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MATERNAL AND FETAL RESPONSE ON PRENATAL EXERCISE: AN QUASI-EXPERIMENTAL PILOT STUDY

ODZIV MATERE IN PLODA NA PRENATALNO VADBO: KVAZI EKSPERIMENTALNA PILOTNA ŠTUDIJA

ABSTRACT

Despite the positive effects of exercise during pregnancy, only a small percentage of pregnant women choose to exercise because of concerns about fetal safety. The purpose of this study was to determine if the selected physiological functions of pregnant women increase or decrease to a limit that is still safe, and what effect this has on fetal heart rate and movement, depending on the type of exercise and physical activity of the pregnant women prior to pregnancy. An experimental study was conducted. Measurements of the pregnant women's heart rate, saturation, blood pressure, and body temperature, fetal heart rate, and fetal movements before and after exercise were collected. Exercises with two different levels of intensities (yoga-low and pilates-moderate) were compared. Thirty-one pregnant Slovenian women with gestational age between 20 and 37 weeks were included in the sample. When comparing pre and post exercise measurements, statistically significant differences were found in post exercise body temperature ($p = 0.005$) and systolic blood pressure ($p = 0.007$) compared with pre-exercise measurements. When comparing the results between yoga and Pilates exercise sessions, no statistically significant differences were found. When comparing results related to pre-pregnancy physical activity, significant differences in pre-exercise saturation were found ($p = 0.041$). Despite small sample size, results indicate that moderate physical activity in pregnancy has no significant effect on the vital functions of the pregnant woman that could indirectly endanger foetus. Larger study should be performed, to confirm these preliminary results.

Keywords: foetal safety, pregnancy, moderate physical activity

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IZVLEČEK

Kljub dokazanim pozitivnim učinkom vadbe v nosečnosti, je le majhen delež nosečnic fizično aktiven. Eden od vzrokov je tudi skrb kako telesna aktivnost vpliva na fetus. V prispevku želimo ovrednotiti vpliv vadbe v nosečnosti na določene fizične parametre otroka (gibanje in srčni utrip) ter vitalne funkcije matere, v odnosu do intenzivnosti vadbe ter fizične aktivnosti nosečnice pred nosečnostjo. S tem namenom je bil izveden eksperiment. Zajete so bile nosečnice, udeležene v sklopu organizirane vadbe joge (primer lahke vadbe) in pilatesa (zmerna intenzivnost). Merili smo pulz, krvni tlak, telesno temperaturo in saturacijo žensk ter srčni utrip in gibanje ploda pred in po vadbi. Sodelovalo je 31 žensk med 20 in 37 tednom gestacije. V primerjavi podatkov pred in po vadbi so bile ugotovljene statistično značilne spremembe v telesni temperaturi ($p = 0.005$) in krvnem tlaku ($p = 0.007$) vadečih, vendar pa ne v tolikšni meri, da bi to vplivalo na varnost ploda. Statističnih razlik v primerjavi glede na nivo intenzivnosti vadbe nismo zasledili. Statistične razlike so se pokazale tudi v saturaciji pred vadbo ($p = 0.041$) med ženskami, ki so bile fizično aktivne že v času pred nosečnostjo in tistimi,ki so z vadbo začele šele v času nosečnosti. Kljub majhnemu vzorcu lahko zaključimo, da je nizka oz. zmerno intenzivna vadba v nosečnosti varna za plod. Smiselno bi bilo ponoviti raziskavo na večjem vzorcu.

Ključne besede: varnost ploda, nosečnost, zmerna telesna vadba

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INTRODUCTION

Exercise in pregnancy has several advantages for the pregnant woman. It increases physical performance, reduces problems with pelvic and back pain (Naugle, Fillingim, & Riley III, 2012; Santos et al., 2016; Šćepanović et al., 2017), helps maintain an appropriate body weight (Kuhrt, Hezelgrave, & Shennan, 2015; Muktabhant, Lawrie, Lumbiganon, & Laopaiboon, 2015; Wiebe, Boulé, Chari, & Davenport, 2015), lowers the incidence of pregnancy-related diseases such as gestational hypertension and gestational diabetes (Berghella & Saccone, 2017). Nevertheless, only 15% of women follow recommendations for physical activity during pregnancy (Kuhrt et al., 2015; Newton & May, 2017). One possible cause may be conflicting information regarding the safety of exercise for the fetus (Mellis, 2015). If exercise is more intense than recommended in guidelines from American College of Obstetricians and Gynecologists and the Association of Chartered Physiotherapy and Women's Health (American College of Obstetricians and Gynecologists, 2020; Pelvic obstetric and gynaecological physiotherapy, 2017), it may jeopardize the health of a pregnant woman or the fetus (Newton & May, 2017; Šćepanović et al., 2017). The acute risks to which the fetus may be exposed include dehydration, hypoglycemia, hyperthermia, bradycardia, and resulting hypoxia (Kuhrt et al., 2015; Newton & May, 2017). Since foetal well-being is closely connected to maternal conditions, it is crucial that woman does not exceed the recommended intensity of physical activity.

