Recreational Physical Activity During Pregnancy and Risk of Preeclampsia

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Abstract—The potential benefits and risks of physical activity before and during pregnancy are not well studied. We studied the relation between recreational physical activity and the risk of preeclampsia in a case-control study of 201 preeclamptic and 383 normotensive pregnant women. Participants provided information about the type, intensity, frequency, and duration of physical activity performed during the first 20 weeks of pregnancy and during the year before pregnancy. Women who engaged in any regular physical activity during early pregnancy, compared with inactive women, experienced a 35% reduced risk of preeclampsia (odds ratio, 0.65; 95% confidence interval [CI], 0.43 to 0.99). Compared with inactive women, those engaged in light or moderate activities (ie, activities with metabolic-equivalent scores <6) experienced a 24% reduced risk of preeclampsia (95% CI, 0.48 to 1.20). The corresponding reduction for women participating in vigorous activities (metabolic equivalent scores ≥ 6) was 54% (95% CI, 0.27 to 0.79). Brisk walking (average walking pace ≥ 3 mi/h), when compared with no walking at all, was associated with a 30% to 33% reduction in preeclampsia risk. Stair climbing was inversely associated with the risk of preeclampsia (P for trend $=0.039$). Recreational physical activity performed during the year before pregnancy was associated with similar reductions in preeclampsia risk. These data suggest that regular physical activity, particularly when performed during the year before pregnancy and during early pregnancy, is associated with a reduced risk of preeclampsia. **(*Hypertension*. 2003;41:1273-1280.)**

Key Words: exercise ■ pregnancy ■ preeclampsia ■ hypertension, pregnancy

Hypertensive disorders during pregnancy are the second leading cause, after embolism, of maternal mortality in the United States, accounting for ≈15% of such deaths.[1] Hypertension in pregnancy is associated with complications, including abruptio placentae, cerebral hemorrhage, hepatic failure, and acute renal failure.[2] Preeclampsia, 1 of the hypertensive disorders, occurs in 3% to 4% of pregnancies and contributes to perinatal morbidity and mortality. Little is known about the occurrence of preeclampsia in relation to modifiable risk factors, such as recreational physical activity. Although the health benefits of recreational physical activity, such as reductions in the risk of essential hypertension, coronary heart disease, and type 2 diabetes are well documented,[3] surprisingly little is known about the relation between maternal physical activity and the risk of hypertensive disorders of pregnancy. More than a decade ago, Marcoux et al,[4] in their case-control study of Canadian women, reported that women who regularly participated in recreational physical activity during the first 20 weeks of pregnancy experienced a 43% reduction in risk of preeclampsia compared with sedentary women. The authors did not study the risk of preeclampsia in relation to maternal physical activity before pregnancy, nor did they evaluate the impact of typical daily activities, such as walking and stair climbing, on the occurrence of preeclampsia. No other published studies have assessed the occurrence of preeclampsia in relation to maternal recreational physical activity. The American College of Obstetricians and Gynecologists (ACOG)[5] has established guidelines for pregnant women who choose to exercise. The guidelines, however, lack specificity with respect to appropriate types, intensities, and duration of prenatal exercise.[6] We therefore conducted the present study to address these gaps in knowledge.

Methods

Study Design and Population

This case-control study was conducted at Swedish Medical Center in Seattle, Wash, and Tacoma General Hospital in Tacoma, Wash. Between April 1998 and June 2001, we identified 201 women with preeclampsia. We used the then-current ACOG guidelines,[1] which defined preeclampsia as sustained pregnancy-induced hypertension

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with proteinuria. Eighty-five percent of eligible preeclampsia cases were enrolled. No eclamptics or women with hemolysis, elevated liver enzyme, and low platelet syndrome were included among the cases. Normotensive women, delivering on the same day as cases, were potential controls. Controls were matched by frequency to cases for maternal age and parity and had no history of pregnancy-induced hypertension or proteinuria during the study pregnancy. Of 772 eligible women, 386 (50%) agreed to participate. Reasons for nonparticipation included (1) not having time for the interview, (2) having no interest in the study, and (3) missed appointments. All cases and controls were normotensive before the study pregnancy. The procedures used in this study were in agreement with the protocols approved by the Institutional Review Boards of Swedish Medical Center and Tacoma General Hospital. All participants provided written, informed consent.

