

Exercise in Pregnancy: Effect on Fitness and Obstetric Outcomes—A Randomized Trial

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ABSTRACT

PRICE, B. B., S. B. AMINI, and K. KAPPELER. Exercise in Pregnancy: Effect on Fitness and Obstetric Outcomes—A Randomized Trial. *Med. Sci. Sports Exerc.*, Vol. 44, No. 12, pp. 2263–2269, 2012. **Objective:** A prospective randomized controlled trial was designed to assess the benefits and possible risks of aerobic exercise during pregnancy, using a fitness regimen based on the 2002 American College of Obstetricians and Gynecologists guidelines for exercise during pregnancy. **Methods:** Inactive women were randomized at 12–14 wk gestation to a group that remained sedentary or to a group that performed moderate aerobic exercise 45–60 min, 4 d·wk⁻¹, through 36 wk gestation. Thirty-one subjects in each group completed the study. **Results:** Compared with women who remained sedentary, active women improved aerobic fitness ($P < 0.05$) and muscular strength ($P < 0.01$), delivered comparable size infants with significantly fewer cesarean deliveries ($P < 0.01$), and recovered faster postpartum ($P < 0.05$), at least related to the lower incidence of cesarean section. Active women developed no gestational hypertension ($P = 0.16$ compared with controls) and reported no injuries related to the exercise regimen. In the active group, there was one premature birth at 33 wk by a woman with a history of premature delivery of twins at 34 wk. There were no differences between groups in the incidence of gestational diabetes, musculoskeletal pains during pregnancy, flexibility on sit-and-reach test, mean length of pregnancy, neonatal Apgar scores, placenta weights, overall length of labor, weight gain during pregnancy, or weight retention postpartum. **Conclusion:** Previously sedentary women who began exercising at 12–14 wk improved fitness and delivery outcomes. **Key Words:** EXERCISE, PREGNANCY, PHYSICAL FITNESS, OBSTETRIC OUTCOMES, POSTPARTUM RECOVERY

In 2002, the American College of Obstetricians and Gynecologists (ACOG) recommended that healthy pregnant women exercise at moderate intensity for at least 30 min most days of the week (1). The American College of Sports Medicine as well as the Centers for Disease Control and Prevention recommended the same guidelines for the general population based on abundant epidemiologic and experimental evidence, which confirms that aerobic exercise of this frequency and intensity improves cardiovascular fitness and reduces the incidence of disease (29). The benefits or risks of exercise in pregnancy are much less clear. Although many studies have reported benefits (2,3,5,8,9,13,14,19,21,23,27,30), the Cochrane review of 10 trials of acceptably controlled programs of aerobic exercise involving 688 women concluded that the data were “insufficient to infer important risks or benefits for mother or infant” (7).

This scientific uncertainty may contribute to the low percentage (16%) of pregnant women reported to be exercising according to the ACOG recommended guidelines (12,24,32). The lack of physical activity during pregnancy may also be attributable to inconsistent motivation, concern about maternal and fetal injury, and insufficient familial and/or community support (20,32). Surveys of obstetricians indicate that a significant portion never discussed exercise or physical activity with their pregnant patients (10,11,15,31), and doctors in obstetric training programs are not provided much information about exercise in pregnancy. Certainly, more reliable data are warranted to provide a clinically significant, evidence-based exercise regimen for pregnant women that will promote consistent and confident use by clinician and patient alike.

The purpose of this prospective, randomized study was to assess the benefits or harms of an exercise program based on the current ACOG guidelines, specifically testing the null hypothesis that moderate exercise by previously sedentary women would have no effect on maternal fitness or a set of delivery outcomes: length of pregnancy, newborn birth weight, or postpartum recovery. Secondary aims were to assess the effect of exercise on maternal strength, flexibility, musculoskeletal discomforts, incidence of gestational diabetes and gestational hypertension, length of first and second stages of labor, frequency of cesarean section, frequency of assisted delivery, newborn Apgar scores, placenta weight, and postpartum weight retention.

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MATERIALS AND METHODS

Sedentary pregnant women were invited to participate in this prospective randomized clinical trial conducted in Austin, Texas, starting at a gestational age of 12–14 wk. Design was parallel with 1:1 allocation of groups, after accounting for five control subjects who refused to participate immediately after randomization (Fig. 1). Participants were recruited through announcements placed at local area obstetric practices. Enrollment began in July 2006 and concluded in March 2010.

