https://doi.org/10.7251/SSH2102223L
Original scientific paper

UDC: 796.41-055.26:796.011.1
Originalni naučni rad

Influence of Physical Activity on Microcirculatory Changes in Healthy Pregnant Women

Uticaj fizičke aktivnosti na mikrocirkulatorne promjene kod zdravih trudnica

Vesna Ljubojević[1], Vlatka Bojanić[2], Saša Skočić Smoljanović[1]

[1]Faculty of Medicine University of Banja Luka, University Clinical Centre Banja Luka, Republic of Srpska, Bosnia and Herzegovina
[2]Pregnancy center "Radosnica", Banja Luka, Republic of Srpska, Bosnia and Herzegovina

Correspondence:
Vesna Ljubojević, Faculty of Medicine University of Banja Luka, University Clinical Centre Banja Luka
ljubojevic.v@gmail.com

[1]Medicinski fakultet Univerziteta u Banjoj Luci, Univerzitetski klinički centar Banja Luka, Republika Srpska, Bosna i Hercegovina
[2]Škola za trudnice "Radosnica", Banja Luka, Republika Srpska, Bosna i Hercegovina

Korespondencija:
Vesna Ljubojević, Medicinski fakultet Univerziteta u Banjoj Luci, Univerzitetski klinički centar Banja Luka
ljubojevic.v@gmail.com

Abstract: *In pregnancy physical activity is considered as a preventive measure for diseases of the cardiovascular system. In studies, the data on microvascular adaptation in pregnancy are scarce. The prenatal program included 35 pregnant women who exercised and 35 women who did not. The shape of the capillaries of the nail skin fold was analyzed with capillaroscopy. At the beginning of the study, the shape of the capillary was normal in all pregnant women. After 8 weeks in 40.91% of pregnant women who exercised and in 47.06% of pregnant women who did not exercise, the shape of the capillary loop was abnormal with bending of the limbs, tortuosity of the limbs, and crossing of the limbs. After the 8th week of the prenatal program, no significant difference in the shape of the capillary loop of the nail skin fold was found between pregnant women who performed prenatal exercises and pregnant women who did not.*
Keywords: *activity, physical, microcirculation, capillaroscopy, morphology, pregnancy.*

Sažetak: *Kod trudnica fizička aktivnost se navodi kao preventivna mjera oboljenja kardiovaskularnog sistema. U studijama podaci o mikrovaskularnoj adaptaciji u trudnoći su oskudni. U prenatalnom programu bilo je uključeno 35 trudica koje su vježbale i 35 koje nisu. Oblik kapilara kožnog nabora nokta je analiziran sa kapilaroskopijom. Na početku studije oblik kapilara je bio normalan kod svih trudnica. Nakon 8 nedelja kod 40.91 % trudnica koje su vježbale i kod 47.06 % trudnica koje nisu vježbale, oblik kapilarnih petlji je bio abnormalan sa savijanjem krakova, tortuozitetom krakova i ukrštanjem krakova. Nakon 8. nedelja prenatalnog programa između trudnica koje su izvodile prenatalne vježbe i trudnica koje nisu nije utvrđena značajna razlika u obliku kapilarnih petlji kožnog nabora nokta.*
Ključne riječi: *fizička aktivnost, mikrocirkulacija, kapilaroskopija, morfologija, trudnoća.*

Introduction

Physical activity is an important part of public health. Regular physical activity before the pregnancy, during the pregnancy, and after the delivery and its impact on health is emphasized in various studies (Deliens et al., 2019; Santos et al., 2016). Leading American, Canadian, Danish, Norwegian, Australian, and United Kingdom's guidelines for exercising in pregnancy recommend aerobic activity with moderate intensity, that is an activity that activates large muscle groups and spends energy sources for which release oxygen is required, and in the duration of 15 to 30 minutes, from three to four times a week (Filipec, 2019; da Silva et al., 2017).

Uvod

Fizička aktivnost („physical activity") je važan dio javnog zdravlja. Redovna fizička aktivnost prije trudnoće, u trudnoći i nakon porođaja i njen uticaj na zdravlje naglašava se u brojnim studijama (Deliens et al., 2019; Santos et al., 2016). Vodeće američke, kanadske, danske, norveške i australijske smjernice, te smjernice Ujedinjenog Kraljevstva za vježbanje u trudnoći preporučuju aerobnu aktivnost umjerenim intenzitetom, tj. aktivnost u kojoj se izvode ritmični pokreti, laganog do srednjeg intenziteta, pri kojima se aktiviraju velike mišićne grupe i troše izvori energije za čije oslobođenje je potreban kiseonik, a u trajanju od 15 do 30 min, od tri do četiri puta sedmično (Filipec, 2019; . da Silva et al., 2017).

