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## Adherence to Walking or Stretching, and Risk of Preeclampsia in Sedentary Pregnant Women

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### Abstract

Pregnant women at risk for preeclampsia may benefit from the positive effects of exercise, but they may be unlikely to adhere to an exercise program. A randomized trial was conducted with 124 sedentary pregnant women to compare the effects of walking exercise to a stretching exercise on adherence and on the preeclampsia risk factors of heart rate (HR), blood pressure, and weight gain. Walkers exercised less than stretchers both overall and as pregnancy advanced. HR and blood pressure were lower among stretchers than walkers, but weight gain did not differ between the groups. For sedentary pregnant women, a stretching exercise may be more effective than walking in mitigating the risk of preeclampsia due to higher adherence and possible cardiac-physiologic effects.

### Keywords

Clinical trial; physical activity; preeclampsia; pregnancy; resting heart rate; sedentary; stretching; walking; weight gain

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The findings of several studies show the protective effects of physical activity for risk of preeclampsia in pregnancy. For example, Marcoux, Brisson, and Fabia (1989) reported that women who regularly performed leisure physical activity during pregnancy had a 37% lower risk of preeclampsia, including a 25% lower risk of gestational hypertension. Similarly, Sorensen et al. (2003) reported that women who engaged in any regular leisure physical activity during pregnancy experienced a 35% reduction in the risk of preeclampsia. If they engaged in vigorous activities, such as running or brisk walking, the reduction was 54%. Even light or moderate activities, such as walking, reduced the risk of preeclampsia by 24%. Yet only 15.8% of pregnant women regularly engage in any leisure physical activity, according to a study analyzing a large population data base from the 2000 Behavioral Risk Factor Surveillance System (Evenson, Savitz, & Huston, 2004). The great majority of pregnant women are sedentary (Rousham, Clarke, & Gross, 2006), and even women who were physically active before pregnancy tend to reduce their activity when they become pregnant (King, 1994; Rousham, Clarke, & Gross, 2006). Thus an important question is whether pregnant women who do not regularly engage in leisure physical activity could be persuaded to do so.

Pregnant women who are not physically active often have other risks for preeclampsia, including obesity (Ros, Cnattingius, & Lipworth, 1998), excessive gestational weight gain (Gavard & Artal, 2008), low income, and low educational attainment (Haelterman, Qvist, Barlow, & Alexander, 2003). Indeed, women with these risk factors are significantly less

likely than other women to exercise during pregnancy (Evenson et al., 2004; Hinton & Olson, 2001; Ning et al., 2003). For example, in one study, pregnant women with college degrees or above were 4.8 times (adjusted odds ratio: aOR) more likely to exercise at recommended levels than pregnant women who had not completed high school (Evenson et al.). Pregnant women with annual household incomes  $\geq$ \$70,000 US were 3.3 times (aOR) more likely to exercise than those with income  $<$ \$30,000 US (Ning et al.).

According to the American College of Obstetricians & Gynecologists (ACOG; 2002), during the last 3 months of pregnancy (28 – 40 weeks gestation) it is normal for women to find it difficult to do exercises they once found easy; nevertheless, the College recommends that pregnant women exercise at least 30 minutes a day on most days of the week, without specifying gestation period for the recommendation. Only a few studies have been conducted on adherence to exercise recommendations (Evenson et al., 2004), or the health effects of exercise during pregnancy (Marcoux et al., 1989; Sorensen et al., 2003; Yeo et al., 2000). In one such study, Cox, Burke, Gorely, Beilin, and Puddey (2003) found that a moderate-intensity-exercise group had higher adherence than a vigorous-exercise group. This suggests that ease of exercise may be an important factor for adherence among sedentary pregnant women.

Adherence to exercise has been defined as an individual's behavior coinciding with a prescribed exercise regimen for executing lifestyle change (McAuley, Courneya, Rudolph, & Lox, 1994; Probstfield, 1989). In most cases, adherence is measured in terms of frequency, intensity, and duration of exercise. It is not clear whether previously sedentary pregnant women can or will adhere to an exercise program such as that recommended by ACOG, and, if they cannot adhere, whether the amount of exercise they do engage in will still benefit them in terms of symptom relief (i.e., relief from minor pregnancy symptoms --- fatigue, lack of sleep, mood change) and reduction of the risk of adverse pregnancy outcomes.

