7 | 0.3 | 1.5 | 6 | 2.1 | 0.6 | 0.2 | 1.6 | 0.6 | 0.2 | 1.6 |
| *p*-trend | | | | 0.33 | | | 0.30 | | | | | 0.32 | | | 0.30 | | | |
| Sports/exercise | | | | | | | | | | | | | | | | | | |
| 1st tertile | 421 | 19 | 4.5 | 1.0 | Referent | | 1.0 | Referent | | 11 | 2.6 | 1.0 | Referent | | 1.0 | Referent | | |
| 2nd tertile | 173 | 7 | 4.0 | 0.9 | 0.4 | 2.1 | 0.9 | 0.4 | 2.3 | 5 | 2.9 | 1.1 | 0.4 | 3.2 | 1.2 | 0.4 | 3.5 |
| 3rd tertile | 294 | 14 | 4.8 | 1.1 | 0.5 | 2.2 | 1.1 | 0.5 | 2.2 | 11 | 3.7 | 1.5 | 0.6 | 3.4 | 1.5 | 0.6 | 3.5 |
| *p*-trend | | | | 0.87 | | | 0.85 | | | | | 0.39 | | | 0.38 | | | |
| Sedentary behavior | | | | | | | | | | | | | | | | | | |
| 1st tertile | 274 | 8 | 2.9 | 1.0 | Referent | | 1.0 | Referent | | 6 | 2.2 | 1.0 | Referent | | 1.0 | Referent | | |
| 2nd tertile | 327 | 22 | 6.7 | 2.5 | 1.1 | 5.7 | 2.6 | 1.1 | 5.9 | 15 | 4.6 | 2.2 | 0.8 | 5.9 | 2.3 | 0.9 | 6.0 |
| 3rd tertile | 297 | 11 | 3.7 | 1.3 | 0.5 | 3.3 | 1.2 | 0.5 | 3.0 | 7 | 2.4 | 1.1 | 0.4 | 3.3 | 1.0 | 0.3 | 3.0 |
| *p*-trend | | | | 0.67 | | | 0.86 | | | | | 0.91 | | | 0.93 | | | |

[a] Met American College of Obstetricians and Gynecologists guidelines of >7.5 MET h/week in sports/exercise activities of moderate intensity or greater.

[b] Adjusted for age, BMI, and parity.

**Table 4**

Multivariable odds ratios of hypertensive disorders of pregnancy according to joint distribution of physical activity ($n$ = 1240); Proyecto Buena Salud, Western Massachusetts, 2006–2011.

| | Total hypertensive disorders | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cases | | Age adjusted | | | Multivariable adjusted[b] | | |
| | *N* | % | OR | 95% CI | | OR | 95% CI | |
| Total physical activity | | | | | | | | |
| Inactive[a] during pre- and early pregnancy | 17 | 4.1 | 1.0 | Referent | | 1.0 | Referent | |
| Active[a] during pre-pregnancy only | 10 | 5.2 | 1.4 | 0.6 | 3.1 | 1.4 | 0.6 | 3.2 |
| Active during early pregnancy only | 2 | 1.9 | 0.5 | 0.1 | 2.2 | 0.6 | 0.1 | 2.6 |
| Active during pre- and early pregnancy | 6 | 3.5 | 0.9 | 0.3 | 2.4 | 1.1 | 0.4 | 2.8 |

[a] "Active" defined as the top tertile and "inactive" defined as the bottom two tertiles of total physical activity.

[b] Adjusted for age, BMI and parity.