Physical activity in pregnancy has numerous advantages. In pregnant women who did prenatal exercises, lower body weight gain was noted in pregnancy (Vargas-Terrones et al., 2019). Also, in pregnant women who exercised during pregnancy, physical activity is cited as a preventive measure for hypertension (Barakat et al., 2016). Physical inactivity and excessive weight gain during pregnancy increase the risk of gestational diabetes, pregnancy-induced hypertension (*pregnancy induced-hypertension*, PIH) (Poston et al., 2016; Szumilewicz et al., 2017), diseases of the cardiovascular system, musculoskeletal disorders, and numerous types of tumors (Deliens et al., 2019; Stutzman et al., 2010).

In pregnancy, the circulatory system is largely adapted to adequately supply the needs of the mother and fetus (Thevissen and Gyselaers, 2017). Blood volume, heart rate (*heart rate*, HR), stroke volume (*stroke volume*, SV), and cardiac output (*cardiac output,* CO) normally increase during pregnancy, while peripheral vascular resistance decreases (American College of Obstetricians and Gynecologists, 2015) from the first to the second trimester (Vasapollo et al., 2018).

Monitoring of microcirculatory changes can be viewed as a method that helps us to record the changes that precede the onset of clinical disease. Capillaroscopy is a non-invasive and effective method for direct visualization and analysis of microcirculation, that is capillaries of the nail skin fold. It is used for the recognition of qualitative, morphological patterns of microangiopathy (Thevissen and Gyselaers, 2017). The data on microcirculatory adaptation in pregnancy are scarce, mainly due to technical limitations. The aim of the study was to determine the shape of the capillary loop in pregnancy with capillaroscopy of the skin fold of the nail and the influence of the prenatal exercise program on microcirculatory changes.

Methods

Seventy pregnant women participated in the study (n = 70) from the western part of Bosnia and Herzegovina. One cycle of psychophysical preparation for childbirth lasted 8 weeks, as long as the subjects were followed. Subjects joined the program during the second and third trimesters, that is at the earliest in the 20th week of gestation and the latest in the 32nd week of gestation. The study was approved by the Ethics Committee of the Faculty of Medicine in Banja Luka.

Criteria for inclusion in the study are normal pregnancy confirmed by a gynecologist, age of pregnant women from 20 to 40 years, duration of pregnancy from

Fizička aktivnost u trudnoći ima brojne prednosti. Kod trudnica koje su izvodile prenatalne vježbe zabilježen je niži tjelesni prirast u trudnoći (Vargas-Terrones et al., 2019). Također, kod trudnica koje su vježbale u trudnoći, fizička aktivnost se navodi kao preventivna mjera hipertenzije (Barakat et al., 2016). Fizička neaktivnost i prekomjerno debljanje tokom trudnoće povećavaju rizik za gestacijski dijabetes, trudnoćom izazvanu hipertenziju (engl. *pregnancy induced hypertension*, PIH) (Poston et al., 2016; Szumilewicz et al., 2017), oboljenja kardiovaskularnog sistema, mišićno-koštanih poremećaja, te brojnih vrsta tumora (Deliens et al., 2019; Stutzman et al., 2010).

U trudnoći se cirkulatorni sistem u velikoj mjeri adaptira kako bi dovoljno opskrbio potrebe majke i ploda (Thevissen and Gyselaers, 2017). Volumen krvi, frekvencija otkucaja srca (eng. heart rate, HR), udarni volumen (eng. stroke volume, SV) i minutni volumen srca (eng. cardiac output, CO) normalno se povećavaju tokom trudnoće, dok se periferni vaskularni otpor smanjuje (American College of Obstetricians and Gynecologists, 2015) od prvog do drugog tromjesečja (Vasapollo et al., 2018).

Praćenje mikrocirkulatornih promjena možemo posmatrati kao metod koji nam pomažu da zabilježimo promjene koje prethode početku kliničke bolesti. Kapilaroskopija je neinvazivna i efikasna metoda za direktnu vizualizaciju i analizu mikrocirkulacije, odnosno kapilara nokatnog kožnog nabora. Koristi se za prepoznavanje kvalitativnih, morfoloških obrazaca mikroangiopatije (Thevissen and Gyselaers, 2017). U studijama podaci o mikrocirkulatornoj adaptaciji u trudnoći su oskudni, uglavnom zbog tehničkih ograničenja (Thevissen and Gyselaers, 2017). Cilj istraživanja je bio da se utvrdi oblik kapilarne petlje u trudnoći sa kapilaroskopijom kožnog nabora nokta i uticaj programa prenatalnih vježbi na mikrocirkulatorne promjene.

Metode

U studiji je učestvovalo sedamdeset trudnica (n= 70) iz zapadnog dijela Bosne i Hercegovine. Jedan ciklus psihofizičke pripreme za porođaj trajao je 8 nedjelja, koliko su ispitanice bile praćene. Ispitanice su se pridružile programu tokom drugog i trećeg tromjesečja, odnosno najranije u 20.nedjelji gestacije i najkasnije u 32.nedjelji gestacije. Studiju je odobrio Etički odbor Medicinskog fakulteta Banja Luka.

Kriterijumi za uključenje u studiju su: uredna trudnoća koju je potvrdio ginekolog, starost trudnica od 20 do 40 godina, trajanje trudnoće od 20. do 32. nedjelje

20 to 32 weeks of pregnancy, BMI before pregnancy <25 kg / m2, singleton pregnancy.