A woman's heart rate is an important indicator of exercise intensity. Moderate intensity is recommended. General recommendation, regardless the type of physical activity in pregnancy is that pregnant woman's heart rate should not exceed 60-80% of her maximum pulse. A cross-sectional study also found an increase in blood pressure during exercise, while the women's saturation remained unchanged (Santos et al., 2016). Fetal body temperature is proportional to the intensity of exercise. The more intense the exercise, the higher the fetal heart rate and the higher the fetal body temperature (Davenport et al., 2019; Kuhrt et al., 2015; May, 2012; Newton & May, 2017). Kuhrt and colleagues (2015) described an association between mother's hyperthermia and fetal neural tube defects, but the most recent meta-analysis shows that the temperature increase during moderate exercise is below the teratogenicity threshold (Davenport et al., 2019; Ravanelli, Casasola, English, Edwards, & Jay, 2019). During moderate exercise, fetal heart rate increases by 10-30 beats per minute (Velloso, Reis, Pereira, & Pereira, 2015). The fetus may become tachycardic up to five minutes after exercise due to vasoactive hormones and maternal stimulation (Moyer & May, 2014; Santos et al., 2016). Fetal bradycardia and

resulting hypoxia can occur when the mother's heart rate exceeds 90% of her maximum pulse and when blood flow through the uterine arteries is less than 50% (Kuhrt et al., 2015; Moyer & May, 2014). Physical activity affects cortisol, dopamine, and serotonin levels, resulting in improved maternal perception of fetal movement and increased frequency of fetal activity (DiPietro, Kivlighan, Costigan, & Laudenslager, 2009; He et al., 2012).

The choice of the type of physical activity during pregnancy depends mainly on the physical capacity of a woman and her individual needs (Šćepanović et al., 2017).

Yoga is one of the exercises that can be, according to the listed benefits (Thakur, Sharma, & Masand, 2015) considered a low intensity activity. By stretching the lung tissue and vagal nervous system, breathing activates the parasympathetic nervous system, resulting in lowering blood pressure, heart rate, and maintenance of saturation (Babbar & Shyken, 2016). Due to the nature of yoga exercise, authors reported no change in fetal heart rate in previous studies (Gavin, Kogutt, Fletcher, & Szymanski, 2020; Polis, Gussman, & Kuo, 2015).

Pilates is an exercise that is in our case considered a moderate activity, however, according to previous studies, should not lead to a change in fetal heart rate or reduced fetal activity (Güder, 2018; Videmšek et al., 2015).

The purpose of the study was to determine the safety of physical activity in physiologically ongoing pregnancy for the fetus when exercise is performed according to recommendations and recent guidelines. We aimed to determine if the pregnant woman's heart rate, saturation, blood pressure, and body temperature increase or even decrease to the safe limit, and how this affects fetal heart rate and its movements during two different exercises (Pilates and Yoga). We hypothesized that after the exercise, the woman's body temperature, heart rate, and blood pressure would increase, and fetal activity would increase. We also predicted a difference in measured parameters between two different forms of exercise and between groups of women, who were active and those non-active before pregnancy.

METHODS

A quasi-experimental pilot study was conducted in which measurements were performed on pregnant women and fetuses. Prior to our experiment, permission for the study was obtained from National Medical Ethics Committee (0120-335/2019/6) to conduct it. Before measurements were performed, pregnant women were informed with the content and purpose

of the research by receiving information leaflet and all participating women voluntarily signed two informed consent forms of which one was kept by participant, and one was kept by research team. All women were informed they could withdraw from the study at any time. Confidentiality was assured to women; the questionnaires and results were coded and only authors knew codes.

Participants

Sample was obtained using purposive sampling. Forty-two pregnant women volunteered to participate in the study, of which only 35 pregnant women met the inclusion criteria. Inclusion criteria were: body mass index lower than 30 kg/m^2, singleton pregnancy, gestational age between 20 and 37 weeks, non-smoking women, healthy women without chronic diseases such as hypertension and diabetes, motor diseases or injuries, cardiac diseases, respiratory diseases, preterm deliveries in previous pregnancies, cervix and isthmus insufficiency or other signs of preterm birth, bleeding, or placenta praevia (American College of Obstetricians and Gynecologists, 2020).