Eligibility criteria included the following: no aerobic exercise more than once per week for at least the past 6 months; viable singleton pregnancy at 12–14 wk by reasonable dates and/or ultrasound; body mass index (BMI) less than $39 \text{ kg}\cdot\text{m}^{-2}$; no chronic heart or lung disease; no poorly controlled diabetes, hypertension, epilepsy, or hyperthyroidism; no severe anemia (hematocrit level $<27\%$); no orthopedic limitations; and no history of premature delivery, infant delivered for small for gestational age, or unexplained fetal death. One participant had a history of premature labor and delivery with twins but was allowed to participate because the current pregnancy was singleton. Subjects, once medically cleared by their physician and deemed eligible, gave written informed consent and were randomized using numbered, opaque envelopes containing an equal number of group assignments prepared by the study statistician. The study's protocol and informed consent were approved by the Austin Multi-Institutional Review Board before the study's inception.

The intervention involved a program of supervised aerobic training of 45–60 min duration, performed four times per week, at moderate intensity (12–14 on Borg Scale of perceived exertion), consistent with exercise guidelines of the

ACOG (1). Subjects did step aerobics on the first day, walked as a group over adjacent hilly terrain on the second day, and performed circuit training on a third day. The circuit consisted of 1–10 min of aerobic exercise on treadmills, elliptical trainers, or stationary bicycles, alternating with an equal time interval of weight training, generally with weight machines, using a weight that allowed one set of 20 repetitions. Upper extremity exercises included overhead press, seated bench press, seated rowing, pectoral flexion, triceps extension, and bicep curls. Lower extremity exercises included leg extension and hip adduction/abduction. Core muscle exercise included back extension and loaded torso rotation on weight machines, followed by crunches as well as prone and supine bridges on 55-cm exercise balls. The circuit session ended with 5 min of hamstring, quadriceps, and calf stretching. To make four exercise sessions per week, each woman also completed a brisk 30- to 60-min walk individually once weekly. The author kept a log of exercise activities and attendance. Active subjects continued to exercise with the group through 36 wk gestation or on to delivery if they wished.

The control group did not participate in exercise sessions and only exerted themselves as needed for work or household chores. Control subjects were told not to exercise because it would blur the distinction between groups, and each who completed the study confirmed at testing every 6 wk after randomization that she avoided exercise. All subjects were told to follow the dietary advice of their obstetricians or midwives, and there was no attempt to estimate calorie intake.

Primary Outcome Variable: Cardiorespiratory Fitness

All study participants underwent five fitness assessments: at 12–14 wk, at 18–20 wk, at 24–26 wk, at 30–32 wk gestation,

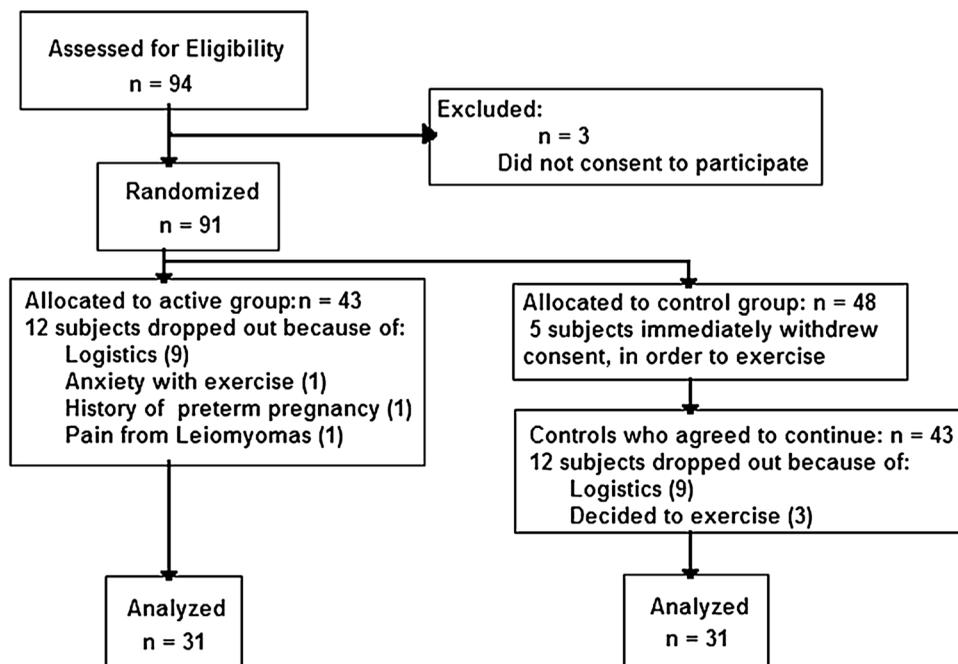


FIGURE 1—Flow of participants through the trial.

