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The effects of a physical exercise program on fetal well-being and intrauterine safety

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ABSTRACT

Objectives: The aim of this study was to evaluate the effects of a supervised physical exercise program on fetal well-being and intrauterine safety. Physical activity is recommended for healthy pregnant women. However, constant evaluation of fetal condition and development is recommended to ensure the safety of the exercise program.

Material and methods: Randomized control trial study design. Sixty-six healthy pregnant women (age 24–35) with singleton gestation were randomly assigned to either an exercise group (EG, n = 34) or a non-active control group (CG, n = 32). The exercise program included 81 sessions (moderate intensity, 3 times per week, 50–60 min/session from weeks 13 to weeks 40/41 of pregnancy). Fetal well-being was assessed in weeks 32 and 37 of pregnancy. The cerebroplacental ratio (CPR) was calculated to evaluate the safety of the exercise program for the fetus.

Results: The differences in the CPR ratio measurements between EG and CG groups in week 37 ($p < 0.05$) were observed. The increase in the CPR ratio was also shown in week 37 of pregnancy in comparison to week 32 ($p < 0.01$). Moreover, maternal heart rate was significantly lower in the exercise group as measured at 37 weeks ($p < 0.05$).

Conclusions: The results of this study confirm that regular and supervised exercise program throughout pregnancy does not affect fetal well-being and is safe for the fetus. Additionally, regular physical activity improves maternal physical fitness and cardiac efficiency which might aid at preparing pregnant women for natural labor.

Key words: pregnancy; physical activity; regular exercise program; fetal safety; cerebroplacental ratio

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INTRODUCTION

Pregnancy is a period in a woman's life when intense changes in her body occur. This requires continuous surveillance of both maternal and fetal well-being. Constant evaluation of uterine blood flows allows for the assessment of fetal health, development, and intrauterine safety [1]. The surveillance of fetal well-being is maintained through a detailed evaluation of blood flow velocity waveforms during noninvasive Doppler ultrasound examinations [2]. It is usually carried out throughout pregnancy, beginning from the end of the first trimester [3].

To determine fetal well-being or distress more accurately, cerebroplacental ratio (CPR) is used. CPR is defined as the ratio of middle cerebral artery pulsatility index (MCA-PI) and the umbilical artery pulsatility index (UA-PI) [3]. CPR ratio is considered as a better indicator of hemodynamic changes and the cardiac output redistribution in the fetus, than the MCA-PI and UA-PI measurements alone [4]. CPR ratio is predictive for fetal health even in cases where the vascular resistance of the umbilical circulation seems to be normal [4]. CPR ratio below 1.04 might be symptomatic of centralization of fetal circulation, known as the brain-sparing effect, in which the blood is redistributed to the organs potentially most vulnerable to hypoxia, namely fetal central nervous system, heart, and adrenal glands [3, 5]. CPR is also considered as more accurate at indicating the potential fetal hypoxia (as compared to the MCA-PI and UA-PI measurements alone) and generally correlates with

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potential perinatal risks. Moreover, it is indicative of a slight increase in placental resistance and a slight reduction in fetal cerebral resistance [3]. In routine clinical care, CPR is potentially the most indicative parameter of fetal intrauterine growth restriction (IUGR) or small-for-gestational-age fetuses (SGA) [6].

Fetal well-being may be associated with numerous lifestyle interventions. One of those interventions is physical exercise adapted specifically for pregnant women [1]. A training program should be individually designed and supervised by a qualified exercise specialist [1, 7]. According to American College of Obstetricians and Gynecologists (ACOG) guidelines [1], the recommendation for pregnant women is to engage in physical activity for at least 20–30 mins/day with moderate intensity, on most (if not all) days of the week. However, ACOG emphasizes the lack of unequivocal data in the literature presenting the influence of regular exercise programs on fetal well-being, to assess the redistribution of oxygen, carbon dioxide, and nutrients through the placenta [1].