Walking does not require as much effort as many other types of exercise. Evenson et al., (2004) found that although the proportion of pregnant women in their sample who were physically active was small, among those 83% chose walking as their main exercise activity, perhaps in part due to the ease of execution of the exercise. Stretching is physical activity that might require even less effort and might, therefore be even easier to adhere to than walking (Lowdermilk & Perry, 2007). Nelson and Kokkonen (2007, p. iv) defined stretching as "any movement that requires moving a body part to the point at which there is an increase in the movement of a joint," and described it as playing a role in improving efficiency in all physical activities. The ACOG guidelines (2003) mentioned stretching, but only to warm up and cool down in order to avoid stiffness and soreness from a main exercise activity, not as exercise in and of itself. To date, the study of stretching has been limited to sports injury prevention (Andersen, 2005; Woods, Bishop, & Jones, 2007).

Exercise is more effective among populations at risk than healthy populations. One of the physiologic benefits of exercise, including stretching, is derived from hemodynamic (Fagard, 2005) and autonomic nervous system regulation (Carter, Banister, & Blaber, 2003). Known risk factors for preeclampsia include increased resting HR (Silver, Tahvanainen, Kuusela, & Eckberg, 2001) and increased blood pressure (Caritis et al., 1998). Fagard, who reviewed 44 randomized controlled intervention trials of exercise programs, reported an average 3.4 and 2.4 mmHg reduction in systolic and diastolic blood pressure, respectively, attributable to exercise programs, with an average 4.9 beats per minute reduction in resting heart rate. He noted that the effect on blood pressure was more pronounced in hypertensive than normotensive individuals. Carter et al. also reported that most spectral analyses of autonomic nervous system regulation supported the theory that exercise increases both HR

variability and parasympathetic activity and thus contributes to bradycardia. These findings suggest that exercise could conceivably decrease preeclampsia risk by lowering blood pressure and resting HR.

Weight gain during pregnancy is also a risk factor for preeclampsia (Gavard & Artal, 2008; Kiel, Dobson, Artal, Bochmer, & Lee, 2007). Kiel et al. noted that if a pregnant woman gains more than the recommended amount based on her pre-pregnant weight, according to the standard set by the Institute of Medicine (IOM, 1990), her risk of preeclampsia increases significantly. For example, if an obese woman (body mass index  $\geq 30$  and  $< 35$ ) gains 26-35 lb. during pregnancy, her risk of preeclampsia increases by 5% over the risk of a 10-14 lb. weight gain. Gavard and Artal conducted a randomized clinical trial comparing an exercise and diet program with a diet-only program to examine the effect of exercise on weight gain during pregnancy. The investigators found significantly less weight gain in the exercise and diet group than in the diet-only group (0.1 +/- 0.4 kg vs. 0.3 +/- 0.4 kg per week,  $p < .05$ ).

There is limited information in the literature, however, about whether previously sedentary pregnant women can adhere to regular easy-to-do exercise programs and what benefit these easy-to-do exercises bring to their health, particularly if they are at risk for preeclampsia (Barakat, Stirling, & Lucia, 2008; Smith & Michel, 2006). Therefore, the purpose of this study was to compare adherence to walking or stretching exercise programs over the course of pregnancy and to examine the effects of these exercises on indicators of risk of preeclampsia (i.e., HR, blood pressure, and weight gain) in pregnant women who had experienced preeclampsia in a previous pregnancy and who led a sedentary lifestyle prior to pregnancy. The research questions were: (a) Will previously sedentary pregnant women adhere to an exercise program for 40 minutes a day 5 times a week in the latter half of pregnancy? (b) Is there a difference in adherence to a walking program or a stretching exercise program? (c) How does adherence to walking or stretching change with the advance of pregnancy (i.e., weeks gestation)? and (d) Which exercise is more effective in reducing the risk of preeclampsia (i.e., maintaining resting HR, blood pressure, and weight gain within normal ranges)?

## Method

The study was a randomized clinical trial conducted between November 2001 and July 2006 involving nine clinics in two health care systems in a Midwestern state and an exercise laboratory at a school of nursing. The primary purpose of the study was to compare the effects of walking or stretching on the incidence of preeclampsia. The primary outcomes have been published elsewhere (Yeo et al., 2008). This paper reports on adherence to the intervention and on the secondary outcomes of changes in resting HR, resting blood pressure and weight gain. The research protocol was approved by Institutional Review Boards at all involved sites. Details of the study protocol have been published elsewhere (Yeo, 2006).

