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Original article

# The effects of physical activity on some physiological indices of mother and neonate

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## Abstract

**Background:** Physical activity can bring about more favorable health results for both mother and neonate.

**Objectives:** The purpose of this study was to investigate the effect of physical activity on some physiological indices of mother and neonate.

**Design and methods:** In this *ex post facto* study, 60 pregnant women (age 26.9 ± 4.0 years, height 161.8 ± 5.2 cm and weight 63.0 ± 4.9 kg) were selected from health centers and private clinics in Shiraz, Iran. Based on the score obtained from completion of a physical activity questionnaire during pregnancy, the participants were classified into 4 groups: 1) active, 2) inactive, 3) becoming active, and 4) becoming inactive. The maternal type of delivery, body weight and body fat percentage, as well as the neonatal birth weight and height and Apgar score at 1 and 5 minutes, were measured. To analyze the data, a one-way ANOVA and Tukey's post hoc test were used at the level of $p \leq 0.05$.

**Results:** The mean weight gain in pregnant women in the active group was significantly lower than that of the inactive group ($p \leq 0.05$), but there was not a significant difference between the becoming active and becoming inactive groups ($p > 0.05$). Participation in physical activity does not affect the body fat percentage and type of pregnancy in pregnant women ($p > 0.05$). Additionally, participation in physical activity does not have a significant effect on the neonate's growth and health ($p > 0.05$).

**Conclusions:** It seems that although the participation of pregnant mothers in physical activity is associated with a lower weight gain in

pregnancy, there is no significant effect on other physiological indices of mother and neonate.

### Keywords

Pregnant, physical activity, mother, neonate.

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### Introduction

During pregnancy, normal metabolic processes are adapted to meet the growing needs of the embryo. The protein content of the tissues increases and the carbohydrates accumulate in the liver, muscles and placenta. Therefore, one of the most prominent changes in pregnancy is maternal weight gain [1]. The normal body mass index (BMI) and appropriate weight in pregnancy are important for the safety, protection and promotion of the health of mothers and neonates, and can bring further beneficial health results for both mother and infant [2]. However, researchers have found that obesity and overweight in pregnancy are associated with complications such as high blood pressure, diabetes, pre-eclampsia, polytoky, macrosomia, cesarean section, abnormal presentation of the fetus, midwifery bleeding, postpartum thrombophlebitis, urinary tract infection, abnormal labor, dystocia of the shoulder, severe perineal rupture, and perinatal asphyxia [2]. It has been suggested that, in women who have a healthy pregnancy, following a mildly intense exercise program promotes maternal health and does not bring about harm to the growing fetus. Physical activity is also associated with a reduced risk of overweight in pregnancy [3]. However, pregnant women typically choose to lead a sedentary lifestyle [4].

Various studies [5-8] have been conducted in different countries into the rate of participation of pregnant women in physical activity. In this regard, a study on a group of healthy women in Ireland showed that only 21.5% of women implemented current recommendations for physical activity during pregnancy [5]. In Brazil, information suggested that only 4.7% of pregnant women were active throughout pregnancy, and 12.9% of women reported undertaking physical activity during some pregnancies [6]. Many pregnant women are willing to start or continue their exercise during pregnancy, but there are consequences such as preterm labor [6] or weight loss during pregnancy [7]. One study reported that women who undertook 24 sessions of exercise during the pregnancy lost body weight after delivery [8].