Several studies considered the influence of physical exercise on fetal well-being based upon a single bout of dynamic, submaximal exercise (usually cycle ergometer) [8–11]. The evaluation of individually advised regular exercise programs during pregnancy and their influence on maternal and fetal well-being in literature is still scarce [12–15]. To determine its safety, current and future research evaluating regular physical activity throughout pregnancy should include a multidimensional approach, examining intensity, duration, and type of exercises used as well as their influence on maternal and fetal blood flow measurements.

Objectives

The aim of this study was to evaluate the effects of a supervised and specifically designed complete physical exercise program on fetal well-being and intrauterine safety.

MATERIAL AND METHODS

Participants

Eighty women with uncomplicated pregnancies were enrolled in this randomized controlled trial. Out of those, fourteen resigned because of personal reasons, before the start of the exercise program. Sixty-six healthy pregnant women (age 24–35 years), with no contraindications to exercise [1], and no clinical signs of IUGR or genetic defects, assessed at 11–14 weeks gestation [2], were finally included in this study. After providing informed written consent, eligible participants were randomly assigned to either the exercise group (EG, n = 34, mean age 27.55 ± 1.70) or non-active control group (CG, n = 32 mean age 27.55 ± 1.70). Women in the EG group, after the initial prenatal Doppler examination at weeks 11–14 [2], took part in an exercise program entitled 'Conscious 9 months'. The exercise program was initiated at 13 weeks gestation and continued until 40–41 weeks gestation. The CG group consisted of randomly assigned 32 healthy pregnant women. All participants also received routine prenatal care throughout pregnancy and were instructed not to participate in any other exercise programs. This study protocol was approved by the Bioethical Committee at the District Medical Chamber in Lublin, Poland. All the women were informed about the aims of the study and that they may discontinue the program at any time. Demographic characteristics of all the participant are presented in Table 1.

Table 1. Characteristics of both the exercise and the control groups

Groups	EG (34)	CG (32)
Maternal age, y	27.18 ± 1.72	27.55 ± 1.70
Maternal BMI kg/m^2	21.5 ± 0.5	23.4 ± 1.23
Maternal body weight before birth [kg]	73.5 ± 3.8	78.9 ± 9.6
Week of delivery	39.8 ± 0.4	38.7 ± 1.6
Type of delivery N*/C*	32/2	18/16
Birthweight, g	3487 ± 315	3468 ± 425
Apgar Score (0–10)	9.94 ± 0.348	8.84 ± 1.04

EG — exercise group; CG — non-active control group; *N — normal delivery; *C — Cesarean delivery

Exercise program

The exercise program included three 50–60 minutes training sessions per week (Monday, Wednesday, Friday). A total of 81 sessions were conducted. Adherence to the program in the EG was exceedingly high, with thirty-two out of thirty-four participants taking part in 100% of the training sessions. The remaining two participants missed only 1 (98.8%) and 2 sessions (97.5%) respectively. Hence, the overall adherence to the exercise program was 99.9%.

Program intensity was moderate, with heart rate (HR) consistent between 100–145 beats per minute (individually advised). Women's HR was monitored during the training sessions, using HR monitor Polar M400, with a range of 15–240 bpm.

All training sessions included a warm-up (100–125 HRmin), core exercises (125–145 HRmin) and a cool down period (90–110 HRmin), which are described in detail in Table 2. Overall, all the sessions included breathing and relaxation techniques, antithrombotic exercises, strengthening exercises, stretching, pilates elements, and pelvic floor exercises.

To ensure maximum safety for both the mother and her fetus, all training sessions included 4–6 participants only, supervised by a qualified prenatal physical activity specialist (who was also the author of the program). Additionally, support from prenatal specialists, such as an obstetrician, a midwife, and a physiotherapist, was available to women at all times.