Data Collection and Assessment of Physical Activity

A structured questionnaire, administered during the participants' postpartum hospital stay, was used to collect information on maternal sociodemographic, medical, reproductive, and lifestyle characteristics during in-person interviews. We asked women to specify which recreational activities they engaged in during the first 20 weeks of the study pregnancy. For each activity, we further asked about the frequency and average time spent participating in these activities. We queried women about their usual walking pace (<2, 2, 3 to 4, or >4 mi/h) and distance (miles) walked each day. We also asked women to report the number of flights of stairs climbed daily. Women were asked to provide the same physical activity information for the 1-year period before the study pregnancy. For physical activity during pregnancy, we limited questions to the first 20 weeks of pregnancy, because this period preceded any clinical manifestation of preeclampsia. As a result of this restriction, cases were unlikely to report changes in physical activity because of symptoms related to preeclampsia. Women were also asked about their height and weight during the 3 months before the study pregnancy.

Specification of Physical Activity Variables

Women were categorized into 2 groups (not active and active) with respect to participation in recreational physical activity during the first 20 weeks of pregnancy and during the year before pregnancy. We also considered preeclampsia risk in relation to several dimensions of physical activity for both periods of study: (1) time engaged in recreational physical activities, (2) intensity of physical activities, and (3) energy expended on recreational activities.

The number of hours per week spent on recreational physical activity, either during the first 20 weeks of pregnancy or during the year before pregnancy, was calculated by dividing the total number of hours spent on each activity by the number of weeks during which the activity was performed and then summing these values over all reported activities. After specifying inactive women as the referent group, physically active women were categorized into quartiles of weekly hours spent in physical activity.

For the intensity of physical activity, we used a standardized classification procedure that allows for the determination of the energy costs of specific physical activities.[7] In brief, this was expressed as metabolic-equivalent (MET) scores, where 1 MET is the caloric need per kilogram of body weight per hour of activity divided by the caloric need per kilogram per hour at rest. We defined light activity as those activities with MET scores <3. Examples of light activities include gardening and golf. Activities classified as moderate intensity (MET scores 3 to <6) included casual swimming and cycling. Recreational activities requiring at least 6 METS (ie, jogging, running, lap swimming, and aerobic exercise) were classified as vigorous. Using the MET scores, we classified physically active subjects according to the intensity of their most vigorous activity performed during the first 20 weeks of pregnancy and during the year before pregnancy. We constructed 3 categories for maximal intensity: not active, light or moderate intensity (MET scores <6), and vigorous intensity (MET scores ≥6). Because only 1 case and no controls reported participation in light-intensity activity (MET scores 1 to 3), we included the 1 case in the group of women who reported participation in moderate-intensity activities.

We assessed the risk of preeclampsia in relation to weekly energy expenditure on recreational physical activity, which integrates intensity and the amount of time spent exercising during pregnancy and during the year before pregnancy. Energy expenditure was calculated as described by Ainsworth et al[7] and expressed in MET hours per week. MET hours per week were calculated by dividing the total number of hours spent on each activity by the number of weeks during which the activity was conducted, multiplying the resultant by the activity intensity score (MET score), and summing over all reported activities. After specifying inactive women as the referent group, physically active women were categorized into quartiles of weekly energy expenditure during the first 20 weeks of pregnancy and the year before pregnancy.

We assessed risk of preeclampsia in relation to walking and stair climbing during pregnancy and during the year before pregnancy. Women were categorized according to the distance and pace of walking daily (≤2 miles/casual, >2 mile/casual, ≤2 miles/brisk, >2 miles/brisk) and the number of flights of stairs climbed daily as 0, 1 to 4, 5 to 9, and ≥10 flights per day. A brisk walking pace was defined as a walking pace of at least 3 mi/h, whereas a casual walking pace was <3 mi/h.

