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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Research on the influence of prenatal exercises on anthropometric and vascular parameters in pregnant women

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SUMMARY

Introduction/Objective The frequency of a sedentary lifestyle during pregnancy increases. This contributes to gestational weight gain and has a negative impact on health.
This study researched the impact of prenatal exercise on gestational weight gain, blood pressure, and microcirculation in pregnant women who exercised and those who did not exercise.

Methods The study included 70 pregnant women with a normal pregnancy, who attended a psychophysical preparation program for childbirth for eight weeks. The control group (n = 35) attended theoretical classes on childbirth, and the experimental group (n = 35) attended prenatal exercises as well. Gestational weight gain, blood pressure, and nailfold capillary density were determined and compared between the two groups.

Results Gestational weight gain of 19.94 kg in non-exercising pregnant women was significantly greater than the gestational weight gain of 11.65 kg in pregnant women who exercised. Pregnant women who did not exercise had an increase in systolic (by 15.56 mmHg) and diastolic pressure (by 16.08 mmHg), which is significantly higher compared to pregnant women who exercised. In this group, systolic pressure increased by 2.5 mmHg, while the diastolic one did not change. A significant difference in the nailfold capillary density at the end of the prenatal program has not been determined.

Conclusion Prenatal exercise of moderate-intensity has a positive effect on gestational weight gain and the level of blood pressure in pregnant women. The nailfold capillary density has not differed significantly after the prenatal program in pregnant women who have exercised and in those who have not.

Keywords: physical activity; pregnancy; gestational weight gain; blood pressure; microcirculation; microvessel density measurement

INTRODUCTION

The incidence of a sedentary lifestyle during pregnancy increases, ranging from 64.5% to 91.5%, and tends to increase in the third trimester of pregnancy. This contributes to the occurrence of obesity in pregnancy, gestational weight gain (GWG), and maintaining postpartum body weight, and has a negative impact on the health of pregnant women. In recent years in Europe, the prevalence of obesity in the entire population has increased epidemically and in pregnant women is around 25% [1–5]. The American Institute of Medicine presented guidelines and recommendations for GWG. GWG for normally fed pregnant women [body mass index – (BMI) 18.50–24.99 kg/m^2], is 11.5–16 kg [6].

Studies have shown that pregnant women who have a sedentary lifestyle are 1.5 times more likely to gain weight during pregnancy compared to pregnant women who exercise [7, 8]. However, concerns about the safety of exercise in pregnancy seem to persist. In studies, there is a large difference in interventions and exercise intensity in pregnancy [9].

Excessive weight gain during pregnancy is a risk factor for gestational diabetes and pregnancy-induced hypertension (PIH). During pregnancy, the circulatory system is largely adapted to meet the needs of the mother and fetus [10, 11]. In a normal pregnancy, blood pressure gradually increases during the second and third trimesters, while peripheral vascular resistance decreases, resulting in maintaining blood pressure values in the normal range. Pregnant women who do not exercise are three times more likely to develop hypertension compared to those pregnant women who exercise [10–15]. There is little data on the effect of exercise in the prenatal period on circulatory characteristics in normal pregnancy. This study researched the effect of prenatal exercise on GWG, blood pressure, and microcirculation

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in pregnant women who exercised regularly, compared to pregnant women who did not exercise regularly.

METHODS

The prospective, randomized study included 70 pregnant women (n = 70) in the northern part of Bosnia and Herzegovina. The study was performed at the university setting of the University of Banja Luka, Faculty of Medicine, and at the Sveti Vračevi Čelinac Health Center, from December 2020 to August 2021. Trial registration: Clinicaltrials.gov identifier – NCT05001906. At the gynecological appointment healthy singleton pregnant women, confirmed by a gynecologist, were assigned to the control and experimental group with a simple randomization process using a list of random numbers. Respondents, aged 20–40 years, with BMI < 25 kg/m^2, joined the birth preparation program from the 20th to the 32nd week of gestation. BMI before pregnancy was determined by dividing body weight in kilograms by squared body height in meters (kg/m^2) [16]. Respondents who agreed to participate in the research voluntarily signed an informed consent form. The Ethics Committee of the Faculty of Medicine in Banja Luka approved the study.

