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# Comparison of Static Postural Stability in Exercising and Non-Exercising Women During the Perinatal Period

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**Background:** The purpose of the study was to determine whether women who exercised during and after pregnancy had better static postural stability compared to those who did not exercise.



**Material/Methods:** Posturographic tests were performed in 31 women at 34–39 weeks gestation, and again at 6–10 weeks postpartum. The center of pressure mean velocity (with directional subcomponents) and sway area were computed from 30-s quiet standing trials on a stationary force plate with eyes open or closed. The women were surveyed about their lifestyle and physical activity in the perinatal period. Based on the survey, 12 of the women were assigned as regular exercisers and 19 as non-exercisers. A Mann-Whitney U test was used to compare data of the exercisers and the non-exercisers in their advanced pregnancy and again at 2 months postpartum.

**Results:** Postural sway measures were not significantly different between the exercisers and the non-exercisers in advanced pregnancy and at 2 months postpartum ( $p > 0.05$ ).

**Conclusions:** Individually performed physical activity during the perinatal period did not affect pregnant/postpartum women's postural stability characteristics of quiet standing.

**MeSH Keywords:** **Exercise • Postpartum Period • Postural Balance • Pregnancy**

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## Background

A fall during pregnancy may result in an injury to the mother, including fractures, contusions, and sprains, as well as an adverse pregnancy outcome such as placental abruption, fetal distress, fetal hypoxia, preterm labor, fetal death, and miscarriage [1,2]. Falls account for over half of reported injuries during pregnancy [3,4]. A large retrospective study indicated that one-quarter of pregnant women fell and one-tenth fell 2 or more times during pregnancy. The fall rate for pregnant women is estimated at 27% [5], similar to the 30% rate of falls for people aged 65 years or over [6]. According to another study, the postpartum fall rate during hospital stay exceeded the mean for adult surgical patient falls [7].

Pregnant/postpartum women may be prone to falls due to undergoing many physiological and biomechanical changes. Posturography is used to assess postural stability, which is the inherent ability of a person to maintain, achieve, or restore a specific state of balance despite internal and external perturbations. Posturographic studies of pregnant women reported alterations in their postural control [8–13]. The longitudinal studies by Butler et al. [8] and Jang et al. [9] indicated an increased postural sway during quiet standing in pregnant women, which suggests the decline in their static postural stability. Butler et al. [8] also reported diminished static stability at 6–8 weeks postpartum. McCrory et al. [13] examined the effect of exercise on fall risk in pregnant women, reporting that participation in regular exercise during pregnancy was associated with fewer falls.

A sedentary lifestyle and insufficient physical activity may have an adverse influence on postural control in pregnant and postpartum women. Conversely, regular exercises in the perinatal period may help to maintain normal muscle strength, which is one of the factors necessary to maintain proper postural stability. According to Angyán et al. [14], increased muscle strength and endurance capacity is associated with better postural stability.

The aim of this study was to compare static postural stability characteristics of women who reported performing regular exercises throughout pregnancy and resumed the exercises after delivery with that of the women who did not exercise in the perinatal period. We wanted to determine whether regular exercisers had better static postural stability in the third trimester of pregnancy and at 2 months postpartum compared to the non-exercisers. These periods were chosen for assessment because reports in the literature suggest altered static stability in advanced pregnancy and postpartum [8,9].

## Material and Methods

Forty-five healthy pregnant women between the ages of 20 and 38 years were enrolled. The women were directed to the testing by obstetricians from antenatal clinics in the region of Upper Silesia, Poland. They were all singleton gestations. Exclusion criteria were any conditions considered by the obstetrician to be a high-risk pregnancy (e.g., gestational diabetes mellitus, hypertension, pre-eclampsia, and toxemia). Additional exclusion criteria were any medical condition that affects postural stability (e.g., uncorrectable vision disorders, a history of musculoskeletal or neurologic abnormalities, diabetes mellitus, and obesity). Subjects were also excluded if they currently took any medication that would affect their balance. Eligibility criteria were confirmed by physical examination and a survey.