Criteria for exclusion from the study are bleeding in the second or third trimester, premature birth in the current pregnancy, rupture of the amniotic sac, pregnancy-induced hypertension, intrauterine fetal growth restriction (*intrauterine growth restriction* – IUGR) in the current pregnancy, anemia, and exclusion from the study at the pregnant woman's own request.

Within the prenatal program, theoretical classes on childbirth and prenatal exercises took place. After the gynecological examination and the confirmed normal pregnancy, the gynecologist included the pregnant women in the program. Subjects were divided into two groups: control and experimental. The control group consisted of pregnant women who spent 60 minutes three times a week in the theoretical part, where they received advice from gynecologists and other doctors on pregnancy, childbirth, nutrition, breastfeeding, etc. The experimental group consisted of pregnant women who exercised three times a week for 45 minutes and participated in the theoretical part of the prenatal program. Prenatal exercises were led by the leader for physical activities in pregnancy, according to the exercise program made according to the recommendations of the American College of Obstetricians and Gynecologists (American College of Obstetricians and Gynecologists, 2015) and guidelines CAPWH (Croatian Association of Physiotherapists for Women's Health) (Vojvodić-Schuster, 2004).

Prenatal training was presented with: exercises for muscle strength, exercises to strengthen the muscles of the abdominal wall, exercises to strengthen the muscles of the legs, exercises to strengthen the gluteal muscles, exercises to increase pelvic mobility, exercises to improve circulation and muscle stretching exercises. The training began and ended with breathing and relaxation techniques for about 10 min. Warm-up consists of moderate walking for about 5 min, followed by strength and stretching exercises for about 30 min. Pregnant women performed exercises in a standing, sitting, kneeling, and lateral position, with or without props (balls, straps, weights, etc.).

Capillaroscopy with a stereomicroscope and digital camera enabled the assessment of capillary shape, as well as the classification and evaluation of capillary abnormalities of the skin fold of the nail (Thevissen and Gyselaers, 2017). In the study, the capillaroscopy method was performed three times, in three time periods, in both groups of subjects: at the beginning of exercise, after the 4th week, and at the end of the completed exercise

trudnoće, BMI prije trudnoće <25 kg/m^2, jednoplodna trudnoća.

Kriterijumi za isključenje iz studije su: krvarenje u drugom ili trećem tromjesečju, prijevremeni porođaj u aktuelnoj trudnoći, ruptura plodovih ovojaka, trudnoćom izazvana hipertenzija, intrauterini zastoj rasta ploda (engl. *intrauterine growth restriction* – IUGR) u aktuelnoj trudnoći, anemija, te isključenje iz studije na vlastiti zahtjev trudnice.

U okviru prenatalnog programa odvijala se teorijska nastava o porođaju i prenatalne vježbe. Nakon obavljenog ginekološkog pregleda te potvrđene uredne trudnoće, ginekolog je uključio trudnice u program. Ispitanice su podijeljene u dvije grupe: kontrolnu i eksperimentalnu. Kontrolnu grupu činile su trudnice koje su tri puta sedmično provodile po 60 min na teorijskom dijelu, gdje su dobijale savjete od ginekologa i drugih ljekara o trudnoći, porođaju, ishrani, dojenju i drugo. Eksperimentalnu grupu činile su trudnice koje su vježbale tri puta sedmično po 45 min i učestvovale u teorijskom dijelu prenatalnog programa. Prenatalne vježbe vodila je voditeljica za fizičke aktivnosti u trudnoći, prema programu vježbanja koji je urađen po preporukama Američkog koledža opstetričara i ginekologa (American College of Obstetricians and Gynecologists, 2015) i smjernicama HUFZŽ (Hrvatska udruga fizioterapeuta za zdravlje žena) (Vojvodić-Schuster, 2004).

Prenatalni trening predstavljen je sa: vježbama snage mišića, vježbama za jačanje mišića trbušnog zida, vježbama za jačanje mišića nogu, vježbama za jačanje glutealnih mišića, zatim vježbama za povećanje mobilnosti karlice, vježbama za poboljšanje cirkulacije, te vježbama istezanja mišića. Vježbe mišića karličnog dna uz tehnike disanja i opuštanja su sastavni dio prenatalnog programa. Trening se započinjao i završavao tehnikama disanja i opuštanja oko 10 min. Zagrijavanje se sastoji od umjerenog hodanja oko 5 min, zatim slijede vježbe snage i istezanja oko 30 min. Trudnice su izvodile vježbe u stojećem, sjedećem, klečećem i bočnom položaju, sa ili bez rekvizita (lopte, trake, utezi i sl.).