Statistical Analysis

We examined the frequency distributions of maternal sociodemographic characteristics and medical and reproductive histories according to case and control status. Logistic regression procedures were used to estimate the relative risk (odds ratios [ORs]) of preeclampsia in relation to varying levels of various dimensions of physical activity examined (eg, time, intensity, and energy expenditure). In bivariate and multivariate analyses, tests for linear trend across increasing categories of physical activity were conducted by treating the median value in each category as a continuous variable.[8]

Final logistic regression models included covariates that altered unadjusted ORs for physical activity variables by at least 10%,[8] as well as those covariates of a priori interest (eg, maternal age and parity). We considered the following as possible confounders in this analysis: maternal race/ethnicity, educational attainment, smoking during pregnancy, marital status, and prepregnancy body mass index (BMI). To assess the potential modifying effect of BMI and parity on the relation between physical activity and preeclampsia risk, we repeated analyses within subgroups defined by these covariates.

Results

The sociodemographic, medical, and reproductive characteristics of cases and controls are shown in Table 1.

Physical Activity During Pregnancy

Women who participated in any recreational physical activity during the first 20 weeks of pregnancy experienced a 34% reduced risk of preeclampsia compared with inactive women (OR, 0.66; 95% confidence interval [CI], 0.47 to 0.94). This reduction remained evident after controlling for maternal age, race/ethnicity, parity, smoking status during pregnancy, and prepregnancy BMI (OR, 0.65; 95% CI, 0.43 to 0.99) (Table 2). Similar inverse associations were observed in nulliparous women (OR, 0.68; 95% CI, 0.37 to 1.25) and multiparous women (OR, 0.79; 95% CI, 0.37 to 1.72).

When we examined physical activity in more detail, the time per week on physical activity during pregnancy was inversely related to the risk of preeclampsia (probability value for linear trend=0.018). The maximal intensity of physical activity was also inversely related to the risk of preeclampsia (probability value for linear trend=0.007).

TABLE 1. Distribution of Preeclampsia Cases and Control Subjects According to Selected Characteristics, Washington, 1998–2001

Characteristic	Cases, % (N=201)	Controls, % (N=383)
Maternal age, y		
≤19	3.5	6.0
20–34	73.6	65.0
≥35	22.9	29.0
Maternal race/ethnicity		
Non-Hispanic white	67.7	70.2
African American	11.9	7.8
Other	20.4	20.4
≤High school education	30.8	19.7
Household income, annual $		
≤29 999	27.4	17.8
30 000–69 999	37.3	32.6
≥70 000	30.3	44.4
Unknown	5.0	5.2
Unmarried	30.8	22.7
Smoke during pregnancy	17.9	13.1
Primigravid	44.3	36.0
Nulliparous	70.6	52.5
Prepregnancy body mass index	27.9±0.8	23.7±0.6
Worked during pregnancy	85.6	85.4

Compared with inactive women, women who participated in light or moderate physical activities (eg, casual swimming or cycling) experienced a 24% reduced risk of preeclampsia (OR, 0.76; 95% CI, 0.48 to 1.20). Women who participated in vigorous activities during pregnancy experienced an even greater reduction in risk (54% risk reduction) compared with inactive women (OR, 0.46; 95% CI, 0.27 to 0.79). The risk of preeclampsia decreased with increasing energy expended performing physical activity. In multivariate analyses, energy expenditure during recreational physical activity remained a very strong determinant of preeclampsia risk (probability value for linear trend=0.010). ORs for increasing levels of energy expenditure, with inactive women serving as the referent, were 0.93, 0.59, 0.58, and 0.44. As shown in Table 2, women who expended ≥9 MET hours per week (equivalent to 1.5 hours per week of vigorous exercise, such as jogging, running, or aerobic dance, or 2.25 hours per week of moderate-intensity exercise such as brisk walking) experienced at least a 41% reduced risk of preeclampsia compared with inactive women.

We next evaluated the relation between walking and risk of preeclampsia. Approximately 50% of cases and 59% of controls reported that they had walked >1 mi/d during pregnancy. Overall, there was no clear evidence of a linear trend in the risk of preeclampsia with the number of miles walked daily (probability value for linear trend=0.195). Brisk walking (average walking pace ≥3 mi/h), however, irrespective of distance walked, when compared with no walking at all was associated with a 30% to 33% reduction in preeclampsia risk. To minimize the potential confounding effect of participation in vigorous activity, we repeated this analysis after restricting the study population to women who reported no vigorous activity (166 cases and 278 controls). Among inactive women and women who participated in light- to moderate-intensity activity, we also noted that pace of walking, but not distance walked, was associated with a reduced risk of preeclampsia. Women who walked ≤2 miles daily but who walked at a brisk pace (at least 3 mi/h), compared with women who walked ≤2 miles daily but at a casual pace (<3 mi/h), experienced a 38% reduced risk of preeclampsia (OR, 0.62; 95% CI, 0.31 to 1.23; data not shown).