Women enrolled in the study reported for testing to the Biomechanics Laboratory at the Department of Human Motor Behavior at the Academy of Physical Education in Katowice. The aim of the study and experimental procedures were explained to all subjects and informed consent was obtained.

This study was part of our prospective longitudinal study assessing the effect of pregnancy on static postural stability, which has been submitted for publication [unpublished]. For the purpose of that study, the women were tested on 4 occasions: during early pregnancy (at 16 weeks or earlier) and advanced pregnancy (~3 weeks before the due date), and then at ~2 and 6 months postpartum. Fourteen women were unable to participate in 1 ( $n=9$ ) or 2 ( $n=5$ ) of the sessions. The reasons for their absences were: complications related to pregnancy ( $n=6$ ), delivery prior to scheduled visit in advanced pregnancy ( $n=3$ ), problems with scheduling a babysitter for the time of the visit ( $n=5$ ), and relocation ( $n=5$ ). Data for these women were excluded from the study. Therefore, 31 women (26 primigravida and 5 multigravida) participated in all 4 test sessions.

For the purpose of the present study, only 2 test sessions were considered: in the third trimester of pregnancy and at ~2 months postpartum. Mean ( $\pm$  standard deviation [SD]) age of the 31 women was  $28.2\pm 3.6$  years. In the third-trimester data collection session, the women's gestational age was  $36.2\pm 1.2$  (34–38) weeks and their body mass index (BMI) was  $26.5\pm 2.9$ . A post-birth visit occurred at a mean ( $\pm$ SD) of  $7.8\pm 1.4$  (6–10) weeks and the women's postpartum BMI was  $23.0\pm 2.7$ .

At each session women were asked to complete a survey that included questions regarding type of work performed (sedentary, standing, or physical) and exercise participation. If a woman reported performing regular exercises (at least 2–3 times a week and at least 30 min per session) from her first trimester of pregnancy until the data collection session in the third

trimester of pregnancy, and she resumed her regular exercises at ~4–6 weeks postpartum continuing until the data collection session at 2 months after delivery, she was considered a pregnant/postpartum exerciser. If no physical work and no or sporadic exercise participation throughout pregnancy and after delivery was reported, a woman was considered a non-exerciser.

Subject height was recorded at the initial visit and body mass was recorded at each visit. The BMI was calculated after each data collection.

Posturographic tests were performed at each session. The women were instructed to stand quietly with their arms at their sides and in a comfortable stance on a stable force plate (model 9281C, Kistler Instruments Corp, Winterthur, Switzerland). This normal barefoot standing position was to ensure the preferred stance width of each woman at each trial in all test sessions. Two 30-s trials were conducted with the eyes open (looking straight ahead) and with the eyes closed (to challenge postural control). Short rest breaks of up to 1 min separated the trials to avoid fatigue.

The center of pressure (COP) signals transmitted from the force plate were amplified and sampled at 100 samples/s. They were digitally filtered with a 12<sup>th</sup> order low pass Chebychev type II filter at a 7-Hz cut-off frequency. The COP mean velocity with directional (anterior-posterior and medial-lateral) subcomponents and sway area were calculated in Matlab (Mathworks®, Natick, MA, USA). The measures were computed on the basis of the means of 2 trials for the eyes-open condition and 2 trials for the eyes-closed condition [15].

The COP is defined as the point of the concentration of the pressure of the body over the soles of the feet, which accommodates a spontaneous postural sway of the body in an upright stance. COP movements reflect both the center of gravity excursions and reaction forces due to muscular activity [16]. The COP mean velocity is a ratio of COP path length to the trial period. It is an average speed of COP movement over the time of a trial. This measure is considered the most reliable of the COP traditional parameters [17–21]. The body sway area is a valuable spatial parameter [18]. It was calculated with a reliable procedure using an ellipse to characterize the COP trajectory [22].