Kapilaroskopija sa stereomikroskopom i digitalnom kamerom je omogućila ocjenu oblika kapilara, kao i klasifikaciju i ocjenjivanje abnormalnosti kapilara kožnog nabora nokta (Thevissen and Gyselaers, 2017). U istraživanju, metoda kapilaroskopije se provodila tri puta, u tri vremenska perioda, u obe grupe ispitanika: na početku vježbanja, nakon 4. nedjelje i na kraju završenog programa vježbanja. Analizirane su kapilare kožnog nabora četvrtog prst lijeve ruke. Dobijene digitalne slike kapilara nokatnog nabora su omogućile određivanje oblika

program. The capillaries of the skin fold of the fourth finger of the left hand were analyzed. The obtained digital images of the nail fold capillaries enabled the determination of the capillary shape. The usual capillary shape has the appearance of a hairpin or similar to the letter "U" upside down (Thevissen and Gyselaers, 2017). Any deviation from this form was registered and described. In the processing of the obtained data, descriptive statistics were performed and a chi-square test was applied, using the SPSS 20 program.

Results

The prenatal program included 90 pregnant women, of whom 70 pregnant women successfully completed the program (77.8%), while 20 pregnant women (22.2%) left the program (Table 1).

Table 1. *Pregnant women who attended the prenatal program and those who left the study.*

kapilara. Uobičajeni oblik kapilara ima izgled ukosnice ili slično slovu "U" naopako (Thevissen and Gyselaers, 2017). Svako odstupanje od ovog oblika se registrovalo i opisalo. U obradi dobijenih podataka urađena je deskriptivna statistika i primjenjen je hi-kvadrat testa, koristeći program SPSS 20.

Rezultati

U prenatalnom programu bilo je uključeno 90 trudnica, od kojih je program uspješno završilo 70 trudnica (77.8%), dok je 20 trudnica (22.2%) napustilo program (tabela 1).

Tabela 1. *Trudnice koje su pohađale prenatalni program i one koje su napustile studiju.*

Reason for exclusion from the study / **Razlog isključenja iz studije**	***Experimental group /*** **Eksperimentalna grupa**	***Control group /*** **Kontrolna grupa**
Miscarriage / Spontani pobačaj	-	2
Premature birth / Prijevremeni porođaj	1	1
Pregnancy-induced hypertension / Trudnoćom izazvana hipertenzija	-	2
Leaving the study at their own request / Napuštanje studije na vlastiti zahtjev	2	3
Failure to meet the minimum number of visits to the program / Nezadovoljavanje minimalanog broja dolazaka na program	2	2
Due to loss of contact after the study and incomplete data / Zbog gubitka kontakta nakon studije i nepotpunih podataka	2	3

Twenty pregnant women left the study for the following reasons: miscarriage (2 pregnant women from the control group), premature birth (1 from the control group, 1 from the experimental group), pregnancy-induced hypertension (2 pregnant women from the control group), leaving the study at their own request (3 pregnant women from the control group, 2 pregnant women from the experimental group), failure to meet the minimum number of visits to the program (2 pregnant women from the control group, 2 pregnant women from the experimental group), and due to loss of contact after the study and incomplete data (3 pregnant women from the control group, 2 pregnant women from the experimental group). Thus, 70 pregnant women participated in a study examining the impact of prenatal exercise on the vascular parameters of pregnant women. There were a total of 35 pregnant women in the experimental group (n = 35) while there were 35 pregnant women in the control group (n = 35). The experimental and control groups were equal

Dvadeset trudnica je napustilo studiju zbog sljedećih razloga: spontani pobačaj (2 trudnice iz kontrolne grupe), prijevremeni porođaj (1 iz kontrolne, 1 iz eksperimentalne grupe), trudnoćom izazvana hipertenzija (2 trudnice iz kontrolne grupe), napuštanje studije na vlastiti zahtjev (3 trudnice iz kontrolne, 2 trudnice iz eksperimentalne grupe), nezadovoljavanja minimalanog broja dolazaka na program (2 trudnice iz kontrolne grupe, 2 trudnice iz eksperimentalne grupe), te zbog gubitka kontakta nakon studije i nepotpunih podataka (3 trudnice iz kontrolne grupe, 2 trudnice iz eksperimentalne grupe) . Na taj način, u studiji ispitivanja uticaja prenatalnog vježbanja na vaskularne parametre trudnica učestvovalo je 70 trudnica. U eksperimentalnoj grupi ukupno je bilo 35 trudnica (n=35) dok je u kontrolnoj grupi bilo 35 trudnica (n = 35). Eksperimentalna i kontrolna grupa su bile ujednačene u odnosu na starosnu dob trudnica i gestacijsku dob trudnica.

Sa kombinacijom stereomikroskopa koji je spojen

in relation to the age of the pregnant women and the gestational age of the pregnant women.

With a combination of a stereomicroscope connected to a digital video camera, capillary loops of the skin fold of pregnant women 's nails were recorded. Digital video capillaroscopy performed digital images of capillary loops of the fourth finger of the left hand: in pregnant women who performed prenatal exercises and in pregnant women who did not perform prenatal exercises. Capillary loops are visible in the skin fold of the nail, which is arranged in rows. In the distal row, the capillary loops of the hairpin shape and the arms of the capillary loop are clearly differentiated (Figure 1).

sa digitalnom videokamerom snimane su kapilarne petlje kožnog nabora nokta trudnica. Digitalnom videokapilaroskopijom urađene su digitalne slike kapilarnih petlji četvrtog prsta lijeve ruke: kod trudnica koje su izvodile prenatalne vježbe i kod trudnica koje nisu izvodile prenatalne vježbe. U kožnom naboru nokta vidljive su kapilarne petlje koje su poredane u redove. U distalnom redu jasno se diferenciraju kapilarne petlje oblika ukosnice i krakovi kapilarne petlje (Slika 1).