Stair climbing was inversely related with the risk of preeclampsia (probability value for trend=0.039). For women who climbed 1 to 4, 5 to 9, and ≥10 flights of stairs daily, compared with those who did not regularly climb stairs, the adjusted ORs and 95% CIs were 0.53 and 0.32 to 0.88; 0.52 and 0.28 to 0.97; and 0.37 and 0.20 to 0.71, respectively. To assess the potential confounding and/or modifying effect of recreational physical activity on the relation between stair climbing and preeclampsia, analyses were repeated within subgroups of maximal intensity of physical activity (ie, not active, light-moderate intensity, and vigorous intensity). Women who generally climbed stairs, irrespective of whether they participated in no, light-to-moderate, or vigorous intensity recreational physical activities compared with those who were inactive tended to experience a reduced risk of preeclampsia. Among physically inactive women, those who climbed just 1 to 4 flights of stairs daily experienced a 29% reduced risk of preeclampsia (OR, 0.71; 95% CI, 0.35 to 1.41) compared with women who did not climb stairs (data not shown). Inferences from these subgroup analyses are hindered somewhat by the relatively small sample size available for study, however.

To further assess the potential modifying effect of maternal prepregnancy adiposity, we repeated analyses of the risk of preeclampsia in relation to energy expenditure on physical activity during pregnancy within subgroups of normal-weight and overweight women (prepregnancy BMI <25 vs ≥25 kg/m^2). The tendency of an inverse relation between physical activity, expressed as energy expenditure and risk of preeclampsia, was apparent among women who were overweight and among those who were not (data not shown).

Physical Activity During the Year Before Pregnancy

Overall, physical activity performed during the year before pregnancy was also predictive of a reduced risk of preeclampsia, although the magnitude of the ORs was generally slightly lower than that reported for physical activity during pregnancy. Participation in any recreational physical activity during the year before pregnancy was associated with a 33% reduction in risk of preeclampsia (OR, 0.67; 95% CI, 0.42 to 1.08; Table 3). Compared with inactive women, the risk of preeclampsia was inversely though very weakly related to the amount of time that the women spent participating in recreational physical activities (probability value for linear trend=0.234). For the year before pregnancy, women who

TABLE 2. Unadjusted (OR) and Adjusted Odds (AOR) and 95% Confidence Intervals for Preeclampsia According to Recreational Physical Activity Performed During the First 20 Weeks of Pregnancy, Washington, 1998–2001

Measurement	Preeclampsia Cases, n (N=201)	Control Subjects, n (N=383)	Unadjusted OR	Adjusted OR (95% CI)*
Any physical activity				
No	99	150	1.00	1.00
Yes	102	233	0.66	0.65 (0.43–0.99)
Hours spent performing physical activity, h/wk				
0	99	150	1.00	1.00
0.1–2.1	33	57	0.88	0.82 (0.47–1.45)
2.2–3.7	30	56	0.82	0.77 (0.44–1.38)
3.8–6.7	14	59	0.36	0.32 (0.56–0.66)
>6.7	23	57	0.61	0.56 (0.31–1.03)
Missing	2	4		
P for trend			0.009	0.018
Maximum intensity of physical activity				
Not active	99	150	1.00	1.00
Light/moderate	67	128	0.79	0.76 (0.48–1.20)
Vigorous	33	101	0.50	0.46 (0.27–0.79)
Missing	2	4		
P for trend			0.003	0.007
Energy expended performing physical activity (MET), h/wk				
Not active	99	150	1.00	1.00
<9.0	34	56	0.91	0.93 (0.53–1.62)
9.0–15.9	24	59	0.64	0.59 (0.32–1.08)
16.0–31.4	24	56	0.64	0.58 (0.31–1.07)
≥31.5	18	58	0.47	0.44 (0.23–0.84)
Missing	2	4		
P for trend			0.007	0.010
Distance walked, mi/d				
≤1.0	83	184	1.00	1.00
1.1–2.0	49	92	0.96	0.86 (0.54–1.36)
2.1–3.0	19	37	0.93	0.94 (0.49–1.74)
>3.0	31	53	0.65	0.66 (0.36–1.21)
Missing	19	17		
P for trend			0.155	0.195
Typical distance and pace of walking daily				
≤2 mi/casual	109	172	1.00	1.00
≤2 mi/ brisk	35	96	0.58	0.67 (0.41–1.10)
>2 mi/ casual	20	46	0.69	0.77 (0.41–1.41)
>2 mi/brisk	18	44	0.65	0.70 (0.37–1.32)
Missing	19	25		
Flights of stairs climbed daily				
0	54	60	1.00	1.00
1–4	81	160	0.56	0.53 (0.32–0.88)
5–9	34	69	0.55	0.52 (0.28–0.97)
≥10.0	25	84	0.33	0.37 (0.20–0.71)
Missing	7	10		
P for trend			0.003	0.039