The results of other studies indicate neonates losing weight at birth time [9, 10]. However, some studies have shown that exercise during pregnancy has no effect on birth weight [11, 12]. Growth of the embryo [13] and a lack of change in fetal growth have equally been reported following the physical activity of mothers [14]. In addition, a few studies have evaluated the effect of exercise on the Apgar score. The Apgar score is a tool used by health care providers to assess the adaptation of neonates to the ectopic environment [15]. The Apgar score is usually evaluated at 1 and 5 minutes after birth, and characterizes the neonate's color, heart rate, reflexes, muscles and respiration sensitivity. The Apgar score is not correlated with long-term outcomes of neonate growth [16]. In one study, the Apgar scores in the first and fifth minutes were higher in the group of mothers who had exercised [17], while in another study, there was no difference in the mean Apgar score at 1 minute or 5 minutes between the mothers who had exercised and those who had not [18]. The importance of sports activities in the physical and mental health of people in the community is well known and is recognized as an integral part of mental health. Paying attention to women's sports during pregnancy as a major part of society is considered necessary regarding their physiological needs. Indeed, physical activity through increased plasma volume of the mother and fetus, cardiac output, and uterine-placental-embryonic blood flow can affect fetal growth.

The effects of exercise during pregnancy have been widely studied, but despite extensive resources regarding the implications of maternal athletic performance during pregnancy, there is not enough evidence on the significant effect of physical activity and its implications on mother and fetal growth. Therefore, since the effect of

physical activity on some of the physiological indices of mother and neonate is still not clear, the present study intends to determine the type of delivery, birth weight and height of the neonate at birth of the women who carry out physical activity on a regular basis in comparison with inactive women. The aim of this study is to investigate the effect of physical activity on some physiological indices of mother and neonate.

## Materials and methods

In this *ex post facto* study, 60 pregnant women (age 26.9 ± 4.0 years, height 161.8 ± 5.2 cm, weight 63.0 ± 4.9 kg, and pregnancy period 39.2 ± 1.2 weeks) from health centers and private clinics in Shiraz, Iran, were selected according to inclusion and exclusion criteria, and based on their physical activity, were assigned into 4 groups: 1) active, 2) inactive, 3) becoming active and 4) becoming inactive. The sample size was determined based on the results of Clapp's study (1990) on the mean weight of neonates and based on the results of previous studies [19]. The criteria for inclusion into this study were 17-week gestational age, singleton pregnancy, a healthy water bag, and the absence of conditions such as previous cesarean delivery leading to cesarean section. Exclusion criteria comprised the prohibition of exercise in pregnancy (due to diseases such as severe anemia, diabetes, epilepsy, respiratory problems, cardiovascular disease, obesity or excessive weight loss, hypertension, skeletal congestion, and hyperthyroidism), history of female diseases and pregnancy (cervical failure, history of infertility, pregnancy hemorrhage, placenta previa), and smoking.

Following the study of Borodulin et al. (2008), a pregnancy physical activity questionnaire was used to assess the physical activity of women during pregnancy. In this questionnaire, the first few questions included information on individual characteristics, while the other questions assessed the womens' physical activity. Out of 32 questions related to the assessment of physical activity, 13 related to home/care activities, 5 to occupational activity, 8 to exercise/training activities, 3 to transportation activities, and 3 to inactivity. The questionnaire output included the duration of the activity per week (h • $wk^{-1}$) and average energy consumption per week (metabolic equivalent [MET] h • $wk^{-1}$) for each activity. To calculate the average energy consumed per week (MET h • $wk^{-1}$), the time spent for each activity was multiplied by the intensity of MET of that activity [20-22]. Depending on the type of activity (home/care, occupation, and exercise/training), the average number of MET hours per week could be calculated for each type of activity [21]. Based on the questionnaire results for pregnancy in weeks 17-22 and 27-30, pregnant women were classified into 4 groups: 1) active (pregnant women who in the second and third trimester of pregnancy gained the recommended score), 2) inactive (those who did not reach the recommended score in the second and third trimester of pregnancy), 3) becoming active (those individuals inactive during the second trimester who started physical activity in the third trimester), and 4) becoming inactive (pregnant women who stopped physical activity between the second and third trimester of pregnancy) [22].