Figure 1. *Capillary loops of the skin fold of the nail*

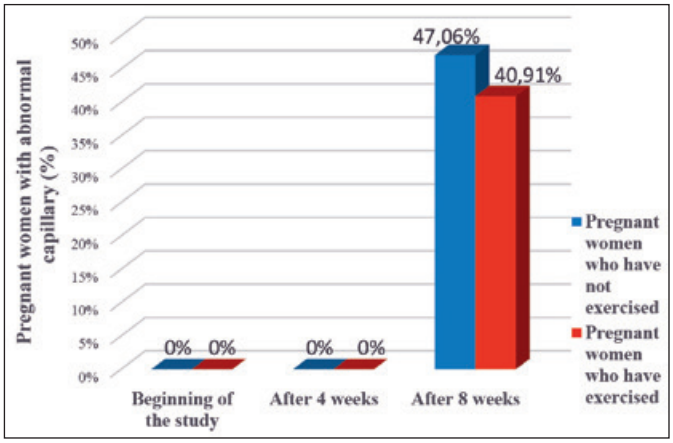
Slika 1. *Kapilarne petlje kožnog nabora nokta*

At the beginning of the study, the capillary shape of the skin fold of the nail was neat, normal, that is in the form of a hairpin, in all pregnant women. The arms of the capillary loop were straight, without bending, tortuosity, and intersection (Figure 1).

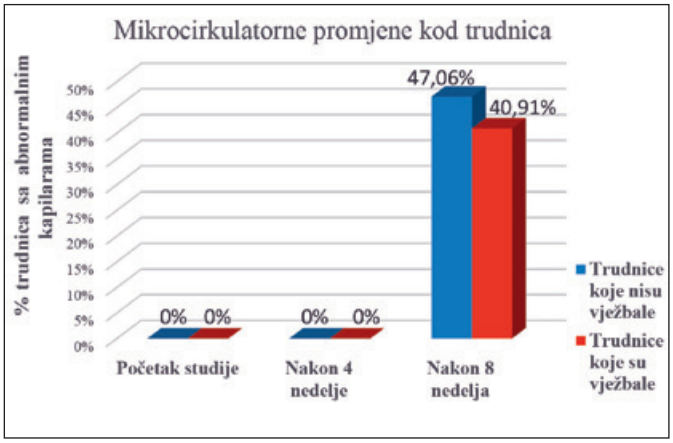
In the second time of measuring the capillaries of the skin fold of the nail, that is after 4 weeks of study, the form did not change in the experimental and control groups (Graph 1).

Na početku studije oblik kapilara kožnog nabora nokta je bio uredan, normalan, tj. u obliku ukosnice, kod svih trudnica. Kraci kapilarne petlje su bili ravni, bez savijanja, tortuoziteta i međusobnog ukrštanja (slika 1).

U drugom vremenu mjerenja kapilara kožnog nabora nokta, tj. nakon 4 nedjelje studije, oblik se nije mijenjao u eksperimentalnoj i kontrolnoj grupi (grafikon 1).



Graph 1. *The shape of the capillary loops of the skin fold of the nail of pregnant women who have exercised and who have not*



Grafikon 1. *Oblik kapilarnih petlji kožnog nabora nokta trudnica koje su vježbale i koje nisu*

At the end of the study, after 8 weeks, in 40.91% of pregnant women who were involved in prenatal exercise and in 47.06% of pregnant women who were not involved in the prenatal exercise, the shape of the capillary loops changed. The presence of capillary loops of altered, abnormal shape with bending of the arms, tortuosity of the arms, and crossing of the arms was determined (Figure 2).

Na kraju studije, nakon 8 nedelja, kod 40.91 % trudnica koje su bile uključene u izvođenje prenatalnih vježbi i kod 47.06 % trudnica koje nisu bile uključene u izvođenje prenatalnih vježbi, oblik kapilarnih petlji se izmijenio. Utvrđeno je prisutvo kapilarnih petlji izmijenjenog, abnormalog oblika sa savijanjem krakova, tortuozitetom krakova i ukrštanjem krakova (slika 2).