*Adjusted for maternal age (continuous), race/ethnicity (Non-Hispanic white, African-American, other), nulliparity (yes, no), smoking during pregnancy (yes, no), and prepregnancy BMI (continuous).

TABLE 3. Unadjusted (OR) and Adjusted Odds (AOR) and 95% Confidence Intervals for Preeclampsia According to Recreational Physical Activity Performed During the Year Before Pregnancy, Washington, 1998–2001

Measurement	Preeclampsia Cases, n (N=201)	Control Subjects, n (N=383)	Unadjusted OR	Adjusted OR (95% CI)*
Any physical activity				
No	58	85	1.00	1.00
Yes	143	298	0.70	0.67 (0.42–1.08)
Hours spent performing physical activity, h/wk				
0	58	85	1.00	1.00
0.1–2.2	41	74	0.81	0.71 (0.40–1.25)
2.3–4.3	33	74	0.65	0.66 (0.36–1.22)
4.4–7.3	28	71	0.58	0.56 (0.30–1.05)
>7.3	39	78	0.73	0.64 (0.35–1.16)
Missing	2	1		
P for trend			0.201	0.234
Maximum intensity of physical activity				
Not active	58	85	1.00	1.00
3.0–5.9	76	110	1.01	0.95 (0.57–1.58)
≥6.0	65	187	0.51	0.40 (0.23–0.69)
Missing	2	1		
P for trend			0.002	< 0.001
Energy expended performing physical activity (MET), h/wk				
Not Active	58	85	1.00	1.00
0.1–11.0	49	74	0.97	0.88 (0.50–1.53)
11.1–21.8	29	74	0.57	0.59 (0.32–1.09)
21.9–36.8	26	75	0.51	0.43 (0.23–0.82)
>36.8	37	74	0.73	0.63 (0.34–1.18)
Missing	2	1		
P for trend			0.120	0.140
Distance walked, mi/d				
≤1	84	143	1.00	1.00
1.1–2.0	54	108	0.85	0.88 (0.56–1.39)
2.1–3.0	28	54	0.88	0.76 (0.43–1.36)
>3.0	25	53	0.80	0.80 (0.45–1.42)
Missing	10	25		
P for trend			0.437	0.370
Typical distance and pace of walking daily				
≤2 mi/casual	90	127	1.00	1.00
≤2 mi/brisk	46	118	0.55	0.56 (0.35–0.89)
>2 mi/casual	23	46	0.71	0.64 (0.34–1.20)
>2 mi/brisk	30	61	0.69	0.62 (0.36–1.09)
Missing	12	31		
Flights of stairs climbed daily				
0	47	57	1.00	1.00
1–4	77	163	0.57	0.60 (0.36–1.02)
5–9	35	65	0.65	0.69 (0.37–1.28)
≥10	34	87	0.47	0.52 (0.28–0.97)
Missing	8	11		
P for trend			0.120	0.349

*Adjusted for maternal age (continuous), race/ethnicity (Non-Hispanic white, African-American, other), nulliparity (yes, no), smoking during pregnancy (yes, no), and prepregnancy BMI (continuous).