and at 6–8 wk postpartum. Maternal weight, blood pressure, and fetal heart rate were documented just before each exercise test. Each participant was asked to walk or run 3.2 km (2 miles) as fast as possible within her comfort zone at a steady pace. Immediately after finishing, she estimated perceived exertion on the Borg Scale. To account for the effect of increasing weight during pregnancy, power produced during the timed walk was calculated based on the following equation: $\text{power} = (\text{weight} \times \text{distance}) / \text{time}$. Temperature and humidity rates were documented during each fitness assessment.

Secondary Outcome Variables of Fitness: Strength, Flexibility, and Discomfort

Before the aerobic fitness test, all study participants performed a submaximal strength assessment by lifting a 7-kg medicine ball from floor to waist high as many times possible within 1 min. Subjects were observed to use good lifting form, bending at the knees rather than at the waist to ensure the consistency of the repetition and proper body mechanics to avoid back injury.

The sit-and-reach test was used to assess hamstring and trunk flexibility. Each subject sat on the floor with bare feet against a box 30.5 cm high (12 inches), and stretched forward as far as possible along a ruler attached to the top of the box. The ruler was placed with the 38-cm (15-inch) mark at the leading edge of the box. The subject's best reach in three tries was recorded.

Before every fitness assessment, subjects completed a 36-item Maternal Physical Discomfort Scale, a psychometrically validated questionnaire designed to measure discomfort in pregnancy (16).

Other Variables

Pregnancy complications. The length of pregnancy was the primary variable. Secondary outcomes included the incidence of gestational diabetes (two or more abnormal values on a 3-h, 100-g glucose tolerance test) and the incidence of gestational hypertension (blood pressure of 140/90 or higher for the first time during pregnancy, with or without proteinuria).

Delivery data. Newborn weight was the primary outcome variable. Secondary outcome variables included length of first and second stage of labor, route of delivery, need for vacuum or forceps, newborn Apgar scores, placenta weight (on Warm-Weight Infant Scale [Air-Shields Vickers] after draining the placenta and cord of blood), and total maternal weight gain, calculated from weight at last prenatal visit minus weight on randomization at 12 wk gestation.

Postpartum recovery. All subjects were requested to report how many days postpartum they returned to three of five listed household tasks: changing sheets and making beds; sweeping, mopping, vacuuming, or other cleaning; washing and folding clothes; shopping for groceries and putting groceries away; preparing, cooking, and serving meals. All were told to refuse help as much as possible from family and friends and to resume each of these activities as

soon as she felt able. A secondary outcome was maternal weight at 6 wk postpartum compared with weight upon randomization at 12–14 wk gestation.

Statistical Analysis

Preliminary pilot data were used to calculate sample size using SOLO (Statistical Power Analysis Program, BMPP Software, Los Angeles, CA), which disclosed that 30 subjects per group were adequate to detect a 10% difference in a 3.2-km (2-mile) walk time, with a significant difference at the 0.05 level and a power of 0.80. The other primary and secondary variables were comparably powered, except for the incidence of gestational hypertension and gestational diabetes, which would have required considerably larger numbers because of lower incidence. Analysis was based on the group of subjects who completed the study and also by the intention to treat: analyzing all collected fitness and delivery data whether the subject dropped out of the study or not. Two statistics software packages were used for analyzing data: Statistix Version 9 Analytical Software (Tallahassee FL) and Statview Version 4 (Abacus Concepts, Inc., Berkeley, CA). In addition to descriptive statistics, data were analyzed using two-sample *t*-tests and Wilcoxon sum rank tests for comparing continuous data between two independent groups and chi-square test for comparing the categorical data. The validation data were analyzed using paired *t*-test and Wilcoxon signed rank tests. Repeated-measures ANOVA was used to assess the over time changes and the between-group difference. A type I error level of 0.05 was used.

Results (Analyzed as Completed by Participants)

The flux of participants through the stages of the study protocol is described in Figure 1. Of the 91 total randomized participants, 29 opted out at various stages of the protocol, nearly evenly distributed over the duration of the study and between groups, leaving 31 participants in each group. Difficulty in logistics (i.e., scheduling conflicts, employment hours, and transportation issues) contributed to most of both active and control subjects opting out. Eight control subjects opted out to exercise rather than to continue in the sedentary group. Five of those refused to participate immediately after randomization. Difficulty in performing or dissatisfaction with the exercise did not appear to affect noncompletion.