Pregnant women were excluded from the study if bleeding appeared during the prenatal program in the second or third trimester, rupture of the amniotic sac, preeclampsia, or PIH, and intrauterine growth restriction in the current pregnancy, or anemia.

The prenatal program lasted for eight weeks and consisted of theoretical classes on childbirth and prenatal exercises. The control group (n = 35) attended theoretical classes three times a week, and the experimental group (n = 35) attended prenatal exercises, as well. According to the American College of Obstetricians and Gynecologists recommendations a prenatal exercise program was created to improve the condition of the pregnant woman, strengthen the extremities, the area of the abdomen, back, pelvic girdle and improve circulation [6]. Breathing exercises were conducted. During the research, pregnant women followed the general recommendations of exercise: they did not exercise additionally in other places, ate normally, dressed lightly, and avoided high heat, the room temperature of the exercise room did not exceed 24°C. Pregnant women exercised three times a week for 45 minutes. The exercise program was conducted by the prenatal instructor and supervised by a physiatrist. Training started and ended with breathing and relaxation techniques for about 10 minutes, warm-up consisted of moderate walking for about five minutes, followed by strength and stretching exercises for about 30 minutes. Pregnant women exercised in standing, sitting, kneeling, and sideways position, with or without props (balls, straps, weights, etc.). Exercises performed in a supine position with bent knees during this study did not last more than five minutes, thus avoiding the reduction of venous flow and hypotension [6]. The exercises were performed alone or in pairs, with another pregnant woman or partner, in two to three sets, with 10–12 repetitions.

At the beginning and end of the study GWG, blood pressure, and nailfold capillary density were analyzed. The blood pressure was measured using a standard mercury manometer before prenatal exercises, at the beginning (between 20 and 32 weeks of gestation), and after eight weeks of prenatal exercises (between 28 and 40 weeks of gestation).

During prenatal exercises, the exercise load of pregnant women was monitored based on the subjective feeling of load using the Borg rating of perceived exertion scale. The applied physical activity was of medium intensity for which the score of perceived effort should be 13–14 (moderately difficult) out of a total of 6–20. The range of 6–20 is actually an analogy with the resting heart rate (60) and at maximum load (200), [2]. Pregnant women were explained that when they subjectively felt "moderately difficult" they should stop doing the exercise. It was also used "talk test". It is believed that as long as a pregnant woman can talk during exercise, she is probably not overburdened or tired [7].

In this study, nailfold capillaroscopy was performed with a Leica Z4 stereomicroscope and a digital camera. Pregnant women sat with their left hand placed on a table at heart level and a drop of immersion oil was placed on the nailfold in order to improve the image resolution. The density of capillary loops of the nailfold was assessed as the number of capillary loops per 1 millimeter of the distal row of nailfold capillary. Nailfold capillary loops of the fourth finger of the left hand of all pregnant women were analyzed. The morphometry of the nailfold capillaries was performed using ImageJ Software (ImageJ, Bethesda, MA, USA).

Statistical analysis was performed with the use of the licensed version of the SPSS 20 software (IBM Corp., Armonk, NY, USA). The obtained data were analyzed by methods of descriptive statistics. The t-test for paired samples, with the appropriate level of significance $p < 0.05$, was used to test the significance of the difference between the two arithmetic means.

RESULTS

The control and experimental groups were equalized in relation to the life age, the gestational age, and the BMI of the pregnant women before pregnancy (Table 1).