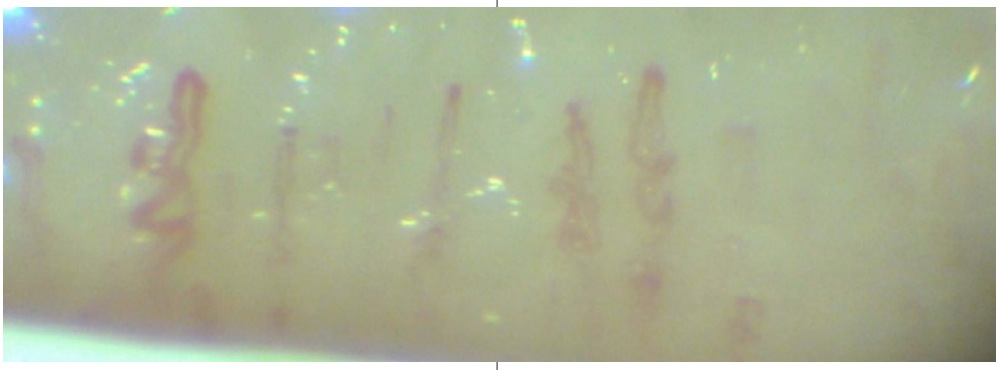


Figure 2. *Tortuosity and crossing of the arms of capillary loops*

Slika 2. *Tortuozitet i ukrštanje krakova kapilarnih petlji*

After 8 weeks of the prenatal program, the percentage of pregnant women who exercised with abnormal capillaries of 40.91% was not statistically significantly lower compared to 47.06% of pregnant women with abnormal capillaries who did not exercise (p> 0.05).

Nakon 8 nedelja prenatalnog programa postotak trudnica koje su vježbale sa abnormalnim kapilarama od 40,91 % nije bio statistički značajno manji u odnosu na 47,06 % trudnica sa abnormalnim kapilarama koje nisu vježbale (p>0.05).

Discussion

The study used capillaroscopy to analyze the shape of the capillary loop of the skin fold of the nail in pregnant women who performed prenatal exercises and in pregnant women who did not perform prenatal exercises. At the beginning of the study in all pregnant women, gestational age from 20 to 32 weeks, the capillary loops of the skin fold of the nail were of normal shape, that is in the form of a hairpin. The arms of the capillary loops were straight, without bending, tortuosity and intersection. Also, after the 4th week of the study, the shape did not change, it remained normal in pregnant women of the experimental and control groups. After 8 weeks, in 40.91% of pregnant women who were involved in performing prenatal exercises and in 47.06% of pregnant women who were not involved in performing prenatal exercises, the shape of the capillary loops changed. The presence of capillary loops of altered, abnormal shape with bending of arms, tortuosity of arms, and crossing of arms was determined.

No study was found in the literature that analyzed the shape of capillary loops in the second and third trimesters of pregnancy and the percentage of capillaries

Diskusija

U studiji je pomoću kapilaroskopije analiziran oblik kapilarne petlje kožnog nabora nokta kod trudnica koje su izvodile prenatalne vježbe i kod trudnica koje nisu izvodile prenatalne vježbe. Na početku studije kod svih trudnica, gestacijske starosti od 20. do 32. nedelje, kapilarne petlje kožnog nabora nokta su bile normalnog oblika tj. u obliku ukosnice. Kraci kapilarnih petlji su bili ravni, bez savijanja, tortuoziteta i međusobnog ukrštanja. Takođe,nakon 4. nedjelje studije, oblik se nije mijenjao, ostao je normalan kod trudnica eksperimentalne i kontrolne grupe. Nakon 8 nedelja, kod 40.91 % trudnica koje su bile uključene u izvođenje prenatalnih vježbi i kod 47.06 % trudnica koje nisu bile uključene u izvođenje prenatalnih vježbi, oblik kapilarnih petlji se izmijenio. Utvrđeno je prisutvo kapilarnih petlji izmijenjenog, abnormalog oblika sa savijanjem krakova, tortuozitetom krakova i ukrštanjem krakova.

U literaturi nije nađena studiju koja je analizirala oblik kapilarnih petlji u drugom i trećem trimestru trudnoće i procenat kapilara abnormalnog oblika. Kapilaroskopija kožnog nabora nokta se koristi za procjenu morfologije kapilara dermalnih papila nokatnog kožnog

of abnormal shape. Capillaroscopy of the skin fold of the nail is used to assess the morphology of the capillaries of the dermal papillae of the nail skin fold, which facilitates the recognition of qualitative, morphological patterns of microangiopathy (Thevissen, 2017). Elongated capillaries are commonly found in hypertension and arteriosclerosis, while shorter capillaries often indicate heart failure and diabetes (Thevissen, 2017). Structural rarefaction of capillaries, which is recorded by reduced capillary density, has been demonstrated in individuals with hypertension compared to individuals who are not hypertensive (Thevissen, 2017). Patients with diabetes have altered capillary morphology with unchanged capillary density (Thevissen, 2017). In the study of Nama et al. (2012) the number of capillary loops of the nail fold, that is the density of capillaries in pregnant women in all three trimesters was analyzed. A statistically significant decrease in the number of capillary loops from the 34th to the 38th gestational week was found. Compared with the first analysis of capillary loops in the period from the 11th to the 16th week of gestation, the earliest statistically significant decrease in the average density of capillary loops was found in the period from the 34th to the 38th week of gestation.