Active and control subjects who completed the study ranged in age from 16 to 44 years, in parity from zero to four, and in body mass index from 19 to 39 kg·m⁻². Groups were not significantly different at randomization in age, parity, body mass, or racial distribution (Table 1). None were smokers. The mix of public and private insurance coverage was comparable between groups.

From enrollment to at least 36 wk gestation, the 31 active subjects participated in 77% of exercise classes. To substitute for an additional 16% of exercise sessions, subjects performed comparable aerobic exercise individually, yielding 93% compliance with the exercise protocol.

TABLE 1. Demographics at randomization.

Group	Active	Control	P
Age	30.5 ± 5	27.6 ± 7.3	0.08
Parity	0.5 ± 0.7	0.67 ± 1	0.46
BMI	26.6 ± 3.1	28.7 ± 5.4	0.08
Mean ± SD			
Whites	17 of 31	13 of 31	0.32

Results (Analyzed as Completed by Participants)

Fitness. Aerobic fitness, measured as power production during the 2-mile aerobic walk, was virtually identical between groups at randomization, improved steadily in the active group compared with control, and became significantly higher at 30–32 wk gestation ($P < 0.05$) (Fig. 2). Compared with their own baseline, active subjects improved most at 24–26 wk, when change from baseline power approached significance ($P = 0.06$). Temperature and humidity during the walks did not vary significantly between groups, nor did perceived exertion at the end of the timed walk, except at 6–8 wk postpartum when the active group reported significantly higher exertion levels ($P < 0.01$).

Strength measured in the 7-kg lift test improved significantly in the active group after 6 wk of exercise and remained significantly higher through 6 wk postpartum ($P < 0.01$) (Fig. 3).

Sit-and-reach flexibility and musculoskeletal discomfort scores did not vary appreciably between groups through pregnancy and postpartum. No subjects in the active group reported injuries related to the exercise regimen.

Pregnancy complications. Length of pregnancy was comparable: 39.2 wk in the active group and 39.4 wk in the control group. There was one case of premature labor and delivery at 33 wk in the active group. This subject had a history of premature labor with twins in a previous pregnancy at 34 wk. There were no cases of gestational hypertension with or without proteinuria in the active group compared with three cases within the control group. The P value for that difference did not reach significance at 0.16. Active subjects developed gestational diabetes in three cases (9.6%), compared with four cases in the control group (12.9%), P value = 0.66.

Delivery data. Births occurred at three Austin area hospitals, a free-standing birthing center, and one home birth between January 10, 2007, and September 18, 2010. Active

subjects and controls were evenly distributed among delivery sites and providers, with about one third of each group delivered by the lead author, and most of the remainder managed in two large obstetric practices at another hospital. Mean newborn birth weight was similar between groups: 3329 g for the active participants versus 3308 g for controls. Birth weight percentile for gestational age was equivalent between groups: 53rd percentile ± 31(±1 SD) for active subjects and 60th percentile ± 29 for controls. Extremes of fetal weight were also comparable with four babies at the 10th percentile or less among the active group and five among controls as well as six at the 90th percentile among active subjects and four among controls. Mean placenta weights were similar in both groups: 691 g for the active group and 625 g for the control (Table 2). Mean Apgar scores at 1 and 5 min were almost identical in both groups. Apgar scores lower than 8 at either interval were rare in both groups.

Overall length of labor was similar in both groups at approximately 8 h. The second stage of labor averaged 47 min among 25 subjects in the active group compared with 28 min among 17 control subjects who delivered vaginally ($P < 0.05$), but 59% (10 of 17) of these controls were multiparous compared with 37% (10 of 27) of the active subjects. Assisted delivery was equally rare (one each) in both groups. Two subjects in each group underwent repeat cesarean delivery. Eighty-seven percent of active subjects delivered vaginally compared with 61% of sedentary controls ($P < 0.02$).