The women were categorized by whether they reached the recommendations for physical activity, based on the guidelines by the American College of Obstetricians and Gynecologists (ACOG), the Centers for Disease Control and Prevention (CDC), and the American College of Sports Medicine (ACSM). The ACOG and CDC/ACSM guidelines suggest 30 minutes or more of moderate intensity activity on most days of the week, but they differ on the type of activity, as the ACOG recommends exercise only and the CDC/ACSM recommends any type of physical activity. The ACSM's recommendation includes any type of activity that is vigorous and is carried out for at least 20 minutes, 3 times per week [22]. The recommended level of activity was less than 5 sessions per week or less than 150 minutes per week of physical activity for any activity with an absolute intensity of 4.8 to 7.1 MET. The physical activity questionnaire took approximately 15 to 20 minutes to complete.

In this study, the weight and height of the participants were evaluated with minimum clothing and no shoes. To assess the body fat percentage of mothers, skinfolds were assessed in four areas (triceps, subscapular, suprailiac and thigh skinfolds) with a caliper every 6 weeks starting at 16 weeks of gestation. All skinfolds from the right side of the body in standing position were evaluated based on the standard ACSM method. All measurements were made twice and to 0.2 mm error. If two measurements had more than 0.2 mm error, a third measurement was made to ensure accuracy. The total mean of the skinfold of the four points was inputted into the Durnin

equation to calculate the body density. The body density was then inputted into the formula for calculating the Siri body fat percentage to determine the percentage of body fat in pregnant women [23].

As for neonatal information, birth weight (g), birth height (cm), as well as the Apgar score of the first and fifth minutes were collected from birth records after gaining consent from the mother. The birth weight of the neonate during the first 12 hours of the birth, without any covering, was measured using a baby weight scale. The birth weight of the neonate at birth was 2,500 to 4,000 grams and the average was 3,400 grams.

The Apgar score is a grading system that is used to assess the health of the neonate in the first minutes after delivery. Overall, the higher the Apgar score is, the better the neonate's condition; therefore, a healthy infant's Apgar score ranges from 7 to 10, an Apgar score between 4 and 6 indicates the infant likely needs medical assistance, and a score between 0 to 3 reflects serious health problems. The ponderal index (PI, g/cubic centimeter), as an index of a neonate's weight loss that is similar to the adult BMI, was calculated using the following formula [24]:

$$PI = (\text{weight [g]} \times 100) / \text{height (cm)}^3$$

Finally, the results of the research were analyzed using the Kolmogorov-Smirnov test and one-way ANOVA with Tukey's post hoc test ($p \leq 0.05$).

## Results

In **Tab. 1**, the mean and standard deviation of the research variables in different groups of research are presented.

The results show that there is a significant difference between the mean weight gain of pregnant mothers during pregnancy in the different groups ($p = 0.004$). There was no significant difference between the neonate fat percentage in pregnant women at 16-22 weeks of gestation in different groups ($p = 0.57$). There was also no significant difference in the body fat percentage in pregnant women at 22-28 weeks of gestation in different groups ($p = 0.95$).

There was no significant difference between the body fat percentage in pregnant mothers at 28-34 weeks of gestation in different groups ($p = 0.90$). In addition, there was no significant difference between the body fat percentage in pregnant mothers at 34-40 weeks of gestation in different groups ($p = 0.74$).

The results also showed that there was no significant difference between the mean of gestational age of pregnant women in the different groups ($p = 0.42$) (**Tab. 2**).

The results of post hoc test showed that the inactive group had more weight gain than the active group during pregnancy (about 2.12 kg; $p = 0.02$) (**Tab. 3**).

The results also showed that there was no significant difference between the mean height ($p = 0.92$) or mean weight ($p = 0.79$) of neonates in the study groups. There was no significant difference between the mean score of the first minute Apgar score in neonates in different groups ($p = 0.98$); and there was no significant difference between the mean score of fifth minute Apgar score in neonates in different groups ($p = 0.95$) (**Tab. 4**).