The experiment was conducted in two parts, in which we measured the blood pressure of the pregnant women with a pre-calibrated electronic pressure monitor Beurer medical - BM 44 with a cuff size of 22-30 centimeters, twice 10 minutes before exercise and twice 2 minutes after the end of exercise, as in the PAMELA randomized control trial (da Silva et al., 2017); pregnant women's body temperature using the Sanitas SFT 75 non-contact thermometer 20 minutes before and 10 minutes after the exercise session; pregnant women's heart rate and saturation, using the EDAN H100B/H100N saturator version 2.4, 15 minutes before and 5 minutes after the exercise session. We also measured fetal heart rate 10 minutes before exercise and 2 minutes after exercise using the Huntleigh DMX/SRX portable digital fetal Doppler and estimated the number of fetal movements based on the mother's self-assessment.

A health questionnaire was used to collect pregnancy-related data. It was developed for the purpose of the study. Data on the women's health status were gathered (so that we assured involvement of women with uncomplicated pregnancies), data on exercise from before the pregnancy and its frequency was identified, and the results of the measurements taken were also gathered in the same document. The identity of the women was not revealed, as the questionnaires were coded and anonymized. The experiment was carried out between 20 and 37 weeks of gestation. Measurements were taken during exercises of two different types and intensities: combined exercise (containing elements of Pilates, yoga, and aerobics), which was

a moderate intensity session, and yoga, which was a low intensity session. The participants voluntarily selected the group where they felt relaxed and willing to participate. We worked with four organizations who provide exercise for pregnant women. Both yoga and combined exercise sessions lasted 60-75 minutes and were led by licensed instructors. Each exercise began with a 5 to 10 minute warm up that consisted of relaxed breathing techniques, and simple stretching exercises. Moreover, the exercises were concluded with relaxation techniques, stretching exercises that lasted for approximately 10 minutes. Measurements were taken by midwifery students under the supervision of mentors. Our study lasted from September 2019 to February 2020.

Data analysis

The results obtained were analyzed quantitatively and descriptively. All data obtained were processed using IBM SPSS STATISTICS version 26 (IBM, 2019). Normal distribution was tested using Shapiro Wilk test. For comparison of pre- and post-exercise results, a paired-samples T-test was used when the data were normally distributed; for non-normally distributed data, a Wilcoxon signed rank test with paired samples was used. Between-exercise measures were compared using an independent-samples t-test when data were normally distributed and a Mann-Whitney U-test when data were not normally distributed. A significance of $p < 0.05$ was used for all tests.