Only two active subjects (6%) delivered by primary cesarean section compared with 10 controls (32%), a highly significant difference ($P < 0.01$) (Fig. 4). Intention-to-treat analysis was performed to confirm that this finding was not related to participant dropout. The primary cesarean section rate was 12% (5/43) among all randomized to the active group compared with 27% (13/48) among all controls ($P = 0.06$). However, 5 of

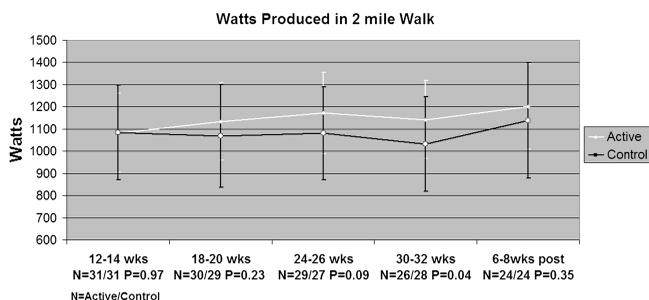


FIGURE 2—Watts produced in the 3.2-km walk.

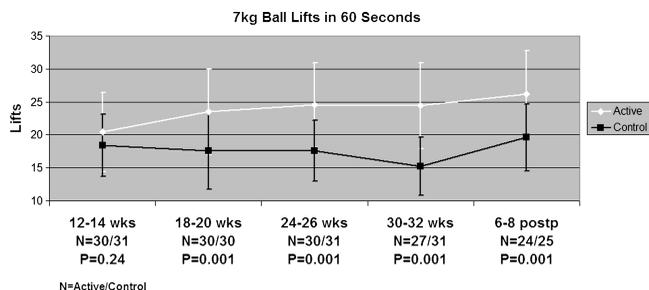


FIGURE 3—Seven-kilogram ball lifts in 60 s.

TABLE 2. Delivery outcomes: 31 participants per group.

	Active (Mean ± SD)	Control (Mean ± SD)	P
Labor (h)	9.4 ± 5	8.4 ± 3.4	0.33
Second stage (min)	47.4 ± 36	28.4 ± 12.5	0.05*
Birth weight (g)	3329 ± 519	3308 ± 103	0.87
Apgar score, 1 min	8.2 ± 1.9	8.1 ± 0.9	0.7
Apgar score, 5 min	9 ± 0.5	8.7 ± 0.5	0.11
Apgar score <8, 1 min	5/30 (16.6%)	3/30 (10.0%)	0.46
Apgar score <8, 5 min	0/30	1/30 (0.3%)	0.32
Placenta weight (g)	691 ± 178	625 ± 103	0.62
Vaginal delivery	27/31 (87%)	19/31 (61.2%)	0.02*
Primary cesarean delivery	2/31 (6.4%)	10/31 (32.2%)	0.01*

* indicates significant at 0.05 or better.

the 48 original control subjects reported exercise frequency and intensity that met ACOG guidelines.

Weight gain from 12 wk gestation to the last prenatal visit averaged 12.4 kg in the active group and 10.5 kg in the control group, not significantly different ($P = 0.15$).

Recovery

Time to resume at least three of five household chores was significantly shorter in the active group, a mean of 4.7 d among active subjects compared with 8.7 d for controls ($P < 0.05$). Even after accounting for route of delivery, recovery was faster among exercisers: 7 versus 13 d after cesarean section and 4.4 versus 5.9 d after vaginal delivery, but the numbers in the subgroups were too small to achieve significance. Postpartum weight retention was comparable in both groups: 2.5 kg above weight at 12 wk in the active group versus 0.7 kg in the control group ($P = 0.54$), similar to the overall difference in weight gain between groups.

Results by Intention-to-Treat Analysis

Subjects who dropped out were demographically comparable with those who completed the study, both within groups and across groups, except control dropouts were significantly older than controls who completed the study ($P < 0.02$). Besides the cesarean section data discussed previously, an analysis of all available data for every randomized subject did not change the results on fitness, pregnancy complications, delivery, or recovery.

DISCUSSION

Subjects in the active group significantly improved aerobic fitness and strength compared with sedentary controls,

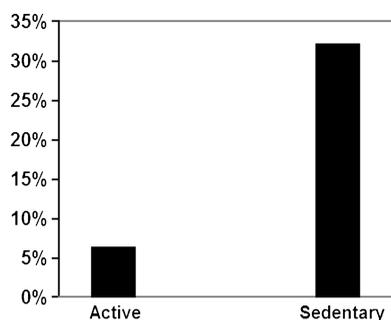


FIGURE 4—Distribution of primary cesarean section by group.

without loss of hamstring flexibility or increased musculo-skeletal discomforts. Although the exercise regimen was vigorous enough to improve fitness, it had no adverse effect on overall pregnancy length, fetal birth weight, Apgar scores, or placenta weight compared with sedentary controls. In fact, placenta weight was slightly higher in the active group, consistent with evidence that exercise augments placental growth during early and mid pregnancy (6). There was one premature birth in the active group by a woman with a history of premature labor and delivery with twins. She was allowed to participate because the current pregnancy was singleton but should have been excluded based on guidelines from ACOG on exercise in pregnancy. Juhl et al. (18) reported that active women in the Danish National Birth Cohort actually had a 40% lower risk for premature birth than nonexercisers.