TABLE 4. Unadjusted (OR) and Adjusted Odds (AOR) and 95% Confidence Intervals for Preeclampsia According to Recreational Physical Activity Performed During the Year Before and During the First 20 Weeks Gestation, Washington, 1998–2001

Measurement	Preeclampsia Cases, n (N=201)	Control Subjects, n (N=383)	Unadjusted OR	Adjusted OR (95% CI)*
Any physical activity before and during pregnancy				
No	54	80	1.00	1.00
Before only	45	70	0.95	0.87 (0.49–1.53)
During only	4	5	1.19	1.24 (0.28–5.48)
Both periods	98	228	0.63	0.59 (0.35–0.98)

*Adjusted for maternal age (continuous), race/ethnicity (Non-Hispanic white, African-American, other), nulliparity (yes, no), smoking during pregnancy (yes, no), and prepregnancy BMI (continuous).

participated in light or moderately intensive physical activities experienced virtually no reduction in risk of preeclampsia compared with inactive women (OR, 0.95; 95% CI, 0.57 to 1.58). Participation in vigorous physical activities before pregnancy, however, was associated with a 60% reduction in risk of preeclampsia (OR, 0.40; 95% CI, 0.23 to 0.69). The reduction in preeclampsia risk was greatest for women who had an energy expenditure score of 21.9 to 36.8 MET hours per week.

There was no clear evidence of a linear trend in risk of preeclampsia with respect to the number of miles walked daily (probability value for linear trend=0.370) before pregnancy. Women who walked >1 each day compared with those who did not experienced a 12% to 24% reduction in risk of preeclampsia, although this reduction in risk did not reach statistical significance. Stair climbing before pregnancy was inversely related to the risk of preeclampsia, although this was not statistically significant (probability value for trend=0.349). For women who climbed 1 to 4, 5 to 9, and ≥10 flights of stairs daily compared with those who did not regularly climb stairs, the OR and 95% CI were 0.60, 0.69, and 0.52, respectively. The tendency toward a reduction in preeclampsia risk with increasing flights of stairs climbed daily was evident among inactive women, women who participated in only light or moderate activities, and in those who participated in vigorous activities (data not shown).

Physical Activity Before and During Pregnancy

Finally, we sought to determine the joint effect of exercise before and during pregnancy in relation to preeclampsia risk. We categorized women into 4 groups (inactive both periods, physically active before pregnancy only, physically active during pregnancy only, and physically active before and during pregnancy). As shown in Table 4, women who were physically active in the year before pregnancy and during pregnancy, compared with those who were inactive before and during pregnancy, experienced a 41% reduced risk of preeclampsia (OR, 0.59; 95% CI, 0.35 to 0.98). Inference from this analysis was limited by our small sample size.

Discussion

We found that regular participation in any recreational physical activity during the first 20 weeks of pregnancy is associated with a 35% reduced risk of preeclampsia and that the risk of preeclampsia tends to decrease with increases in the intensity and amount of energy expended in these activities. This observation is in accord with the only other published report that assessed preeclampsia risk in relation to maternal recreational physical activity during pregnancy. Marcoux and colleagues,[4] in their study of Canadian women, reported that women who engaged in leisure time physical activity during the first 20 weeks of pregnancy compared with inactive women had a 43% reduced risk of preeclampsia (OR, 0.67; 95% CI, 0.46 to 0.96). The investigators also noted that the risk of preeclampsia was inversely related with the average time spent engaged in physical activity and with energy expended in leisure time physical activity.

Our study extends the observations by Marcoux and colleagues,[4] as we also documented a possible reduction in risk of preeclampsia in relation to walking and stair climbing, activities that pregnant women routinely carry out. We noted that women who regularly climbed stairs experienced a reduction in risk of preeclampsia and that the reduction was evident among all women, irrespective of their participation in recreational physical activities. We also showed that the risk reductions associated with physical activity during pregnancy were similar for nulliparous and multiparous women and that women who were overweight or obese, like their leaner counterparts, experienced reductions in preeclampsia risk with increasing levels of energy expended on recreational physical activities. Our study extended the existing literature by documenting the relation between physical activity performed during the year before pregnancy and risk of preeclampsia. We found that the risk reduction for preeclampsia was greatest for women who were physically active both before and during pregnancy.