RESULTS

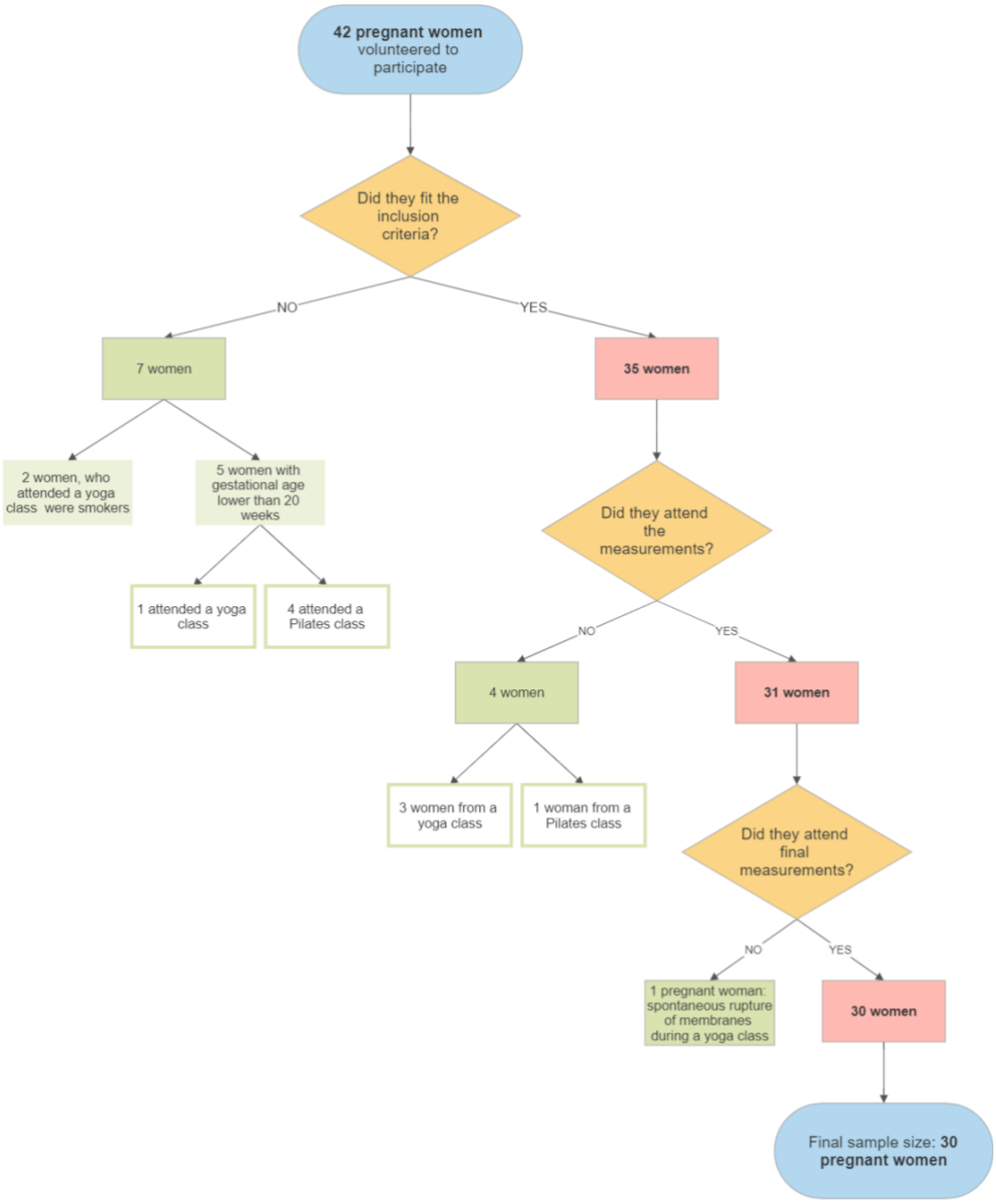
All participating women were Slovenian and were selected using a health questionnaire based on criteria from American College of Obstetricians and Gynecologists (American College of Obstetricians and Gynecologists, 2020). Age of participating women varied from 26 to 42 years (participants characteristics are shown in Table 1), 64,5% of them were primiparas and 35,5% were multiparas.

Table 1. Characteristics of participants.

Characteristics of participants	
Age, mean ± SD (range)	32.8 ± 3.9 (26–42)
Body mass index, mean ± SD (range)	23.6 ± 2.4 (19.5–28 .7)
Employed/unemployed	29/1
Primipara/multipara	20/10
Weeks of gestation, mean ± SD (range)	27.9 ± 5.6 (20–37)
Health issues/no health issues	3/27

Healthy primiparas and multiparas with gestational age above 20 and below 37 weeks were included in our study, as Newton and May (2017) state that the period of maximum linear fetal growth is between 22 and 25 weeks of gestational age. Out of 35 women, 4 pregnant women did not attend for measurements, and 1 pregnant woman did not attend final measurements due to spontaneous rupture of membranes during an exercise session. A total of 30 pregnant women were included in the study (Figure 1).

Figure 1. Flow chart of the study participants.



71% of them were physically active before pregnancy and 29% of them started with physical activity within pregnancy.

The results of measurements of maternal body temperature, pulse, blood pressure, saturation and fetal pulse before and after the exercise are shown in Table 2.

Table 2. Calculated average values, standard deviation and limit values of measurements performed in the experiment.

Variable	Average	Standard deviation	Median	MIN	MAX	Statistical value	p-value
BT before the exercise	36.36	0.26	36.30	36.00	36.90	t = -3.067	0.005
BT after the exercise	36.53	0.30	36.50	36.00	37.10		
SpO_2 before the exercise	99.58	0.81	100.00	97.00	100.00	W = 37.0	0.305
SpO_2 after the exercise	99.74	0.51	100.00	98.00	100.00		
HR before the exercise	79.06	10.56	78.00	62.00	100.00	t = 0.637	0.529
HR after the exercise	77.52	13.05	78.00	57.00	110.00		
BP syst. before the exercise	119.90	10.24	120.00	93.00	140.00	t = 2.917	0.007
BP syst. after the exercise	115.84	9.68	116.00	86.00	133.00		
BP diast. before the exercise	75.97	8.00	76.00	58.00	94.00	t = 1.455	0.156
BP diast. after the exercise	74.59	7.99	76.00	54.00	89.00		
FHR before the exercise	146.03	9.39	148.00	125.00	163.00	t = 0.972	0.339
FHR after the exercise	143.97	9.27	144.00	127.00	163.00		