## Sample

Pregnant women were eligible for the study if they (a) were less than 14 weeks gestation; (b) had a lower than average cardiovascular fitness level, or peak oxygen consumption  $\leq$  the 50th percentile of women in their age group, as measured by fitness tests using the Cornell protocol (Okin et al., 1986), and (c) led a sedentary lifestyle, or had an estimated energy expenditure for daily physical activity during the index pregnancy of less than 840 kcal/week, as assessed by the Minnesota Leisure Time Physical Activity Questionnaire (Pereira et al., 1997). They were excluded if any of the following were present: (a) diagnosed chronic hypertension or pre-gestational diabetes at the time of recruitment; (b) medical or physical condition prohibiting daily regular exercise; (c) recommendation of primary care provider

not to participate; or (d) inability to communicate sufficiently to maintain an exercise program, because of language or mental status.

Nurses in the clinics identified potential candidates, emphasized the voluntary nature of study participation, and gave contact information to the research staff if patients agreed. Research staff members assessed eligibility, and women who agreed to participate visited the exercise lab at 14 weeks gestation. The consent process took place during the first visit. Baseline data were collected after the participant gave informed consent and before randomization.

A total of 210 women agreed to participate in the study. Of these, 86 were excluded before randomization: 25 women did not meet the study criteria, and 61 women opted out (“I don’t have time”). When the opted-out women were compared to those who remained in the study, no group differences were observed in age, race/ethnicity, household income, education, number of children at home, or hours spent at work per week (Yeo et al., 2008). The remaining 124 women (59%) were randomized to two groups, using a pre-generated allocation schedule with sealed envelopes to withhold knowledge of future assignments from both the women and the researchers; 64 women were assigned to the walking group and 60 to the stretching group. Power analyses indicated that 40 subjects per group were needed to provide 80% power to detect a difference between the two groups (using a two-tailed alpha of .05). The expected difference in resting HR was 7 bpm, and it was 5 mm Hg for resting diastolic blood pressure, based on existing data (Cohen, 1988, Yeo et al., 2000).

Table 1 shows the sample characteristics by group. No significant group differences were observed in any variables including daily physical activity levels at baseline. The majority (85%) identified themselves as non-Hispanic White. They were on average 31 ( $SD = 5$ ) years of age; they had 15 ( $SD = 2$ ) years of education; were affluent (52% reported household incomes above \$75,000); were employed (80%); and worked an average of 30 ( $SD = 13$ ) hours a week. The majority (82%) had one child at home.

### Walking or Stretching Interventions

The interventions consisted of 40 minutes of walking or stretching 5 times a week, starting at 18 weeks of gestation and continuing until the end of the pregnancy. The walking exercise involved moderate-intensity walking, defined as a HR between 55% and 69% of the age-determined maximum HR (American College of Sports Medicine, 2000) and a Rating of Perceived Exertion (RPE) of either 12 or 13 (Borg & Linderholm, 1967).

The stretching program consisted of slow muscle movements that had neither aerobic nor muscle resistance components. A 40-minute videotape of the stretching movements was given to each stretching participant so she could follow movement sequences at a pre-specified pace. Once randomized, participants individually visited the exercise lab three times in the 18th week of gestation. During these visits, a staff exercise specialist trained and supervised participants in their assigned exercises. Walkers were trained to walk at the prescribed target HR and at RPE 12 or 13 and were taught the warning signs indicating that they should either stop or not start exercise to ensure maternal and fetal safety (ACOG, 2002). Stretchers were trained in stretching maneuvers and also were taught the warning signs. Participants were instructed to exercise two more times on their own at home, for the required five times a week. In the 19th week of gestation, participants exercised twice at the exercise lab under the supervision of an exercise specialist and three times on their own at home. From then on, they visited the exercise lab once a week for supervised exercise by a trained staff member and completed the other four exercise sessions on their own at home. On-site supervised childcare was provided free of charge, and participants received a \$10 gift certificate at each weekly visit.

## Measures

Fitness level was assessed as a screening criterion. Baseline data were collected on demographic data, health data, resting HR, resting blood pressure, weight, and attitude towards exercise. After randomization, the following data were collected weekly: (a) adherence: the number of days exercise was performed in the previous week for both groups, plus duration of each session for walkers; (b) resting HR, resting blood pressure, and exercise intensity, (c) daily steps in the previous week; and 4) weight at the exercise lab visit.