Table 1. The average life age of pregnant women, gestational age at the time of participation in the study, and body mass index of pregnant women before pregnancy

Parameters	Age of pregnant women (years)	Gestational age of pregnant women (gestational weeks)	BMI (kg/m^2)
Pregnant women who did not exercise	29.72 ± 3.24	28.97 ± 3.38	22.23 ± 1.84
Pregnant women who did exercise	30.12 ± 3.31	29.35 ± 3.56	21.32 ± 1.87

The results are presented as mean values ± standard deviation

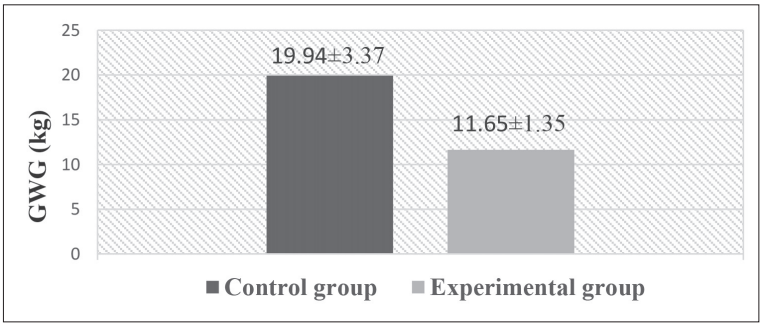


Figure 1. Gestational weight gain in pregnant women who did not exercise and in pregnant women who exercised; the results are presented as mean values ± standard deviation

Table 2. Systolic and diastolic blood pressure in the control group and the experimental group, at the beginning and end of the prenatal program

Parameters		Beginning of the prenatal program	End of the prenatal program	p value
Pregnant women who did not exercise	Systolic blood pressure (mmHg)	111.67 ± 9.41	127.22 ± 13.44	p < 0.001
	Diastolic blood pressure (mmHg)	71.11 ± 7.85	87.19 ± 17.97	p < 0.001
Pregnant women who did exercise	Systolic blood pressure (mmHg)	108.68 ± 9.79	111.18 ± 9.77	p = 0.039
	Diastolic blood pressure (mmHg)	68.38 ± 9.43	68.24 ± 8.25	p = 0.887

The results are presented as mean values ± standard deviation

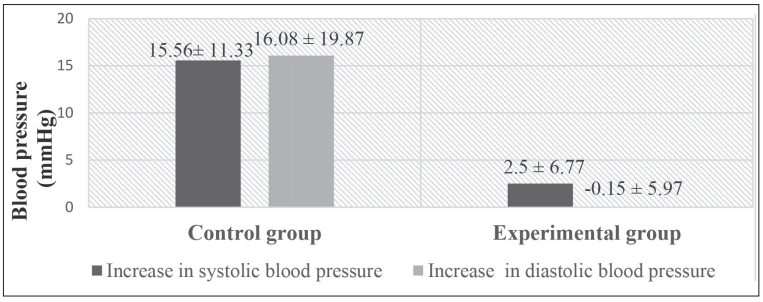


Figure 2. Increase in systolic and diastolic blood pressure after eight weeks of monitoring in pregnant women who performed prenatal exercises and in pregnant women who did not perform prenatal exercises; the results are presented as mean values ± standard deviation

In the control group after eight weeks of attending theoretical classes on childbirth, the GWG was 19.94 ± 3.37 kg [mean value (MV) ± standard deviation (SD)] (Figure 1). The smallest weight gain in this group was 13 kg and the largest 29 kg. In the experimental group, after eight weeks of attending prenatal exercises, the GWG was 11.65 ± 1.35 kg (Figure 1). The smallest weight gain in this group was 9 kg and the largest 15 kg.

Using a t-test, a significant difference in the increase in GWG was found between pregnant women who did not exercise (MV = 19.94, SD = 3.37) and pregnant women who exercised (MV = 11.65, SD = 1.35), ($t = 13.658$, $p < 0.001$). The difference in GWG (MV = 8.30) between the two groups of pregnant women is large ($\eta^2 = 0.70$). Pregnant women who did not exercise had significantly higher GWG.