Table 2. An example session of the 'Conscious 9 months' exercise program

	EXERCISES	NOTES
Preparatory part *Warm-up 10–12 mins*	Sitting on the ball: — finding the correct position — spine mobility exercises — short sequence: marching, step touch, side lunge, forward lunge	Exercise ball of the right size Bare feet Both sides
Dynamic stretching y 2–3 mins (8–12 repetitions)	Forward lunge: dynamic leg stretching From sitting on a ball (wide-legged): — lunge side stretches — spine rolls (up and down)	Gentle stretching — both sides
Main part *20–25 mins* *(repetitions: individually advised, suggested 6–12)* *(repetitions: individually advised, suggested 6–12)*	Strengthening exercises on the ball (various positions): In sitting: — squats and arm circles — marching with spine rolls — wide-legged sit: 'crushing' the ball — sitting with legs in front: lifting one foot at a time and holding In lying on the back: — lifting the hips — lifting the hips and heels In lying on the side: — kneeling: opening and closing the chest (thoracic spine mobilization) with breathing coordination On hands and knees: — lifting the legs — press-ups — lifting the arms, arm circles	Strengthening exercises for main muscle groups, intertwined with breathing exercises and exercises for spine mobility Maintaining breath awareness As a variation: introducing balancing element Both sides in all asymmetrical exercises
Finishing part *Stretching and relaxation* *12–15 mins* *(6–8 repetitions)*	Sitting on the knees, transitioning to kneeling Kneeling with one leg straight: hip flexors stretching Wide-legged seated forward bend Cross-legged seated forward bend and opening the arms backward — chest opening Relaxation Lying supine on a medium soft ball, next to a wall, feet together, knees open	Both sides in asymmetrical exercise During relaxation, blankets or cushions under the knees Relaxing music In relaxation, the participants are covered with blankets

Fetal well-being

Fetal well-being assessment included blood flow velocity measurement obtained by a VOLUSON 730 EXPERT color Doppler ultrasound system. Prenatal examinations were carried out in weeks 11–14 of gestation [2]. Fetal Doppler examinations were performed in both groups in weeks 32 and 37 and included the assessment of the pulsatility index (PI) in the middle cerebral artery (MCA) and in the umbilical artery (UA). This allowed for completion of a quantitative analysis of fetal blood flow velocities and resistance, as well as calculation of the CPR.

In the method used, the speed of blood flow is characterized by several indicators which express the level of pulsation of the curve of blood flow. Those indicators are based on the maximum Doppler wave shift of the blood flow in one cycle of a heartbeat. They express maximum speed in the systolic and diastolic phases of a heartbeat.

Doppler examinations were carried out according to the recommendations of the Fetal Medicine Foundation (FMF) [16] and the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) [17].

Additionally, fetal heart rate (FHR) and resistance index (RI) were measured.

Statistical analysis

The data are presented as group mean values ± standard deviation (SD). The data were tested for normality of distribution using the Shapiro-Wilk test. A two-way (group x time) repeated measurement ANOVA with Tukey post-hoc adjustments was used to compare the changes in the dependent variables inside the groups over the intervention period. Statistical significance was set at $p < 0.05$. Statistica vs 13.1 program was used for all calculations.

RESULTS

Mean ± SD values were measured in 32 and 37 weeks (Tab. 3). A significant interaction was observed as follows: group (EG, CG) x time (32 and 37 weeks), CPR ($F_{1,66} = 7.05$;

Table 3. CPR values (mean ± SD) in the exercise group and the non-active control group

Group	CPR 32 week	CPR 37 week
EG	1.78 ± 0.34	2.08 ± 0.52*^
CG	1.80 ± 0,33	1.71 ± 0.66

CG — control group; CPR — cerebroplacental ratio; EG — exercise group; *statistical difference between the EG and CG ($p < 0.05$); ^statistically different from the value at week 32 ($p < 0.01$)

Table 4. MCA PI values (mean ± SD) in the exercise group and the non-active control group