The study analyzed the influence of prenatal exercises on the microcirculation of pregnant women, which was analyzed with capillaroscopy of the skin fold of the nail. After the 8th week of the prenatal program, the percentage of pregnant women who exercised with abnormal capillaries of 40.91% was not statistically significantly lower compared to 47.06% of pregnant women who did not exercise with abnormal capillaries ($p > 0.05$).

No study has been found in the literature examining the effect of prenatal exercise on the microcirculatory adaptation of pregnant women. In pregnancy, there is an adaptation of the macrocirculation and microcirculation of the pregnant woman. In studies, data on microcirculatory adaptation are scarce, mainly due to technical limitations (Thevissen, 2017). Microcirculation disorders are associated with most risk factors for cardiovascular disease. In patients with hypertension and in patients with the initial stage (prehypertension) capillary remodeling and change in capillary shape are manifested (Gurfinkel, 2015). The study by Haakstad et al. (2016) was analyzed the impact of prenatal exercise on blood pressure. They found that in pregnant women who exercised, systolic blood pressure values were lower compared to pregnant women who did not exercise. To improve the cardiovascular health of pregnant women, physical activity in the form of prenatal exercises is a desirable way of life.

nabora, što olakšava prepoznavanje kvalitativnih, morfoloških obrazaca mikroangiopatije (Thevissen, 2017). Izduženi kapilari obično se susreću kod hipertenzije i arterioskleroze, dok kraći kapilari često ukazuju na srčanu insuficijenciju i dijabetes (Thevissen, 2017). Strukturno prorjeđivanje kapilara, koje se evidentira smanjenom gustinom kapilara, dokazano je kod osoba s hipertenzijom u poređenju sa pojedincima koji nisu hipertenzivni (Thevissen, 2017). Kod pacijenata sa šećernom bolešću se javlja izmijenjena kapilarna morfologija sa nepromijenjenom gustinom kapilara (Thevissen, 2017). U studiji Nama i sar. (2012) je analiziran broj kapilarnih petlji kožnog nabora nokta, odnosno gustina kapilara kod trudnica u sva tri trimestra. Utvrđeno je statistički značajno smanjenje broja kapilaranih petlji od 34. do 38. gestacijske nedelje. U poređenju sa prvom analizom kapilarnih petlji u periodu od 11. do 16. gestacijske nedelje, najranije statistički značajno smanjenje u prosječnoj gustini kapilarnih petlji se utvrdilo u period od 34. do 38. nedelje gestacije.

U studiji se analizirao uticaj prenatalnih vježbi na mikrocirkulaciju trudnica koja se analizirala sa kapilaroskopijom kožnog nabora nokta. Nakon 8. nedelja prenatalnog programa postotak trudnica koje su vježbale sa abnormalnim kapilarama od 40,91 % nije bio statistički značajno manji u odnosu na 47,06 % trudnica koje nisu vježbale sa abnormalnim kapilarama ($p>0.05$).

U literaturi nije nađena studija koja je ispitivala uticaj prenatalnim vježbi na mikrocirkulatornu adaptaciju trudnica. U trudnoći dolazi do adaptacije makrocirkulacije i mikrocirkulacije trudnice. U studijama podaci o mikrocirkulatornoj adaptaciji su oskudni, uglavnom zbog tehničkih ograničenja (Thevissen, 2017). Poremećaji mikrocirkulacije povezani su sa većinom faktora rizika kardiovaskularnih oboljenja. Kod pacijenata sa hipertenzijom i kod pacijenata sa početnim stadijumom, prehipertenzijom, manifestuje se kapilarno remodelovanje i promjena oblika kapilara (Gurfinkel, 2015). U studiji Haakstad i sar. (2016) je analiziran uticaj prenatalnih vježbi na krvni pritisak. Utvrdili su da kod trudnica koje su vježbale su vrijednosti sistolnog krvnog pritiska niže u odnosu na trudnice koje nisu vježbale. Za poboljšanje kardiovaskularnog zdravlja trudnica fizičku aktivnost u obliku prenatalnih vježbi je poželjan način života.

Conclusion

The method of videocapillaroscopy of the skin fold of pregnant women 's nails enables the determination of microcirculatory changes in pregnancy. The shape of the capillary loops changed both in pregnant women who performed prenatal exercises and in those who did not. In pregnant women in the third trimester of pregnancy who attended the prenatal program, the presence of abnormal capillary loops with bending of the arms, tortuosity of the arms, and crossing of the arms was determined after 8 weeks of follow-up. After the 8th week of the prenatal program, no significant difference in the shape of the capillary loop of the skin fold of the nail was found between pregnant women who performed prenatal exercises and pregnant women who did not perform prenatal exercises.

Zaključak

Metoda videokapilaroskopije kožnog nabora nokta trudnica omogućava da se utvrde mikrocirkulatorne promjene u trudnoći. Oblik kapilarnih petlji se izmijenio i kod trudnica koje su izvodile prenatalne vježbe i kod onih koje nisu. Kod trudnica u trećem trimestru trudnoće koje su pohađale prenatalni program je utvrđeno, nakon 8 sedmica praćenja, prisutvo kapilarnih petlji abnormalog oblika sa savijanjem krakova, tortuozitetom krakova i ukrštanjem krakova. Nakon 8. nedelja prenatalnog programa između trudnica koje su izvodile prenatalne vježbe i trudnica koje nisu izvodile prenatalne vježbe nije utvrđena značajna razlika u obliku kapilarne petlje kožnog nabora nokta.