Statistical analyses were performed on women’s descriptive variables and COP measures recorded in the eyes-open and eyes-closed conditions. A Mann-Whitney U test was used to compare the measures of the exercisers and the non-exercisers in their third trimester of pregnancy and at 2 months postpartum. The level of significance was set to  $\alpha=0.05$ . The statistical analyses were performed using Statistica 9.0 (StatSoft Inc., Tulsa, OK, USA).

**Table 1.** Exercise type and frequency in 12 women who reported being regular exercisers throughout pregnancy and resumed the exercises at 4–6 weeks postpartum.

n	Exercise modality	Frequency
1	Walking	Daily
	Swimming	2 × week
2	Walking	Daily
3	Stationary bicycling	2 × week
4	Fitness	5 × week
5	Walking	Daily
6	Walking	Daily
	Swimming	4 × week
7	Walking	Daily (only in pregnancy)
	Swimming	2 × week (only post-birth)
8	Walking	Daily
	Fitness	2 × week (only post-birth)
9	Yoga	2 × week
	Swimming	2 × week
10	Fitness	2 × week
	Swimming	1 × week
11	Swimming	2 × week
12	Walking	Daily

This study was conducted following the approval of the Senate Ethics Committee of the Katowice Academy of Physical Education, Poland.

## Results

Twelve of the 31 pregnant/postpartum women (38.7%) met the criteria to be assigned as the exercisers and 19 women (61.3%) were classified as non-exercisers. Six of the 12 exercisers reported participation in more than 1 exercise modality. Seven of the 12 women practiced daily walking, 6 reported swimming, 3 performed fitness exercises, 1 practiced stationary bicycling, and 1 performed yoga exercises (Table 1).

There were no significant differences between the exercisers and the non-exercisers in age, gestational age, post-birth evaluation period, height, weight, or BMI during testing in advanced pregnancy, as well as at 2 months postpartum (Mann-Whitney U test,  $p>0.05$ ; Table 2).

In eyes open and eyes closed conditions, the average COP mean velocity (total as well as in the anterior-posterior and medial-lateral directions) and a sway area were not significantly different between the exercisers and the non-exercisers in

**Table 2.** Demographic data of 12 exercisers and 19 non-exercisers in advanced pregnancy and at 2 months postpartum.\*

	Age (years)	Height (cm)	Body mass (kg)	BMI (kg/m <sup>2</sup> )	Gestational age (weeks)
Exercisers in pregnancy	27.6±3.3	167±6	76.2±8.1	27.3±2.2	35.9±1.2
Non-exercisers in pregnancy	28.6±3.9	165±5	70.6±11.1	26.0±3.2	36.4±1.2
Post-birth period (weeks)					
Exercisers postpartum			65.8±8.6	23.5±2.3	7.7±1.6
Non-exercisers postpartum			61.5±10.0	22.6±2.9	7.9±1.4

\* Data are shown as means ±SD. Mann-Whitney U test, *p*>0.05.

**Table 3.** Center of pressure measures reflecting spontaneous body sway during 30 s of quiet standing with the eyes open or closed in 12 exercisers and 19 non-exercisers in advanced pregnancy and at 2 months postpartum.\*

Measure	Pregnancy		Postpartum	
	Exercisers	Non-exercisers	Exercisers	Non-exercisers
AP velocity (mm/s)				
EO	5.6±1.3	6.4±3.0	5.1±1.3	5.8±1.5
EC	7.3±2.0	7.8±2.6	7.1±2.3	6.6±2.1
ML velocity (mm/s)				
EO	7.5±2.0	8.6±2.7	7.7±1.5	8.5±1.8
EC	8.9±2.3	9.9±2.7	10.0±3.2	9.4±2.7
Total velocity (mm/s)				
EO	10.2±2.6	11.7±4.6	10.0±2.2	11.1±2.6
EC	12.6±3.2	13.8±3.9	13.4±4.3	12.5±3.5
Sway area (mm <sup>2</sup> )				
EO	175±96	322±303	179±77	315±225
EC	205±87	342±306	269±181	282±185

\* Data are shown as means ±SD. No significant inter-group differences in both test sessions, Mann-Whitney U test, *p*>0.05. EO – eyes open; EC – eyes closed; AP – anterior-posterior direction; ML – medial-lateral direction.

their third trimester of pregnancy or at 2 months postpartum (Mann-Whitney U test, *p*>0.05; Table 3).