**Fitness level**—At 17 weeks gestation (i.e., after consenting, but prior to randomization) each participant had a treadmill-stress test twice in 1 week between 3 and 7 pm at the exercise lab. Participants were asked to avoid a big meal, caffeine, cigarette smoking, and rigorous physical activities for 2 hours before testing. A portable indirect metabolic system VO2000 (Medical Graphics Corporation, Minneapolis, MN) was used to measure oxygen uptake, carbon dioxide, and minutes ventilation. The Cornell protocol (Okin et al., 1986) and the metabolic system were tested for validity and reliability with pregnant women before the study (Yeo, Ronis, Antonakos, Roberts, & Hayashi, 2005). We measured each participant's fitness level twice and used the average as the fitness level, because the variability of VO2000 was slightly larger than the gold standard. Fitness levels were rated as very poor (16%), poor (25%), fair (39%), average (14%) or good (6%). No participant's fitness level was judged very good or exceptionally good. The 6% who were judged as good were screened out.

**Exercise adherence**—When participants visited the exercise lab, they received a weekly exercise log; they were asked to check off the date and time after each exercise session. They submitted the form filled out for the previous week and received a new form for the next week. Stretchers recorded the number of completed stretching sessions. The total number of sessions for each week was entered as the frequency of exercise performed.

The walkers brought in their HR monitors at weekly lab visits. HR data during each exercise session were downloaded to determine the length of exercise and the proportion of exercise within target HRs. For walkers, these data represented the intensity and length of walking exercises. In order to monitor their daily physical activity during the interventions, all participants wore a pedometer (DigiWalker SW200, Lees Summit, MO) daily from when they woke up until bedtime, from the beginning of 18 weeks gestation until the end of pregnancy.

**Weight, HR, and blood pressure**—At weekly lab visits, a staff member first weighed participants with a standard Detecto Balance Beam Scale (Cardinal Scale Manufacturing Company, Webb City, MO). The staff recorded the measurement in kilograms and had the participants sit quietly for 5 minutes before measuring resting HR and blood pressure. Resting HR and blood pressure were taken by trained research assistants following the ACSM protocol (ACSM, 2000). Briefly, resting HRs were manually recorded by placing the index and middle fingers on the thumb side of the lower part of the forearm, followed by manual measurement of blood pressure.

**Exercise intensity**—Because of potential HR modifications due to pregnancy, RPE was used to monitor exercise intensity, instead of exercising HR only. The Canadian Academy of Sport Medicine (Alleyne, 1998) supports the use of RPE for monitoring pregnant women's exercise intensity as the measure least likely to be affected by gestational adaptations. (No comparable statements are available from ACOG in recent years.) For walkers, target HR was calculated with Karvonen's formula once at 18 and once at 28 weeks gestation in order



to take into account gestational physiological changes (Easterling, Benedetti, Schmucker, & Millard, 1990). Walkers monitored the intensity of their exercise using a Polar S810 Heart Rate Monitor (Werminster, PA). The correlations between the monitor and electronic cardiogram (ECG) measures were high ( $r = .99$  at resting;  $r = .98$  at walking; both  $p < .001$ ), and the  $\beta = .955$  (95% Confidence Interval:  $.904 \sim 1.00$ ) with a standard error of estimate of  $.012$  (Terbizan, Dolezal, & Albano, 2002; Yeo et al., 2005).

**Potential confounders**—Demographics (age, race/ethnicity, household income, educational background, occupation, number of children at home), social support (Hinton & Olson, 2001), body size (Gavard & Artal, 2008), daily physical activity, and attitude toward exercise (McAuley et al., 1994) were identified as potential confounders, based on existing studies. Data on these variables were collected at baseline using a questionnaire, and body size was assessed as current weight. Participants recorded their daily steps in weekly exercise log forms. Intraclass correlation over 1 week among women has been reported as moderate ( $r = .72$ ; Felton, Tudor-Locke, & Burkett, 2006). To offset a relatively modest reliability, we validated each pedometer at 18 and 28 weeks gestation by a 100-step test; participants were asked to count 100 steps, and we then checked the pedometer for the measurement. A discrepancy of  $\pm 10$  steps between the actual steps and the value on the pedometer was considered acceptable. Daily pedometer readings allowed calculation of means of daily steps for each gestation week. Attitude toward exercise was assessed with one question: “Do you think exercise is beneficial?” (*yes, no*).