Several limitations in our study should be considered when interpreting our findings. We cannot exclude the possibility of selection bias. In this study, the control participation rate was 50% and the case participation rate was 80%. However, the characteristics of controls who participated appeared similar to those of all women delivering at the study hospitals. We also used self-reported physical activity to classify study participants. To help mitigate the likelihood of recall bias, well-trained interviewers used a standard questionnaire to

collect information. Moreover, neither the interviewers nor the participants were aware of any of the specific study hypotheses. Some random misclassification of the duration, intensity, and energy expended during participation in physical activity might have occurred. The questionnaire used in this study was not validated. The fact that our study yielded results similar to those reported by Marcoux et a,[4] suggest that the relation between preeclampsia risk and physical activity might be robust and can be detected, even when physical activity is measured by relatively imprecise means. Inferences concerning the protective effect of physical activity and preeclampsia, however, would be enhanced with data from prospective studies and randomized lifestyle intervention trials.

The findings from our study are biologically plausible. Preeclampsia, though characterized clinically by maternal high blood pressure and proteinuria, is also characterized by metabolic disorders such as hypertriglyceridemia,[9,10] excessive lipid peroxidation or oxidative stress,[11] insulin resistance,[9] systemic chronic inflammation,[12] and elevated plasma homocysteine.[13,14] Physical activity has profound effects on a multitude of physiological functions, and these effects could mediate the risk of preeclampsia via several different biological pathways. First, results from observational epidemiological studies and from randomized trials have consistently demonstrated an inverse relation between physical activity (of varying intensity) and blood pressure in nonpregnant[15,16] and pregnant women.[17] Yeo and colleagues[17] noted that exercise treatment reduced the diastolic blood pressure in pregnant women with a history of mild hypertension, gestational hypertension, or a family history of hypertensive disorder. Second, physical activity is associated with improvements in lipid concentrations. Exercise significantly lowers plasma triglycerides and increased HDLs.[18] Third, moderate- or vigorous-intensity physical activity is associated with improved insulin sensitivity[19] and reductions in fat mass[3] in both nonpregnant and pregnant women. Fourth, moderate-intensity physical activity results in decreased concentrations of proinflammatory cytokines and C-reactive protein in the peripheral circulation.[20] Clapp and Kiess[21] reported recently that regular weight-bearing exercise during pregnancy influences alterations in plasma tumor necrosis factor-α during pregnancy.

Strenuous physical activity has been noted to increase the risk of oxidative stress[22] by some but not all investigators.[23] Emerging evidence suggests that physical activity also results in increased antioxidant enzyme activity, and this increase compensates for any possible increase in oxidative stress that might be attributable to vigorous physical activity.[24,25] Given the central role of oxidative stress in the pathophysiology of preeclampsia,[11] more studies are needed to clarify the relation between maternal and fetal enzymatic and nonenzymatic antioxidant response to physical activity during pregnancy. Last, physical activity has been linked to improvements in emotional well-being and reductions in stress and anxiety.[26] Given that investigators have shown that pregnant women experiencing anxiety and/or depression are at a 3-fold increased risk of preeclampsia,[27] it is reasonable to speculate that the risk of stress-induced preeclampsia might be influenced by the psychophysiological benefits of regular physical activity.

Perspectives

Despite intense effort, maternal mortality and morbidity from hypertensive disorders of pregnancy including preeclampsia remain high worldwide.[28] At present, other than elective delivery, there is no effective management strategy for early-onset and severe preeclampsia. Moreover, pharmacological interventions have generally proven ineffective in preventing or ameliorating the adverse effects (both maternal and fetal) of the disorder. In our sample of largely well-educated, white, middle-class women, only a small handful of participants (4 cases and 5 controls) reported initiating physical activity during pregnancy. Fully 27% of cases and 21% of controls were physically inactive before and during pregnancy. These figures are similar to results from a national survey that indicated that ≈29% of Americans reported no participation in recreational physical activity in 1998.[29] It was encouraging, however, to note that even among women who did not participate in regular recreational physical activity, those who climbed as few as 1 to 4 flights of stairs daily might experience some protection against the risk of preeclampsia. Our results suggest that current public health efforts to increase physical activity might contribute to a reduction in preeclampsia risk and support ACOG's recommendation for active women to remain physically active during pregnancy. In our study, these women experienced a 41% reduced risk of preeclampsia compared with sedentary women. Further studies are needed to confirm the present findings and specifically, to evaluate maternal and fetal risk and benefits of physical activity characterized by type, intensity, and duration before and during pregnancy.

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