The results of the Chi-square test show that there is no significant difference between the type of delivery of pregnant mothers in different groups; in other words, the difference in the frequency of cesarean section and normal delivery in the four groups is not significant ($p = 0.83$) (**Tab. 5**).

**Table 1.** Descriptive data of the research variables.

| Group variable | Active (15 subjects) | Inactive (15 subjects) | Becoming active (15 subjects) | Becoming inactive (15 subjects) |
|---|---|---|---|---|
| Weight (kg) | 3.44 ± 0.78 | 3.28 ± 0.57 | 3.33 ± 0.96 | 3.57 ± 0.91 |
| Height (cm) | 49.80 ± 3.72 | 49.22 ± 3.15 | 49.27 ± 3.46 | 49.90 ± 2.88 |
| Head circumference (cm) | 34.11 ± 2.21 | 34.00 ± 2.47 | 35.00 ± 2.00 | 33.80 ± 1.68 |
| Apgar score (minute 1) | 9.28 ± 0.90 | 9.22 ± 0.87 | 9.18 ± 0.87 | 9.20 ± 1.01 |
| Apgar score (minute 5) | 9.66 ± 0.57 | 9.66 ± 0.48 | 9.48 ± 0.47 | 9.66 ± 0.51 |
| PI | 2.81 ± 0.66 | 2.84 ± 0.84 | 2.88 ± 1.08 | 2.94 ± 1.00 |

PI: ponderal index.

**Table 2.** The results of one-way ANOVA to compare the research variables between mothers.

| Variable | Source | df | Mean of squares | F | p |
|---|---|---|---|---|---|
| Weight changes in gestation period | Between groups | 3 | 15.27 | 4.97 | 0.004 |
| | Within group | 56 | 3.07 | | |
| | Total | 59 | | | |
| Body fat percentage (16-22 weeks) | Between groups | 3 | 6.68 | 0.67 | 0.57 |
| | Within group | 56 | 9.92 | | |
| | Total | 59 | | | |
| Body fat percentage (22-28 weeks) | Between groups | 3 | 1.09 | 0.11 | 0.95 |
| | Within group | 56 | 9.89 | | |
| | Total | 59 | | | |
| Body fat percentage (28-34 weeks) | Between groups | 3 | 2.16 | 0.18 | 0.90 |
| | Within group | 56 | 11.50 | | |
| | Total | 59 | | | |
| Body fat percentage (34-40 weeks) | Between groups | 3 | 4.42 | 0.42 | 0.74 |
| | Within group | 56 | 10.57 | | |
| | Total | 59 | | | |
| Gestational age | Between groups | 3 | 1.38 | 0.95 | 0.42 |
| | Within group | 56 | 1.46 | | |
| | Total | 59 | | | |

df: degrees of freedom; F: F ratio.

**Table 3.** The results of Tukey's post hoc test to compare the weight gain of pregnant women in 4 groups of study.

| Group | Inactive | Becoming active | Becoming inactive |
|---|---|---|---|
| Active | M = -2.12<br>p = 0.02 | M = -1.31<br>p = 0.19 | M = -0.65<br>p = 0.77 |
| Inactive | - | M = -0.80<br>p = 0.63 | M = 1.46<br>p = 0.16 |
| Becoming active | - | - | M = -1.46<br>p = 0.17 |

**Table 4.** The results of one-way ANOVA to compare the research variables between neonates.

| Variable | Source | df | Mean of squares | F | p |
|---|---|---|---|---|---|
| Newborn's height growth | Between groups | 3 | 1.80 | 0.16 | 0.92 |
| | Within group | 56 | 11.45 | | |
| | Total | 59 | | | |
| Newborn's weight growth | Between groups | 3 | 0.21 | 0.34 | 0.79 |
| | Within group | 56 | 0.62 | | |
| | Total | 59 | | | |
| First minute Apgar score | Between groups | 3 | 0.03 | 0.04 | 0.98 |
| | Within group | 56 | 0.83 | | |
| | Total | 59 | | | |
| Fifth minute Apgar score | Between groups | 3 | 0.03 | 0.10 | 0.95 |
| | Within group | 56 | 0.27 | | |
| | Total | 59 | | | |

df: degrees of freedom; F: F ratio.