## Data Analysis

Two sample *t*-tests were used to examine differences between the walking and stretching groups. Chi-square and Fisher’s exact tests were used to compare proportion differences between the groups. Repeated measure ANOVA was used to compare continuous variables over time. Random effects maximum likelihood (REML) regression was used to compare group differences, gestation weeks, and their interaction with adherence, resting HR, and blood pressure changes during the interventions. Stata 9.2, (2006) was used for statistical analyses.

## Results

### Potential Confounders

At the time of their first prenatal visit, 81.2 % of the participants had a body size greater than  $29 \text{ kg/m}^2$  (i.e., they were obese). Average energy expenditure due to daily leisure time physical activity at baseline was  $65.28 \text{ kcal/day}$  (95% C.I.:  $57.63 \sim 72.93$ ). This equated to a mean weekly energy expenditure of  $449.82 \text{ kcal/week}$  (95% C.I.:  $395.3 \sim 504.4$ ). Mean fitness level ( $\text{VO}_{2\text{peak}}$ ) was  $29.2 \text{ ml/kg/min}$  (95% CI:  $28.3 \sim 30.1$ ). Ninety-three percent of the participants responded positively to the question: “Do you think exercise is beneficial?” Likelihood that Previously Sedentary Pregnant Women Will Exercise Almost Every Day for at Least 40 Minutes in the Latter Half of Pregnancy

**Frequency**—Walkers and stretchers, together, exercised an average of 3.4 times per week ( $SD = 1.7$ ) at 18 weeks, 3.6 times ( $SD = 1.9$ ) at 28 weeks, and 2.7 times ( $SD = 2.1$ ) at 38 weeks.

**Duration**—The walkers exercised an average of 36 minutes each time ( $SD = 5.8$ ), as reported at 18 weeks, 33.7 minutes ( $SD = 6.6$ ) at 28 weeks, and 31.3 minutes ( $SD = 11.8$ ) in the last week of exercise. The stretchers followed a 40-minute tape for each session.

**Intensity**—Mean HR during the walking exercise and the proportion of exercise duration within individually prescribed target HRs (moderate intensity) were calculated. HRs during exercise were, on average, 133 beats per minutes (bpm;  $SD = 9.5$ ) at 18 weeks, 126.1 bpm ( $SD = 10.4$ ) at 28 weeks, and 124.3 bpm ( $SD = 13.6$ ) in the last week, all within or lower than target HR ranges. Using repeated-measures ANOVA, exercise HRs were found to drop significantly over the three time points ( $p < .05$  between 18 and 28 weeks;  $p < .01$  between 28 and the last week), indicating that the intensity of walking exercise decreased over time.

Walkers exercised within the target HR (i.e., moderate intensity) for 35% of the duration of walking at 18 weeks gestation, but significantly less (21.8% of the duration;  $p < .05$ ) at 28 weeks. At 38 weeks, they exercised within the target HRs only 17% of the duration, compared to 35% at 18 weeks ( $p < .01$ ). Thus, although walkers exercised, the intensity of exercise dropped significantly as pregnancy advanced.

### Differences in Adherence to Walking or Stretching Exercises

Figure 1 shows the adherence to walking or stretching exercise regimens (frequency of exercise performed per week) at three data points. At 18 weeks, stretchers exercised 4.2 times ( $SD = 1.5$ ) compared with 3.7 times ( $SD = 1.5$ ) by walkers; the group difference was significant ( $p < .05$ ). At 28 weeks gestation, stretchers exercised on average 4.2 times ( $SD = 1.8$ ), while walkers exercised 3.4 times ( $SD = 1.8$ ;  $p < .001$ ). At 38 weeks gestation, the stretchers still exercised on average 3.4 times ( $SD = 2.1$ ), while walkers exercised 2.6 times ( $SD = 2.0$ ;  $p < .001$ ).

### The Effects of Advance of Pregnancy on Adherence to Walking or Stretching

Mixed effects REML regression showed that both the group effect ( $p < .001$ ) and the group-by-gestation interaction effect ( $p < .001$ ) were significant. That is, walkers exercised less frequently than stretchers and as pregnancy advanced, walkers reduced exercise frequency more than stretchers did.