Abbreviations: MIN – minimum, MAX – maximum, BT – women's body temperature, SpO2 – women's saturation, HR – women's heart rate, BP syst. – women's systolic blood pressure, BP diast. – women's diastolic blood pressure, FHR – fetal heart rate, W - Related-Samples Wilcoxon Signed Rank Test, t - Paired Samples t-test

Using the paired-samples T-test, we found that there were statistically significant differences in body temperature ($p = 0.005$) and systolic blood pressure ($p = 0.007$) before and after exercise was completed. There were no statistically significant differences in the pregnant women's pulse ($p = 0.529$), diastolic blood pressure ($p = 0.560$), and fetal heart rate ($p = 0.339$) data. Based on the related-samples Wilcoxon signed rank test, no statistically significant differences were found in the saturation of the pregnant woman before and after exercise ($p = 0.305$). Fetal movement data were not included in the analysis of the results due to the low reliability of the results. All women with a gestational age of 28 weeks or more (15 women) provided a

subjective assessment of fetal movements. Most of them (80%) described increased or no change in fetal activity after exercise.

Nineteen pregnant women (61%) participated in yoga and twelve (39%) in combined exercise. 33,3% of women who participated in combined exercise and 26,3% of women who participated in yoga were not physically active before pregnancy. Table 3 and 4 shows a comparison of the results of the group that performed yoga and the group that performed combined exercise.

Table 3. Calculated average values, standard deviation and limit values of measurements performed by type of exercise before the exercise.

	Exercise type	Average	Standard deviation	Median	MIN	MAX	Statistical value	p-value
BT before the exercise	Yoga	36.34	0.22	36.40	36.00	36.80	t = -0.337	0.738
	CE	36.38	0.32	36.30	36.00	36.90		
SpO2 before the exercise	Yoga	99.36	0.83	100.00	97.00	100.00	U = 101.0	0.617
	CE	99.50	0.80	100.00	98.00	100.00		
HR before the exercise	Yoga	78.53	11.37	78.00	62.00	100.00	t = -0.352	0.728
	CE	79.92	9.58	78.50	65.00	99.00		
BP syst. before the exercise	Yoga	118.79	9.39	119.00	93.00	132.00	t = -0.756	0.455
	CE	121.67	11.67	122.50	106.00	140.00		
BP diast. before the exercise	Yoga	74.47	7.94	73.00	58.00	86.00	t = -1.325	0.195
	CE	78.33	7.83	77.50	69.00	94.00		
FHR before the exercise	Yoga	146.05	8.75	147.00	125.00	157.00	t = 0.015	0.988
	CE	146.00	10.72	148.50	128.00	163.00		

Abbreviations: MIN – minimum, MAX – maximum, CE ─ combined exercise, BT – women's body temperature, SpO2 – women's saturation, HR – women's heart rate, BP syst. – women's systolic blood pressure, BP diast. – women's diastolic blood pressure, FHR – fetal heart rate, U – Mann Whitney U test, t – Independent Samples t-test

Based on the independent samples T-test, we found no statistically significant differences between yoga and combined exercise in body temperature before exercise (p = 0.738), pulse before exercise (p = 0.728), pulse after exercise (p = 0.103), systolic blood pressure before exercise (p = 0.450), diastolic blood pressure before exercise (p = 0.195), diastolic blood pressure after exercise (p = 0.300), fetal pulse before exercise (p = 0.988), and fetal pulse after exercise (p = 0.399). Using the Mann-Whitney U test, we found no statistically significant differences between yoga exercise and combined exercise in post-exercise body temperature (p = 0.141), pre-exercise satiety (p = 0.617), post-exercise saturation (p = 0.795), and post-exercise

systolic blood pressure (p = 0.110). There were no statistically significant differences between exercise sessions.

Table 4. Calculated average values, standard deviation and limit values of measurements performed by type of exercise after the exercise.