**Table 5.** The results of Chi-square test to compare the delivery type in 4 groups of study.

| Delivery type (%) | Active | Inactive | Becoming active | Becoming inactive | $X^2$ | p |
|---|---|---|---|---|---|---|
| Normal delivery | 12 (57.1%) | 10 (55.6%) | 6 (54.5%) | 4 (40.0%) | 0.88 | 0.83 |
| Cesarean section | 9 (42.9%) | 8 (44.4%) | 5 (45.5%) | 6 (60.0%) | | |

## Discussion

The results of this study showed that the mean of weight gain in active pregnant women was significantly lower than that of the inactive women, but did not differ significantly from the becoming active and becoming inactive groups. There was also no significant difference between the body fat percentage of pregnant women who participated in physical activity and that of the inactive pregnant women during 16-40 weeks of pregnancy. The findings of this study are consistent with the results of some previous studies [25-27] but not with the results of Zand and Zamani (2009) [28]. Sedaghati et al. showed that there is a significant difference between the mean weight gain during pregnancy in the experimental and control groups. Therefore, proper physical activity during pregnancy not only does not harm the fetus and mother, but makes labor easier and provides healthier births for neonates [26]. Most women participate in physical activity during pregnancy, with 41.2% performing 60 to 149 minutes activity per week and 32.1% at least 150 minutes per week [3].

Nascimento et al. reported that 47% of pregnant women who undertook physical activity during pregnancy gained weight above their recommended level, compared with 57% of women in the control group. However, there was no difference in weight gain between the two groups. It is worth noting that overweight women undertaking athletic exercise had lower weight gain in comparison with women in the control group during the whole period of pregnancy and after entering the study [29]. Additionally, the results of this study showed that there is no significant difference between types of delivery for active, inactive, becoming active and becoming inactive groups. Our findings are consistent with previous studies [11, 12, 26, 30]. Among women who follow physical activity recommendations during pregnancy, about 5% are reported to have premature births, 29% cesarean sections, and 20% are admitted to hospitals during pregnancy [30]. The delivery status can affect the health of mother and neonate. Despite ongoing advances in women and midwifery disciplines, cesarean sectional surgery is still one of the adverse consequences of pregnancy, as instrumental delivery or cesarean section can have many complications that affect postpartum recovery.

While previous studies do not support the effect of exercise on the type of delivery, it has been reported in some studies that there is a relationship between exercise during pregnancy and reducing the need for cesarean section, so regular sport exercise is accompanied with a reduced rate of cesarean section in women [26, 28, 31]. Sports activity may also decrease (or increase) the cesarean section through several possible pathways, including the placement or breach or non-perineal position of the embryo during pregnancy. Strengthening abdominal muscles and increasing self-efficacy can give a pregnant woman a positive attitude toward the ability to perform normal labor, and therefore, the choice of a cesarean section is likely to be reduced. The results also showed that there was no significant difference between mean height and weight of newborns in different groups. This result of the study is consistent with the findings of some studies [11, 12, 26, 28].

In one study, Jukic et al. reported that the birth weight was not related to the physical activity indices, and it seems that physical activity does not affect birth time or birth weight adversely [32]. Khaledan et al. studied the effect of one bout of aerobic training on the development of the fetus in pregnant women. A comparison of embryo weight at different stages and postpartum weight with primary weight showed that weight gain in the experimental group was 1.37% higher than the control group, but the difference was not significant. The mean head circumference and height of neonates in the experimental group were higher than the control group (0.12 cm and 0.09 cm, respectively), but there were no significant differences. According to the results, there was no decrease in fetal growth after sport activity; on the other hand, the weight gains of the fetus and also the height and head circumference in the experimental group were more than that of the control group, but the difference was not significant. Thus, they stated that the aerobic training program did not have an adverse effect on the development of the fetus and may even be beneficial [33]. With regard to the growth pattern of the embryo, which was the highest in the last trimester of pregnancy, and considering the effect of exercise on reducing the blood flow of the uterus and the placenta, it was found that exercise affects the nutrition and growth of the fetus.