**Daily physical activity (daily steps) as a potential confounder**—Weekly averages of daily steps represented daily physical activity for the week. The walker's daily steps included the steps taken during the walking exercise and other daily physical activities; the stretching exercise hardly required tracking because it was performed in a standing or sitting position. Overall, walkers tracked on average 7,790 steps ( $SD = 3,890$ ) a day, compared to 5,355 steps ( $SD = 3,044$ ) a day for stretchers. Daily physical activity gradually declined in both walkers and stretchers. Figure 2 shows the weekly means of daily steps between 18 and 37 weeks gestation for the walking and stretching groups. Daily physical activity was modeled as a function of gestation week and its square term, group assignment, and the gestation-week-by-group interaction. Using mixed effects REML regression, no quadratic or interaction terms were found to be significant, but group difference ( $\beta = -2369.6$ ;  $p < .001$ ) and gestation in weeks ( $\beta = -88.9$ ;  $p < .001$ ) were significant in the final model. Thus, daily-step changes were linear in both groups, but the walkers decreased daily steps at a faster rate (a sharper slope) than the stretchers as pregnancy advanced, and this group difference remained significant throughout the intervention.

### Comparing Effectiveness of Stretching and Walking in Reducing the Risk of Preeclampsia

Table 2 shows the baseline values and changes in HR, blood pressure, and weight gain over the intervention period for the walking and stretching groups.

**HR**—Mean resting HR at baseline, prior to randomization, was 83 bpm ( $SD = 11$ ; 95% C.I.: 82 ~ 86). For walkers, resting HR increased an average of 13.5 bpm ( $SD = 16.0$ ; 95% C.I.: 9.1 ~ 17.9) from baseline to 36 weeks ( $p < .001$ ). For stretchers, resting HR increased an

average of 8.0 bpm ( $SD = 10.5$ ; 95% C.I.: 5.1 ~ 11.2) during the same period ( $p < .001$ ). With mixed effects REML regression analysis, group effect (walking vs. stretching), gestation effect (18 – 28 weeks), and its quadratic term, the group-gestation interaction effect, and the group-gestation quadratic effect were significant: group ( $\beta = -10.13$ ;  $p < .001$ ), gestation ( $\beta = 3.93$ ;  $p < .001$ ), gestation square ( $\beta = -.07$ ;  $p < .001$ ), interaction between group and gestation ( $\beta = -1.36$ ;  $p = .002$ ), and interaction between group and gestation square ( $\beta = .04$ ;  $p = .002$ ). Thus, although everyone experienced higher resting HRs as pregnancy progressed, the stretchers experienced smaller increases in resting HR than walkers.

**Blood pressure**—No difference in blood pressure was observed between stretchers and walkers. Diastolic blood pressure increased significantly, by 4 mm Hg ( $SD = 11$ ) for walkers during the intervention period (95% C.I.: 7.4 ~ 1.2;  $p < .01$ ); however, for stretchers, diastolic blood pressure did not change significantly. Systolic blood pressure decreased by 4 mmHg ( $SD = 12$ ) for stretchers from before to after the intervention, and this change was significant (95% CI:  $-7.8 \sim -0.86$ ;  $p < .05$ ). Systolic blood pressure did not change significantly for walkers. Group and gestation week differences in systolic and diastolic pressures were not significant in the mixed-effect REML regression analysis.

**Weight gain**—The average self-reported pre-pregnant weight was 75.65 kg ( $SD = 21.18$ ). The average pre-pregnant body mass index (BMI) was 34.69 kg/m<sup>2</sup> ( $SD = 7.17$ ). Thus, prior to pregnancy, 81% of the participants were obese (BMI > 29 kg/m<sup>2</sup>); 16% were overweight (26.0 < BMI < 29.0); and 3 % were normal weight (19.8 < BMI ≤ 26). No differences were observed in the distribution of body sizes between groups. At baseline, body weight (kg) for walkers was 81 kg ( $SD = 20$ ), and for stretchers it was 82 kg ( $SD = 19$ ). This difference was not significant. Weight gain was calculated as: weight at the last lab visit – pre-pregnant weight. The average weight gain was 15.70 kg (95% C.I., 14.23 ~ 18.19), and the group difference was not significant. The IOM (1990) recommended different total weight gains depending on pre-pregnant BMI. Based on the IOM's framework, 94.5% of the participants gained more than the recommended weight; 11% of the stretchers but none of the walkers stayed within the recommended weight gain (Fisher's exact test:  $p = .041$ ). Thus, although no difference was observed in absolute weight gain, more participants in the stretching program than in the walking program stayed within the recommended weight gain.