	Exercise type	Average	Standard deviation	Median	MIN	MAX	Statistical value	p-value
BT after the exercise	Yoga	36.45	0.30	36.50	36.00	36.90	U = 150.5	0.141
	CE	36.65	0.26	36.55	36.3	37.1		
SpO2 after the exercise	Yoga	99.97	0.42	100.00	99.00	100.00	U = 107.5	0.795
	CE	99.67	0.42	100.00	98.00	100.00		
HR after the exercise	Yoga	74.47	11.76	76.00	57.00	105.00	t = - 1.682	0.103
	CE	82.33	14.03	80.00	62.00	110.00		
BP syst. after the exercise	Yoga	113.32	9.32	115.00	86.00	131.00	U = 153.5	0.110
	CE	119.83	9.22	120.50	106.00	133.00		
BP diast. after the exercise	Yoga	73.32	8.19	75.00	54.00	89.00	t = - 1.005	0.300
	CE	76.42	7.60	76.00	67.00	89.00		
FHR after the exercise	Yoga	145.11	10.00	144.00	127.00	163.00	t = 0.856	0.399
	CE	142.17	8.07	141.00	133.00	154.00		

Abbreviations: MIN – minimum, MAX – maximum, CE ─ combined exercise, BT – women's body temperature, SpO2 – women's saturation, HR – women's heart rate, BP syst. – women's systolic blood pressure, BP diast. – women's diastolic blood pressure, FHR – fetal heart rate, U – Mann Whitney U test, t – Independent Samples t-test

Nine pregnant women (29%) started physical activity during pregnancy. Most pregnant women were physically active once a week (61%), 29% twice a week and 10% three times a week. Table 5 and 6 shows a comparison of the results between the pregnant women who were physically active before pregnancy and those who were not. Based on the independent samples T-test, we found no statistically significant differences between pregnant women who were physically active before pregnancy and those who were not in pre-exercise body temperature (p = 0.227), post-exercise body temperature (p = 0.179), pre-exercise pulse (p = 0.845), post-exercise pulse (p = 0.828), pre-exercise systolic blood pressure (p = 0.078) , pre-exercise diastolic blood pressure (p = 0.266), post-exercise systolic blood pressure (p = 0.931), post-exercise diastolic blood pressure (p = 0.931), post-exercise diastolic blood pressure (p = 0.600), pre-exercise fetal heart rate (p = 0.395), post-exercise fetal heart rate (p = 0.239) and post-exercise saturation (p = 0.928). A statistically significant difference was observed in pre-exercise satiety (p = 0.041), but the latter represents a highly variable value.

Table 5. Calculated average values, standard deviation and limit values for measurements preformed based on physical activity prior to pregnancy before the exercise.

	Physical activity before pregnancy	Average	Standard deviation	Median	MIN	MAX	Statistical value	p-value
BT before the exercise	YES	36.38	0.26	36.40	36.00	36.90	t = 1.055	0.300
	NO	36.27	0.26	36.20	36.00	36.70		
SpO2 before the exercise	YES	99.51	0.91	100.00	97.00	100.00	U = 135.0	0.124
	NO	100.00	0.00	100.00	100.00	100.00		
HR before the exercise	YES	78.88	11.68	77.50	62.00	100.00	t = 0.021	0.983
	NO	79.06	7.76	78.00	65.00	92.00		
BP syst. before the exercise	YES	118.15	9.95	118.50	93.00	132.00	t = -2.024	0.052
	NO	125.27	9.21	125.50	114.00	140.00		
BP diast. before the exercise	YES	75.17	8.03	74.50	58.00	86.00	t = -1.211	0.236
	NO	78.30	7.68	77.00	70.00	94.00		
FHR before the exercise	YES	145.01	10.60	147.00	125.00	163.00	t = -1.393	0.174
	NO	148.98	4.84	149.50	139.00	155.00		

Abbreviations: MIN – minimum, MAX – maximum, BT – women's body temperature, SpO2 – women's saturation, HR – women's heart rate, BP syst. – women's systolic blood pressure, BP diast. – women's diastolic blood pressure, FHR – fetal heart rate, U – Mann Whitney U test, t – Independent Samples t-test

Table 6. Calculated average values, standard deviation and limit values for measurements preformed based on physical activity prior to pregnancy after the exercise.