Group	MCA PI Week 32	MCA PI Week 37
EG	1.86 ± 0,27	1.63 ± 0.34*^
CG	1.91 ± 0,27	1.42 ± 0.37

CG — control group; EG — exercise group; *statistical difference between the EG and CG ($p < 0.05$); ^statistically different from the value at week 32 ($p < 0.01$)

Table 5. MCA RI values (mean ± SD) in in the exercise group and the non-active control group

Groups	MCA RI Week 32	MCA RI Week 37
EG	0.83 ± 0.05	0.79 ± 0.08*^
CG	0.84 ± 0.05	0.74 ± 0.10

CG — control group; EG — exercise group; *statistical difference between the EG and CG ($p < 0.05$); ^statistically different value from the value at week 32 ($p < 0.05$)

Table 6. UMBA PI values (mean ± SD) in the exercise group and the non-active control group

Groups	UMBA PI Week 32	UMBA PI Week 37
EG	1.05 ± 0.18	0.79 ± 0.09
CG	1.10 ± 0.18	0.88 ± 0.23

CG — control group; EG — exercise group

Table 7. UMBA RI values (mean ± SD) in the exercise group and the non-active control group

Groups	UMBA RI Week 32	UMBA RI Week 37
EG	0.64 ± 0.08	0.57 ± 0.07
CG	0.68 ± 0.08	0.59 ± 0.11

CG — control group; EG — exercise group

Table 8. HR values (mean ± SD) in the exercise group and the non-active control group

Groups	FHR Week 32	FHR Week 37
EG	138.33 ± 8.51	136.45 ± 6.86*^
CG	142.57 ± 6.27	147.43 ± 7.35

CG — control group; EG — exercise group; FHR — fetal heart rate; *statistical difference between the EG and CG ($p < 0.05$); ^statistically different value from the value at week 32 ($p < 0.05$)

$p < 0.01$, $\eta p2 = 0.097$), $\eta p2 = 0.097$. The CPR cerebroplacental ratio difference was statistically significant between EG and CG groups at 37 weeks ($p < 0.5$). Moreover, CPR increased in week 37 as compared to week 32.

Moreover, a significant interaction was observed between groups (EG, CG) x time (32 and 37 weeks), MCA PI ($F_{1,66} = 5.60$; $p < 0.05$, $\eta p2 = 0.078$). The MCA PI parameter difference was statistically significant between EG and CG groups at 37 weeks ($p < 0.05$), which can be seen in Table 4.

There was also another significant interaction observed as follows: group (EG, CG) x time (32 and 37 weeks), MCA RI ($F_{1,66} = 6.52$; $p < 0.05$, $\eta p2 = 0.089$). The MCA RI parameter difference was statistically significant between EG and CG groups at 37 weeks ($p < 0.05$), which can be seen in Table 5.

Furthermore, there was no significant interaction between groups (EG, CG) x time (32 and 37 weeks), in UA-PI ($F_{1,66} = 0.86$; $p > 0.05$, $\eta p2 = 0.012$). The UA-PI parameter difference was not statistically significant between EG and CG groups at 32 and 37 weeks ($p > 0.05$), which can be seen in Table 6.

There was also no significant interaction between groups (EG, CG) x time (32 and 37 weeks), in UA-RI ($F_{1,66} = 1.33$; $p > 0.05$, $\eta p2 = 0.019$). The UA-RI parameter difference was not statistically significant between EG and CG groups at 32 and 37 weeks ($p > 0.05$), which can be seen in Table 7.

In addition, a significant interaction was observed as follows: group (EG, CG) x time (32 and 37 weeks), maternal HR ($F_{1,66} = 7.34$; $p < 0.05$, $\eta p2 = 0.100$). The HR parameter difference was statistically significant between EG and CG groups at 37 weeks ($p < 0.05$), which can be seen in Table 8.