## Discussion

In summary, walkers exercised less frequently than stretchers and as pregnancy advanced, walkers exercised significantly less frequently than stretchers (an interaction effect). Furthermore, stretchers experienced more favorable blood pressure changes over the course of pregnancy than walkers did; they were more likely to stay within recommended weight gain; and they experienced less change in resting HR in late pregnancy. These findings suggest that the type of exercise and advances of pregnancy influenced adherence to exercise and, thus, resulted in different levels of effects on risks of preeclampsia. The differences observed in physiologic measures of risk of preeclampsia may have been due to the low adherence in the walking exercise group, physiologic exercise effects specific to the stretching exercises, or a combination of both.

The study results highlight the importance of the relationship between adherence and physiologic dose effects of exercise interventions, and suggest that the type of exercise may mediate this relationship. The stretching exercise was performed more frequently than the walking exercise until the end of pregnancy. Because of higher adherence, the participants in the stretching group may have benefited more than the walking group did. These results do not deny the effects of walking exercise on risk of preeclampsia. Rather, the findings



suggest that previously sedentary pregnant women may not adhere to walking exercise, and thus may fail to benefit from it.

Different types of exercise require different arrangements to execute. McAuley et al., defined exercise adherence as “execution of life-style changes with an exercise” (1994, p. 498). That is, life-style needs to be changed to perform exercises, but different exercises require different changes in life-style. Participants may have experienced less difficulty in executing life-style changes with stretching than with walking exercise. The difficulty may stem from the requirements each exercise type imposes. For example, walking may require walking shoes, taking a shower and management of hair, selection of favorite music or programs during exercise, arrangement of childcare for older children, and other accommodations.

Individual’s perception about required modifications for execution of exercises may influence adherence. Hallam and Petosa (2004) linked exercise adherence among adults to social cognitive variables, including self-efficacy (one’s perceived confidence to overcome barriers to exercise), outcome-expectancy values (values set on the expectation that exercising will lead to less weight gain, less fatigue, or better pregnancy outcomes), and self-regulation (the skills used to implement exercise intentions and to overcome personal and situational barriers to regular exercise). Self-regulation may be less demanding with stretching than walking. In the current study, because no group differences were observed in terms of beliefs about exercise benefit or any of the other potential confounders at baseline, the difference in adherence may be attributed to the difference in the type of exercise.

Better adherence to exercise interventions may have another benefit unrelated to the exercise itself. In the current study, two participants in the stretching group gained weight within the amount recommended by the IOM (1990); all participants in the walking group gained more than the recommended amount. Because stretching does not expend energy as walking exercise does, it was not the exercise itself that helped participants manage weight gain. Further research is needed to determine whether adherence to exercise helps pregnant women manage other lifestyle behaviors such as eating.

An important component in the discussion of adherence is the intensity and duration of exercise. Although a limited number of studies of exercise adherence in sedentary pregnant women were found, findings for non-pregnant sedentary women indicate that they may adhere to exercise better if it is of moderate, rather than high intensity (Cox et al., 2003). The intensity of the stretching exercise was lower than that of the walking exercise, because stretching had neither aerobic nor muscle strengthening components. On the other hand, many walkers in the current study adjusted the intensity of their exercise by walking at HRs lower than their target HRs and also for shorter durations. Even with these self-adjustments, walkers still exercised less frequently than stretchers. Thus, proposing walking exercise at lower intensity or a shorter duration (e.g., two 15-minute sessions a day) may not result in sufficient adherence to bring protective physiologic effects for sedentary pregnant women.

The duration of prescribed exercise also influences adherence. For example, Schachter, Busch, Peloso, and Sheppard (2003), who compared adherence to two short daily versus one long daily exercise in sedentary women with fibromyalgia, found that participants adhered better to the one long exercise. Although the long exercise required more physical effort to complete, it was considered better than repeating an exercise twice a day. The current study made the duration of both exercises equal; however, different types of exercise may require different durations to achieve high adherence.