	Physical activity before pregnancy	Average	Standard deviation	Median	MIN	MAX	Statistical value	p-value
BT after the exercise	YES	36.49	0.29	36.50	36.00	36.90	t = -1.396	0.173
	NO	36.66	0.32	36.70	36.00	37.1		
SpO2 after the exercise	YES	99.80	0.55	100.00	98.00	100.00	U = 100.5	0.949
	NO	99.81	0.44	100.00	99.00	100.00		
HR after the exercise	YES	76.54	12.78	77.50	57.00	105.00	t = -0.369	0.715
	NO	78.21	14.38	78.00	60.00	110.00		
BP syst. after the exercise	YES	116.23	10.16	115.50	86.00	133.00	t = -0.179	0.859
	NO	116.26	8.94	117.00	104.00	130.00		
BP diast. after the exercise	YES	74.91	8.53	75.50	54.00	89.00	t = 0.080	0.937
	NO	73.98	6.95	76.00	67.00	88.00		
FHR after the exercise	YES	142.48	9.78	142.00	127.00	163.00	t = -1.172	0.251
	NO	147.28	7.53	152.00	135.00	154.00		

Abbreviations: MIN – minimum, MAX – maximum, BT – women's body temperature, SpO2 – women's saturation, HR – women's heart rate, BP syst. – women's systolic blood pressure, BP diast. – women's diastolic blood pressure, FHR – fetal heart rate, U – Mann Whitney U test, t – Independent Samples t-test

DISCUSSION

We aimed at identifying the impact of low to moderate exercise in pregnancy on maternal and foetal vital signs and estimate whether the pre-pregnancy physical activity affects these changes. There was an increase of 0.17°C in the body temperature of the pregnant women after exercise. Body temperature at the end of exercise did not exceed 37.1°C, indicating that it was at least 1.9°C below the teratogenicity threshold (Miller et al., 2002). The temperature increase during low or moderate intensity exercise was within normal limits and did not pose a threat to fetal health, which is consistent with the study findings of Ravanelli and his colleagues (Ravanelli et al., 2019).

Researchers (Perales Santaella et al., 2015; Santos et al., 2016) describe a linear relationship between exercise intensity, heart rate, and blood pressure in pregnant women. The more intense the exercise, the more likely it is to increase a pregnant woman's heart rate and blood pressure

(Santos et al., 2016). Our research showed conflicting results. When analyzed, a decrease of 4.06 mmHg in systolic blood pressure was found after exercise, which can be attributed to the intense relaxation at the end of each exercise. This confirms the positive effects of exercise in hypertensive disorders during pregnancy. No statistically significant differences were found in the heart rate, diastolic blood pressure and saturation of the pregnant women when comparing the data from before and after physical activity.

Fetal activity or maternal perception of fetal movements is more intense after the cessation of a physical exercise. Any exercise, even low intensity exercise, results in increased fetal activity and respiratory movements. The hormonal cascade triggered by exercise also improves maternal perception of fetal movements (DiPietro et al., 2009; He et al., 2012). Increased fetal activity has been described in women with elevated levels of cortisol in saliva after the exercise (DiPietro et al., 2009). Pregnant women who are regularly physically active perceive fetal movements better (Sheikh, Hantoushzadeh, & Shariat, 2014). During the experimental work, we obtained a subjective assessment of fetal activity from the participants, which is consistent with the results of the above-mentioned authors.

Yoga is a low intensity exercise, but when combined with other exercises, the intensity is moderate. One of the participants, who was 39 weeks pregnant, experienced a spontaneous rupture of membranes during a yoga session. This could be a consequence of the exercise itself, but since it happened during relaxation within the first 5 minutes of the session, this connection could be accidental. A few researchers describe lower heart rate and blood pressure in a pregnant woman and unchanged fetal heart rate when performing yoga (Babbar & Shyken, 2016; Gavin et al., 2020; Polis et al., 2015), while others describe an increase in heart rate in the pregnant woman and fetus when performing moderate intensity exercise (Moyer & May, 2014). Although our study was conducted at two different intensity levels, there were no statistically significant differences in the vital signs of the pregnant woman and the fetus. The results obtained may be attributed to the intense relaxation and deep breathing at the end of the exercises, as researchers have not described exercises with relaxation included in other studies. The stretching of the lung tissue and vagal nervous system activates the parasympathetic nervous system, resulting in a decrease in blood pressure and heart rate in the pregnant woman and an unchanged fetal heart rate and woman's saturation (Babbar & Shyken, 2016; Gavin et al., 2020), which might have an influence on our results.

Velloso and colleagues (Velloso et al., 2015) found that fetal heart rate increases by 10-30 beats/minute during exercise, which was not confirmed in our study. Fetal heart rate may be increased by increased maternal body temperature, which was minimal in our case and therefore may not have affected fetal heart rate. No statistically significant differences were observed between exercises at two different intensities. The reason for the discrepancy between our results and the findings of other researchers may be that the measurements were taken immediately after intense relaxation. Even if the fetal heart rate increased during exercise, it was expected to return to normal after two minutes.