In the control group, at the beginning of the theoretical classes on childbirth, systolic blood pressure was 111.67 ± 9.41 mmHg (Table 2). The lowest recorded value of systolic blood pressure was 90 mmHg, and the highest value was 120 mmHg. At the end systolic blood pressure was 127.22 ± 13.44 mmHg. The lowest recorded value was 90 mmHg, and the highest value was 150 mmHg, which is a hypertensive value. Four pregnant women developed hypertension. A significant large difference was found in the systolic blood pressure determined in the first measurement time and the second measurement time ($t = -8.241$, $p < 0.001$; $\eta^2 = 0.66$) (Table 2). The increase in systolic blood pressure in the control group was 15.56 mmHg (Figure 2).

In the control group at the beginning of the theoretical classes, diastolic blood pressure was 71.11 ± 7.85 mmHg (Table 2). The lowest recorded value of diastolic blood pressure was 60 mmHg, and the highest value was 80 mmHg. At the end of the classes, diastolic blood pressure was 87.19 ± 17.97 mmHg. The lowest recorded value was 60 mmHg, and the highest value was 110 mmHg. There is a significant large difference in diastolic blood pressure found in the first and second measurement time ($t = -4.857$, $p < 0.001$; $\eta^2 = 0.40$). The increase in diastolic blood pressure in the control group was 16.08 mmHg (Figure 2).

In the experimental group at the beginning of prenatal exercise, systolic blood pressure was 108.68 ± 9.79 mmHg (Table 2). The lowest recorded value of systolic blood pressure was 90 mmHg, and the highest value was 130 mmHg. At the end of prenatal exercise, systolic blood pressure was 111.18 ± 9.77 mmHg. The lowest value of systolic blood pressure was 90 mmHg, and the highest value was 130 mmHg. In the experimental group there was a significant increase in systolic blood pressure (mean difference = 2.50 mmHg) with systolic pressure remaining within normal limits, that is hypertension did not develop ($t = -2{,}153$, $p = 0.039$). The difference is of medium intensity ($\eta^2 = 0.12$) (Figure 2). In the experimental group, it was observed that some pregnant women had to slow down with exercise because they felt tired and weak.

In the experimental group, at the beginning of exercise, the MV of diastolic blood pressure was 68.38 ± 9.43 mmHg (Table 2). The lowest determined value of diastolic blood pressure was 60 mmHg, and the highest was 80 mmHg. At the end of exercise, diastolic blood pressure was 68.24 ± 8.25 mmHg (Table 2). The lowest recorded value was 60 mmHg, and the highest value was 85 mmHg. A significant difference in the MV of diastolic blood pressure in the first and second measurement time was not found ($t = 0.144$, $p = 0.887$). Diastolic blood pressure was within normal limits (Figure 2).

In pregnant women who exercised, the increase in systolic blood pressure of 2.50 mmHg was significantly

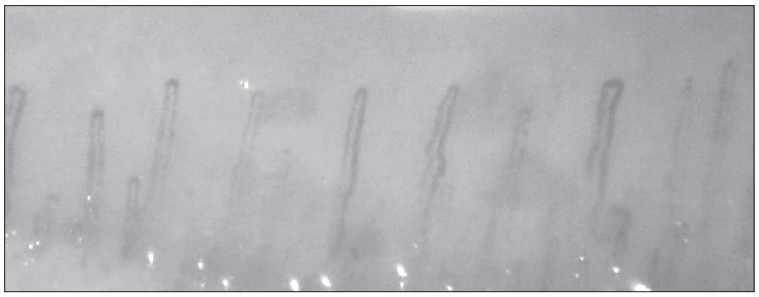


Figure 3. Nailfold capillary loops

Table 3. Nailfold capillary density in the control group and the experimental group, at the beginning and end of the prenatal program

Parameters	Nailfold capillary density (capillary/mm)	
	Pregnant women who did not exercise	Pregnant women who exercised
Beginning of the prenatal program	7.29 ± 1.21	7.05 ± 1.36
End of the prenatal program	7.29 ± 0.98	7.05 ± 1.36

The results are presented as mean values ± standard deviation

less compared to the increase in systolic blood pressure of 15.56 mmHg in pregnant women who did not exercise ($t = -5.892$, $p = 0.0001$) (Figure 2). In pregnant women who exercised, there was no significant increase in diastolic blood pressure after eight weeks of follow-up, while in non-exercising pregnant women there was an increase in diastolic blood pressure of 16.08 mmHg, which is a significant difference ($p < 0.0001$) (Figure 2).