Gestational diabetes was slightly less common among the active group, but numbers were too small to achieve significance. The incidence of gestational hypertension was also not significantly different between groups, although the exercise group had no cases at all. This favorable trend is supported by experimental and epidemiological evidence (22,25,28,34). Clearly, more clinical investigation is warranted to confirm this potential benefit.

The primary cesarean section rate in the active group was only 6% compared with 32% in controls, a rate comparable with the 26% incidence of primary cesarean section during the study at the hospital where most deliveries occurred. Six of the inactive group required cesarean sections for failure to progress, despite fetal size (mean = 3256 g) and maternal body mass index (mean = 27) comparable with the active group. Was the mechanism of labor less efficient among these sedentary women? Nonreassuring fetal heart tracings prompted primary cesarean section in four other sedentary subjects but only one in the active group, consistent with reports of beneficial effects of regular exercise on the placenta (5). Cesarean section rates vary greatly among different providers and delivery sites as well as by population characteristics, particularly parity and body mass index. However, these confounding variables were comparable between active and control groups in this study. The primary difference between groups was the exercise intervention.

Supporting evidence for exercise reducing primary cesarean section rates seems to vary with the exercise dose. Barakat reported no difference in delivery outcomes between controls and active subjects who did only light resistance and

toning exercise 3 d·wk⁻¹ (4), whereas Zeanah reported significantly fewer cesarean sections in women who performed 40 min of moderate intensity exercise regularly during pregnancy (35). Similarly, Melzer reported that inactive women were 3.7 times more likely to require operative delivery than active women who did at least 30 min of moderate physical activity per day (26). Certainly, reducing the rate of cesarean section has enormous potential for reducing complications and cost.

The significantly longer length of the second stage of labor in the active group (48 vs 27 min) is a function of lower parity among the active versus control group subjects who progressed to vaginal delivery.

Postpartum recovery to perform a set of household chores was significantly faster among active subjects primarily because of their lower rate of cesarean delivery, and there was a nonsignificant trend toward faster recovery among exercisers regardless of route of delivery. Postpartum weight retention was nonsignificantly higher among exercisers (2.5 vs 0.7 kg) possibly related to increased muscle mass, consistent with active subjects' significantly superior performance on the strength test postpartum and similar to the 1.9-kg increase in lean body mass in women reported in a strength training study (17).

Compliance is the Achilles heel of any exercise intervention. Fortunately, compliance with the exercise regime in this study was very good for several reasons. The class was held at 5:30 p.m., allowing women to exercise after work. The gym was centrally located within a large urban area, and the exercise regimen was varied often for diversity and interest. The informal bonding process that developed between members of the exercise group certainly augmented compliance. Support from significant others also helped, as did reliable transportation. The addition of childcare would have increased enrollment and participation.

The benefit of exercise apparent to women in this study should apply to many pregnant women for several reasons:

most women are not regular exercisers (33), starting exercise at 12–14 wk gestation appears not too late to benefit, necessary resources are available at most gyms and fitness centers, and group exercise programs for pregnant women are feasible and likely to enhance compliance.

Strengths of the study include randomized and controlled design, prospective data collected during 28 wk of pregnancy as well as 6–8 wk postpartum, objectively observed exercise program that extended through most of pregnancy, and closely monitored nonexercising control group. The main weakness was the difficulty getting all the projected data on all subjects at every data point.

Sedentary women who become pregnant often receive mixed messages from friends, family, and even their doctors about the wisdom of exercising during pregnancy. The data from this study supports the safety of exercise in this population, particularly the absence of gestational hypertension and the low incidence of cesarean section. The one premature birth among exercisers occurred in a woman with a history of premature labor and delivery; hence, she should have been excluded from exercise. Overall, the study appears to validate the ACOG guidelines on exercise in pregnancy (1), particularly in the overall design of an exercise program for pregnant women, and in who should be included or excluded. The data are strong enough to suggest that every practicing obstetrician would be wise to provide each newly pregnant woman a prescription for exercise in pregnancy.

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The results of the present study do not constitute endorsement by the American College of Sports Medicine.

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