References

American College of Obstetricians and Gynecologists. (2015). Physical activity and exercise during pregnancy and the postpartum period. Committee Opinion No. 650.*Obstet Gynecol*, 126(6), e135-142.

Barakat, R., Pelaez, M., Cordero, Y., Perales, M., Lopez, C., Coteron, J., Mottola, M.F. (2016). Exercise during pregnancy protects against hypertension and macrosomia: randomized clinical trial. *American journal of obstetrics and gynecology*, 214(5), 505-507.

da Silva, S. G., Hallal, P. C., Domingues, M. R., Bertoldi, A. D., da Silveira, M. F., Bassani, D., & Evenson, K. (2017). A randomized controlled trial of exercise during pregnancy on maternal and neonatal outcomes: results from the PAMELA study. *The International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 1-11.

Deliens, T., Versele, V., Eynde, H.V., Clarys, P., Devlieger, R., Bogaerts, A., … & Aerenhouts, D. (2019). Body weight, body composition and energy balance related behaviour during the transition to parenthood: study protocol of a multi-centre observational follow-up study (TRANSPARENTS). *BMC public health*, 19(1), 1-9.

Filipec, M. (2019). *Utjecaj terapijskoga vježbanja na smanjenje sakroilijakalne disfunkcije u trudnoći [The influence of exercise on reduction of sacroiliac dysfunction in pregnancy]* Doctoral dissertation. Zagreb: Sveučilište u Zagrebu Medicinski fakultet. [in Croatian]

Gurfinkel, Y. I., Sasonko, M. L., Kuznetzov, M. I., & Priezzhev, A. V. (2015). Importance of image processing in digital optical capillaroscopy for early diagnostics of arterial hypertension. *In 2015 International Conference on BioPhotonics (BioPhotonics)* (pp. 1-4). IEEE.

Haakstad, L. A., Edvardsen, E., & Bø, K. (2016). Effect of regular exercise on blood pressure in normotensive pregnant women. A randomized controlled trial. *Hypertension in pregnancy*, 35(2), 170-180.

Nama, V., Antonios, T. F., Onwude, J., & Manyonda, I. T. (2012). Capillary remodelling in normal pregnancy: Can it mediate the progressive but reversible rise in blood pressure? Novel insights into cardiovascular adaptation in pregnancy. *Pregnancy Hypertension: An International Journal of Women's Cardiovascular Health*, 2(4), 380-386.

Poston, L., Caleyachetty, R., Cnattingius, S., Corvalán, C., Uauy, R., Herring, S., & Gillman, M. W. (2016). Preconceptional and maternal obesity: epidemiology and health consequences. *The lancet Diabetes & endocrinology*, 4(12), 1025-1036.

Santos, C. M. D., Santos, W. M. D., Gallarreta, F. M. P., Pigatto, C., Portela, L. O. C., & Morais, E. N. D. (2016). Effect of maternal exercises on biophysical fetal and maternal parameters: a transversal study. *Einstein (São Paulo)*, 14(4), 455-460.

Stutzman, S. S., Brown, C. A., Hains, S. M., Godwin, M., Smith, G. N., Parlow, J. L., & Kisilevsky, B. S. (2010). The effects of exercise conditioning in normal and overweight pregnant women on blood pressure and heart rate variability. *Biological research for nursing*, 12(2), 137-148.

Szumilewicz, A., Worska, A., Piernicka, M., Kuchta, A., Kortas, J., Jastrzębski, Z., Radzimiński, Ł., Jaworska, J., Micielska, K., Ziemann, E. (2017). The exercise-induced irisin is associated with improved levels of glucose homeostasis markers in pregnant women participating in 8-week prenatal group fitness program: a pilot study. *BioMed Research International*, 17, 1-10.

Thevissen, K, & Gyselaers, W. (2017). Capillaroscopy in pregnancy. *Expert review of medical devices*, 14(12), 961-967.

Vargas-Terrones, M., Nagpal, T. S., Barakat, R. (2019). Impact of exercise during pregnancy on gestational weight gain and birth weight: an overview. *Brazilian journal of physical therapy*, 23(2), 164-169.

Vasapollo B, Lo Presti D, Gagliardi G, Farsetti D, Tiralongo G. M., Pisani I, Novelli GP, Valensise, H. (2018). Restricted physical activity in pregnancy reduces maternal vascular resistance and improves fetal growth. *Ultrasound in Obstetrics & Gynecology*, 51(5), 672-6.

Vojvodić-Schuster, S. (2004). Vježbe za trudnice: cjeloviti program vježbanja kroz tromjesečja i priprema za porođaj. *Zagreb: Biovega*. [in Croatian]

Primljen: 05. jun 2021. / Received: Juny 05, 2021
Prihvaćen: 31. avgust 2021. / Accepted: August 31, 2021