The density of nailfold capillary loops was analyzed. Nailfold capillary loops had a hairpin shape and were organized in rows (Figure 3). In non-exercising pregnant women nailfold capillary density was 7.29 ± 1.21 capillaries/mm at the beginning of the study and 7.29 ± 0.98 capillaries/mm at the end of the study (Table 3). The nailfold capillary density in non-exercising pregnant women did not change after eight weeks of gestation ($p < 0.001$).

In pregnant women who exercised nailfold capillary density was 7.05 ± 1.36 capillaries/mm at the beginning of the study and 7.05 ± 1.36 capillaries/mm at the end (Table 3). The density of nailfold capillary loops in pregnant women who exercised did not change after eight weeks of pregnancy ($p < 0.001$).

DISCUSSION

In this study pregnant women who exercised had significantly less GWG. A study by Vargas-Terrones et al. [8] showed that prenatal exercise and diet during pregnancy reduced GWG. Non-exercising pregnant women were 1.5 times more likely to gain weight during pregnancy [15]. da Silva et al. [9] found that an exercise program reduced GWG. In pregnant women different types of prenatal exercises have reduced GWG [17]. Multiple factors can affect GWG, including type and/or intensity of exercise, lifestyle, diet, lifestyle alignment, and socioeconomic and environmental factors [8]. Weight gain is caused by an imbalance between energy intake and energy spending. In this study, pregnant women who exercised, ate normal, but did not have a sedentary lifestyle, and therefore, had higher energy spending. The weight of pregnant women during the prenatal program can be controlled and possible complications for the health of the mother and baby can be prevented.

Weight gain increases the risk of developing hypertension during pregnancy. Blood pressure gradually increases during the second and third trimesters [14]. Physical activity may reduce the risk of developing hypertensive disorders and functional status depends on individual patient performance [18, 19, 20].

In this study, at the end of theoretical classes, non-exercising pregnant women had a significant increase in systolic blood pressure of 15.56 mmHg, and diastolic blood pressure of 16.08 mmHg. In pregnant women who exercised, a significant increase in systolic blood pressure of 2.50 mmHg was found, and diastolic blood pressure did not change significantly.

In pregnant women who exercised, the increase in systolic blood pressure after eight weeks of 2.50 mmHg was significantly less than the increase in systolic blood pressure in non-exercising pregnant women. In pregnant women who exercised, there was no significant increase in diastolic blood pressure after eight weeks of follow-up, which is a significant difference compared to non-exercising pregnant women in whom there was an increase in diastolic blood pressure of 16.08 mmHg.

In pregnant women who exercise there were improvements in blood pressure [15, 21]. Boparai et al. [14] showed that pregnant women who exercised, showed after intervention an attenuated increase in arterial pressure compared to the control group. Pregnant women who have not exercised are three times more likely to develop hypertension compared to pregnant women who have exercised [15, 21]. The potential reason why pregnant women who exercised had a lower systolic and diastolic blood pressure increase than the non-exercising pregnant women, could be the beneficial effects of exercise in the prevention of excessive GWG. Obesity is associated with hypertension. Weight gain leads to an increased risk of developing hypertension during pregnancy. Pregnancy is a unique opportunity to improve health outcomes for both mother and child. Physical activity in pregnancy had beneficial effects on anxiety and blood pressure [22, 23, 24].

During pregnancy, the macrocirculation and microcirculation of pregnant women adapt. Data on the microcirculatory adaptation of pregnant women are scarce, mostly due to technical limitations [10].