## Discussion

In this study we wanted to verify whether women who reported being regular exercisers throughout their perinatal period had better static postural stability than those who did not exercise. The assessment of postural sway parameters in advanced pregnancy and at 2 months postpartum indicated a similar postural control of quiet standing in the exercisers compared to the non-exercisers.

According to exclusion criteria used in this study, our findings apply to healthy women with normal BMI. Women classified as exercisers were those who reported regular physical activity of at least 30 min per session and at least 2–3 times per week. Types of reported physical activity were walking, swimming,

fitness, stationary bicycling, and yoga. Since there was not a specific supervised exercise program employed, the exercise intensity and muscle engagement could have varied between subjects. Additionally, our results should be considered with caution because in comparing small samples of healthy subjects the inter-individual differences in postural stability characteristics of quiet standing may be the reason that significant between-group differences are not detected.

A sedentary lifestyle and insufficient amount of physical activity predisposing to muscle weakness may have an adverse influence on the postural control system [23]. Participation in regular, moderate-intensity exercise is recommended in healthy uncomplicated pregnancy [24]. Several studies suggest that physical activity may play a role in maintaining proper postural stability [14,25,26]. Angyán et al. [14] showed that increased back muscle strength and endurance capacity were associated with better postural stability in healthy young adults. Karinkanta et al. [25] classified home-dwelling elderly women

as regular exercisers (practicing walking, Nordic walking, cross-country skiing, swimming, and aquatic exercises) and sedentary. Their study indicated that increased leg extensor muscle strength was associated with better dynamic balance. Melzer et al. [26] reported that healthy older subjects who walked on a regular basis had a better static postural stability and stronger ankle plantar flexor and knee extensor muscles than those who did not. The daily walkers did not suffer from falls within a period of 6 months before testing, whereas 16% of the non-walkers reported at least 2 falls. The authors concluded that walking on a regular basis might have the potential to modulate stability in old age. Kerschman et al. [27], however, found no inter-group differences in muscle strength and body sway between healthy postmenopausal women who followed a home-based exercise program and controls who did not exercise. The study suggested that the home-based exercises did not yield enough force to improve muscle strength and postural stability in that population.

The insignificant inter-group differences in static postural stability characteristics between the exercisers and the non-exercisers demonstrated in our study in advanced pregnancy and at 2 months postpartum may suggest that the individually performed physical activity during the perinatal period was not sufficient to modulate women's postural control of quiet standing, perhaps because of inadequate exercise intensity and insufficient strengthening of antigravity muscles. This study focused only on the assessment of women's stability during quiet standing. Although a demonstration of their muscle strength would be very valuable, maximal muscle strength testing should be avoided in pregnancy in

order not to induce the undesirable effect of the Valsalva maneuver [28].

The lack of expected significant differences in postural sway characteristics between the exercisers and the non-exercisers observed in this study also suggests that the posturographic assessment of a quiet standing task may be insufficient to detect the differences in postural control in the population of healthy pregnant/postpartum women. Perhaps a more challenging task, such as reacting to a perturbation, would have resulted in significant between-group differences.

Further studies are needed to assess the relation of women's postural stability with their physical activity estimated by a validated questionnaire [29,30]. A verification of the impact of supervised exercise programs on postural control in pregnant/postpartum women would also be warranted.

## Conclusions

The results of this study suggest that individually performed physical activity during the perinatal period may be insufficient to modulate pregnant/postpartum women's static postural stability characteristics.

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