DISCUSSION

The aim of this study was to evaluate the effects of a regular complete physical exercise program in the course of pregnancy on fetal well-being and intrauterine safety. To assess fetal well-being and safety, Doppler examinations were used, allowing for non-invasive evaluation of fetal hemodynamic changes and the degree of flow resistance [6, 18–21].

The results of this study present that during 27 weeks of this experiment, neither fetal hypoxia, growth retardation, placental exchange nor amniotic fluid volume abnormalities were observed in any of the fetuses, which is consistent with previous research [22–24]. The results of this trial are in accordance with the results of other studies, presenting that regular moderate physical activity program in pregnancy is not posing any health risks neither to the mother nor to the fetus [1, 12–15].

The results confirm no adverse influence of physical exercise on fetal well-being both in weeks 32 and 37. In week 32 the CPR ratio was within its normal range in both groups, which indicates that maternal physical exertion as part of the exercise program had no effect on the fetus. Similarly, in week 37, the CPR ratio was also within norms, showing no adverse effect on fetal health. Importantly, CPR is seen to be a more effective parameter of fetal hemodynamic changes, as well as the cardiac output and blood flow redistribution of the fetus, than the MCA-PI and UA-PI measurements alone [4]. Several other studies assessed fetal well-being based upon the above-mentioned parameters alone, which defines the vascular resistance in the progress of blood flow, measuring this flow in the tested vessel [11, 25–27], which is not as accurate.

In this field, some studies are based on surveys and questionnaires in which pregnant women evaluate their physical activity subjectively [14, 28, 29]. Clearly, this method has clinical limitations. Moreover, the choice of exercises (their intensity, duration, and type) to determine physical activity's influence on a woman's body, still remains to be examined in further studies [11, 30]. Little data is available on physical activity in the course of pregnancy.

Barakat et al. [12] suggested that more research is needed on specifically designed regular exercise programs, including exercise guidelines and safety.

Fetal well-being assessment for this study included blood flow velocity measurements obtained by a color Doppler ultrasound system. UA and MCA were examined. The analysis of blood flow was based on the shape of the Doppler wave shift and the assessment of the PI in the MCA and in the UA.

The results show there was a slight decrease in both the MCA-PI and MCA-RI parameters, which are normal physiological mechanisms in an uncomplicated pregnancy. Hence, in both groups in weeks 32 and 37, this decrease was comparable and within a normal range.

The exercise program did not significantly influence fetal umbilical artery flow parameters. In weeks 32 and 37, the PI and RI parameters did not differ significantly or clinically in both exercise and control groups. Additionally, the dynamics of PI and RI decrease was comparable in both groups and was within normal range with the progression of pregnancy.

All of those further confirm that the exercise program did not adversely affect the fetus, as examined by Doppler ultrasound.

Additionally, the described regular exercise program had a positive effect on maternal HR in week 37. HR was significantly lower in the exercise group, which is not in line with the current research [31–35]. This result can indicate general improvement of maternal physical fitness and cardiac efficiency. It might also serve as an important factor in preparation for normal labor.

The innovation of this study, next to the use of CPR ratio, lies also in the intervention used. The exercise program was complete and rounded, included various elements, not generally available to pregnant women in routine care. Moreover, the program was individually designed, aimed at preparing women towards labor and led by an experienced prenatal exercise specialist, who continually communicated with medical personnel, ensuring maximum safety for both mother and fetus. This also had its impact on ensuring an exceedingly high adherence of the participants to the exercise program.

CONCLUSIONS

The results of the current experiment confirm that the specifically designed regular exercise program 'Conscious 9 months' (taking into consideration specific types, intensities, and duration parameters) does not pose a risk to fetal well-being and is safe for the fetus.

Additionally, the program described positively affected maternal HR in the exercise group, indicating potentially improved maternal physical fitness and cardiac efficiency, which may significantly influence normal labor.

Conflicts of interest

The authors declare that they have no competing interests, financial or otherwise.

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