Our study included both pregnant women who were physically active before pregnancy and those who were not. The literature review showed that pregnant women who were physically active before pregnancy had lower blood pressure and were more physically prepared (Bø et al., 2016). Despite the increased endurance of active women, the guidelines, and recommendations for exercise in pregnancy (American College of Obstetricians and Gynecologists, 2020; Videmšek et al., 2015) are designed for the general population. Recent research (Bø et al., 2016) predicted lower level of maternal heart rate (VO_{2peak} is higher in pregnant women) for pregnant women who were active before pregnancy compared to pregnant women who were not, but analysis of our results found almost no statistically significant differences. Only a difference in saturation before exercising was found, with physically inactive women having 0.49% higher saturation compared to active pre-pregnancy women. The obtained result could be due to three reasons: a relatively small sample size in which physically inactive pre-pregnancy women constituted only a small proportion; low intensity of exercise, which had no significant effect on women's vital signs; and high variability of the measured value - saturation, as it is constantly changing.

Study limitations

During the study, we encountered certain limitations. Due to the small groups of pregnant women in the exercise courses, our sample size was small. If more pregnant women participated, the evaluation of the observed parameters would be more accurate. Therefore, sample should consist of at least 60 to 90 pregnant women (Perales Santaella et al., 2015; Santos et al., 2016). For more reliable, accurate results and non-invasive measurements, body temperature should be measured using a different type of thermometer (Ryan-Wenger, Sims, Patton, & Williamson, 2018). The aim should be to asses the body-core temperature Fetal heart rate should be monitored by recording a 20-minute cardiotocograph before and after exercise,

as dos Santos and colleagues did in their cross-sectional study (Santos et al., 2016). This would more accurately assess fetal heart rate and detect the possible presence of accelerations or decelerations. Pregnant women were given written and verbal instructions how to record fetal movements two hours before and after exercise along with a nationally established chart. The instructions were given at the exercise session before the scheduled time for the measurements. Some women forgot to count the movements, some came unannounced to the exercise, and some did not come for the measurements. Therefore, after the exercise, we only asked the participating women whether they usually found the fetus more, less, or similarly active than 2 hours before the exercise. It would be useful to monitor fetal activity more precisely, by encouraging women to count fetal movement using national fetal movement count chart, to determine the difference in perception of fetal movements before and after the exercise and to determine differences between prenatally physically active and inactive pregnant women. Another recommendation for future studies would be also that the exercise sessions are conducted by researchers to ensure direct contact with the women involved, have better control over the information given to participants using their direct contacts, so it would be easier to give instructions and remind them of additional tasks, important for the study. A larger study would require professional measuring equipment (such as a cardiotocograph), space, more people and longer periods of time, which would consequently mean a larger financial outlay.

Implications for practice and/or policy

Although the study found no differences between physically active and inactive pregnant women, it would be useful to have separate guidelines and recommendations for exercise for these two groups. We believe that physical activity is rarely recommended in pregnancy, which was evident in our study, as groups of exercising pregnant women were very small in all participating organizations, therefore we assume only few pregnant women are given health advice to join organized physical activity. More emphasis should be placed on promoting physical activity in pregnancy and women should be referred to qualified instructors for physical activity in pregnancy. The development of materials with exercises that improve the most common pregnancy complaints, such as lower back pain, would be useful. An online platform could also be created with video content, written instructions, or even online exercises (30-60 minutes of exercise) that pregnant women could do at home. This would encourage them to exercise even when staying at home is advised, such as in times of the current pandemic.

CONCLUSION

The results of this pilot experimental study suggest that moderate physical activity, such as yoga or combined exercise that incorporates elements of other types of exercise, do not impair the vital functions of the pregnant woman or fetus to such an extent that it could pose a risk to the fetus. The increase in maternal body temperature was minimal, however it has to be taken into consideration that we did not use the equipment to measure body-core temperature. Maternal heart rate, fetal heart rate and maternal saturation remained unchanged. Based on our findings, we could assume that physically activity could be safe for women with uncomplicated pregnancies. However, due to a relatively small sample size and the method of this study, further studies are needed on a larger sample size, such as randomized controlled trials, with more sophisticated measuring equipment to confirm these results.

There were no differences found between active and inactive women before pregnancy, probably because the measurements were performed after the intensive relaxation at the end of the training. More studies with measurements of vital signs, directly after the exercises, might confirm the differences between those two groups. In case of sedentarism in preconception period, physical activity should be introduced with individual adjustments and gradually, before larger study does not confirm safety.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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