The weight of the infants in the different groups was within the normal range. However, exercise during pregnancy can be one of the factors affecting baby weight at birth. Some researchers

believe that performing aerobic training during the last trimester of pregnancy can reduce the weight of the neonate at birth [9, 10, 34]. It has been observed that the children of mothers who had trained for 5 to 7 days a week did not have a lower weight at birth than the non-training group, but the children of mothers who had been exercising 3 to 4 days a week had a higher weight than the control group [34]. Ghodsi and Asltoghiri (2014) studied the effect of aerobic training on maternal and neonatal outcomes. In this study, 80 pregnant women with 26-29 weeks of gestation were randomly divided into experimental and control groups. The intervention group performed the training with an ergometer bike for 15 minutes, 3 times a week and at 50-60% of the maximum heart rate. The results showed that the mean newborn weight in the intervention group was significantly lower than that of the control group. They stated that exercise with an ergometer bike is useful during pregnancy for mother and baby [25]. It should be noted that the type of exercise during pregnancy as well as the nutritional quality of this period may be an effective factor in the birth weight of the neonate and perhaps this is the reason for the difference observed in the research, so that it prevents weight gain in mothers, and, on the other hand, it affects the neonate's birth weight. Based on different studies, some of the characteristics of pregnant mothers such as pre-pregnancy weight, the mother's height, gestational age at delivery, the mother's age, and the number of maternal births were effective in the infant's weight. Not checking the BMI in some studies may be the cause for the difference in the research. In addition, the difference in the results in the aforementioned studies depends on the history of physical fitness, nutrition, extent and intensity of exercise, heritability, and socio-economic status of mothers.

According to the results of this study, there was no significant difference between the Apgar scores of the first and fifth minutes of the babies in the research groups. The lack of significant difference in the Apgar score in the current study was consistent with the results of some previous studies [11, 26], but not with the results of the research done by Gehan et al. (2015), and Foroud et al. (2006) [18, 35]. In a study that examined the effect of sport activities during pregnancy on the outcome of pregnancy in primiparae, the findings showed that there was no significant difference in terms of the Apgar score of the neonates between the group of mothers who exercised and the group who did not [25]. However, Foroud et al. (2006) showed that performing aerobic training for 8 weeks, 3 days a week, for 15-30 minutes per day and at an intensity of 50-70% $VO_2$max during pregnancy can improve the Apgar score of the fifth minutes in neonates [35]. Also, Gehan et al. (2015) examined the effectiveness of prenatal exercises on maternal and neonatal outcomes in primiparous women. A total of 60 primiparous women (mean age 35-40 years) were randomly divided into two equal groups during the 14$^{th}$ week of pregnancy. The first group performed prenatal exercises for 6 months, while the second group did not performed exercise. Participants in the first group showed a significant difference in the Apgar rating at minutes 1 and 5 compared to the participants in the second group [18]. In order to justify the difference between these findings and other studies, one can note the nature, type, intensity and frequency of exercise in individuals during the pregnancy period.

## Conclusions

Considering that there is no significant difference between the type of delivery and the duration of pregnancy of the mothers who participated in sport activities and those who did not, it can be concluded that exercise does not have an adverse effect on the type of delivery and the length of the pregnancy. Concerning the newborn, the results of this study showed that participating in sport activities has no negative effect on the growth of neonates and their health. Therefore, with full confidence, pregnant mothers may be advised to participate in sport activities.

## Declaration of interest

The Authors declare that there is no conflict of interest. Funding: at the expense of the Authors.

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