Protective physiological effects from daily stretching exercise also were observed in the current study. These are important findings, because pregnancy-specific diseases such as

preeclampsia (Ros et al., 1998) bring risks for cardiovascular disease and diabetes for women in later life (Wolf et al., 2004). Studies on the effects of stretching exercises are limited. However, researchers who have examined the effects of Yoga and Tai Chi, which both contain stretching (Lu & Kuo, 2003; Motivala, Sollers, Thayer, & Irwin, 2006; Narendran, Nagarathna, Gunasheela, & Nagendra, 2005), reported some improvement in HR variability and attributed this to autonomic nervous system regulation. The current findings provide indications that the autonomic nervous system may be involved in the effects of stretching exercises when regularly performed. Another possible mechanism may be oxidative stress (Yeo & Davidge, 2001). Oxidative stress has been associated with the development of preeclampsia (Rogers et al., 2006), and findings from a few small studies have suggested a possible decrease in oxidative stress with yoga (Bhattacharya, Paney, & Verma, 2002). Further examination of the physiologic autonomic and oxidative stress models of the effects of stretching on the risk of preeclampsia, followed by testing in a large clinical trial, is needed.

A limitation of this study was that the majority of the participants were White and they were relatively affluent and well educated; the results therefore can not be generalized to other groups of pregnant women, especially those at risk for pregnancy-related complications by virtue of race/ethnicity and social class. Also, inability to separate out walking exercise from total daily physical activity was a design limitation. Finally, data on duration and intensity of exercise were not collected for stretchers.

Despite these limitations, the results of the study suggest the value of stretching exercises for sedentary women during pregnancy. Regular stretching in the latter half of pregnancy may be more effective than walking for previously sedentary women either because of higher adherence with this form of exercise or because of its physiologic effects.

## Acknowledgments

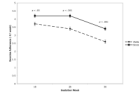
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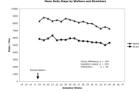
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**Figure 1.** Mean exercise weekly frequencies (+ standard error) for the walking and the stretching groups at 18, 28, and 38 weeks gestation. *p*-values for two-sample *t*-tests





**Figure 2.**  
Mean of Weekly Mean Daily Steps of Gestation Weeks 18 – 37 in Walking and Stretching Groups.

**Table 1**

## Characteristics of Walkers and Stretchers

Characteristic	Walkers ( <i>n</i> = 64) %	Stretchers ( <i>n</i> = 60) %
Maternal age (years)		
<= 19	1.5	0
20- 34	66.7	66.7
>=35	31.8	33.3
Race/ Ethnicity		
Non-Hispanic White	87	82
Other	13	18
Income		
< \$75,000	39	57
\$75,000+	61	43
Employed		
Yes	78.1	68.1
No	27	31.4
“Do you think exercise is beneficial for you?”		
Yes	95	93
No	5	5
Don't know	0	2
BMI pre-pregnancy		
19.8 to < 26.0 (normal)	2.4	2.6
26.0 to < 29.0 (overweight)	17	15.8
≥ 29.0 (obese)	80.9	81.6
	Mean ( <i>SD</i> )	
Education (yrs.)	15 (2)	15 (2)
work outside home (hr/wk)	32 (13)	28 (13)
# of children at home	1 (1)	1(1)

\* All values were non-significant for group differences.

**Table 2**

Baseline Values and Changes Over Time in Heart Rate, Blood Pressure, and Weight Gain in Walkers and Stretchers

	Baseline (14 - 17 wk)	Changes between baseline and last week of the interventi	p *
	Mean (SD)	Mean (SD)	
<u>Heart rate (bpm)</u>			
Walkers	83.0 (9.6)	+13.5 (16)	< .001
Stretchers	83.0 (9.4)	+8.0 (10.5)	< .001
<u>Systolic Pressure (mmHg)</u>			
Walkers	104.2 (7.8)	+5.0 (18)	n.s.
Stretchers	106.4 (9.3)	-4.0 (12)	< .05
<u>Diastolic Pressure (mmHg)</u>			
Walkers	63.7 (8.0)	+4.0 (11)	< .01
Stretchers	64.0 (9.4)	-1.0 (9)	n.s.
	<u>Pre-pregnant</u>	Changes between pre-pregnant and last week of the intervention	
<u>Weight Gain (Kg)</u>			
Walkers	74.9 (20.5)	15.4 (5.9)	n.s.
Stretchers	76.3 (22.1)	15.9 (6.8)	n.s.
<u>% of participants gained more weight than recommended by IOM</u>			
		%	
Walkers	--	100.0	n.s.
Stretchers	--	88.6	

\* ...one-sample t-test was applied to heart rate, blood pressure and weight gain. Fisher's exact test was applied to % in each group.

bpm (beats per minutes)

IOM (Institute of Medicine)