In this study, the density of nailfold capillary loops in non-exercising pregnant women and those who exercised did not change after eight weeks of pregnancy. The average density of nailfold capillary in non-exercising pregnant women, at the beginning of the study was 7.29 capillaries/mm, and at the end was 7.29 capillaries/mm. The density

of nailfold capillary in pregnant women who exercised at the beginning of exercise was 7.05 capillaries/mm, and at the end 7.05 capillaries/mm.

In studies, the average capillary density ranges 7.3–10.3 capillaries/mm in healthy adults [25, 26, 27]. In previous research during pregnancy was observed an increase in capillary density and neoangiogenesis, and a reduction in capillary dilations [10]. Monitoring of microcirculatory changes can be viewed as a method that helps us to record the changes that precede the onset of clinical disease. Decreased capillary density has been demonstrated in individuals with hypertension [28]. Studies have revealed that the method of nailfold capillaroscopy facilitates the identification of women who have a more pronounced tendency to PIH because of the structural rarefaction of capillaries. In the control group, where a significant increase in blood pressure was found after eight weeks of follow-up, there was no decrease in capillary density. It is possible that the increase in blood pressure is reflected more in other characteristics of nailfold capillaries, such as the shape or length of capillaries, and further research is needed.

The described birth preparation program was developed for the purpose of promoting physical activity during pregnancy as a healthy lifestyle, reducing anxiety, and improving the self-control of pregnant women in childbirth.

Identifying risk factors for future cardiovascular diseases and early assessment of the circulatory status of pregnant women can lead to earlier lifestyle changes and disease prevention.

CONCLUSION

Prenatal exercise of moderate intensity has a positive effect on GWG. Pregnant women who did not exercise had a significantly greater increase in GWG. Prenatal exercise of moderate-intensity has a positive effect on blood pressure. In pregnant women who exercised, the increase in blood pressure was less compared to the increase in blood pressure in pregnant women who did not exercise. After eight weeks of the prenatal program, the difference in the capillary density of the nailfold was not determined in pregnant women who exercised and pregnant women who did not exercise.

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Conflict of interest: None declared.

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Истраживање утицаја пренаталних вежби на антропометријске и васкуларне параметре трудница

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САЖЕТАК

Увод/Циљ Учесталост седалачког начина живота током трудноће се повећава. То доприноси гестацијском повећању телесне тежине и има негативан утицај на здравље.
У овој студији се истраживао утицај пренаталних вежби на гестацијско повећање телесне тежине, крвни притисак и микроциркулацију код трудница које су вежбале и оних које нису вежбале.

Методе Испитивање је укључило 70 трудница са уредном трудноћом, које су осам недеља похађале програм психофизичке припреме за порођај. Контролна група (n = 35) похађала је теоретску наставу о порођају, а експериментална група (n = 35) похађала је и пренаталне вежбе. Утврђени су гестацијско повећање телесне тежине, крвни притисак и густина капилара кожног набора нокта и упоређени између две групе.

Резултати Гестацијско повећање телесне тежине од 19,94 *kg* код трудница које нису вежбале је значајно веће од гестацијског повећања телесне тежине од 11,65 *kg* код трудница које су вежбале. Труднице које нису вежбале су имале значајно веће повећање систолног притиска (за 15,56 *mmHg*) и дијастолног притиска (за 16,08 *mmHg*) у односу на труднице које су вежбале. У овој групи систолни притисак се повећао за 2,5 *mmHg*, док се дијастолни није мењао. Значајна разлика у густини капилара кожног набора нокта на крају пренаталног програма није утврђена.

Закључак Пренатално вежбање умереног интензитета има позитиван утицај на гестацијско повећање телесне тежине и на висину крвног притиска трудница. Густина капилара кожног набора нокта није се значајно разликовала након пренаталног програма код трудница које су вежбале и код оних које нису.

Кључне речи: физичка активност; трудноћа; гестацијско повећање телесне тежине; крвни притисак; микроциркулација; мерење густине микроваскуларних судова