REVIEW ARTICLE

Maternal-fetal response resulting from the practice of physical exercise during pregnancy: a systematic review

Resposta materno-fetal resultante da prática de exercício físico durante a gravidez: uma revisão sistemática

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ABSTRACT

Introduction: pregnancy determines adaptive systemic and local modifications, with the main objective to promote fetal growth and development. These are physiological adaptations and occur in reaction to the presence of a fetus and his tissues, modulated by the enhanced action of several trophoblastic/placental, fetal, and maternal hormones. In spite of these physiological adaptations, pregnant women benefit from regular exercise. However, there are still controversies, both in relation to the practice of regular exercise during pregnancy and fetal risk imposed by exercises. **Objectives:** to carry out a bibliographic research on the physiological alterations and physical exercise in pregnancy and fetal responses to its effects. **Methodology:** a systematic review addressed physiological alterations and physical exercises in pregnancy, from the 80s to the present. **Results:** there was significant increase in fetal HR (heart rate) after the protocol of exercises without fetal distress (SF). However, when the maternal HR exceeded 140 bpm, SF happened. **Conclusion:** the practice of physical exercise at moderate intensity (up to 140 bpm of maternal HR) seems beneficial to the mother and fetus in non-complicated pregnancies.

Key words: Pregnant Women; Exercise Tolerance; Cardiovascular System; Fetus.

RESUMO

Introdução: *a gravidez determina modificações adaptativas locais e sistêmicas, com o objetivo principal de promover o crescimento e o desenvolvimento fetal. Essas adaptações são fisiológicas e ocorrem em reação à presença do concepto e seus tecidos, modulados pela ação crescente de vários hormônios trofoblásticos/ placentários, fetais e maternos. A despeito dessas adaptações fisiológicas, as grávidas beneficiam-se do exercício físico regular. Entretanto, ainda existem controvérsias tanto em relação à realização do exercício físico regular na gestação quanto ao risco fetal imposto pelos exercícios.* ***Objetivos:*** *realizar pesquisa bibliográfica sobre as alterações fisiológicas e exercícios físicos na gravidez bem como a resposta fetal aos seus efeitos.* ***Metodologia:*** *revisão sistematizada abordando as alterações fisiológicas e exercícios físicos na gravidez, desde a década de 80 até os dias atuais.* ***Resultados:*** *houve significativo aumento da FC (frequência cardíaca) fetal após o protocolo de exercícios sem ocorrer sofrimento fetal (SF). Porém, quando a FC materna ultrapassou os 140 bpm houve SF.* **Conclusão:** *a prática de exercícios físicos na intensidade moderada (até 140 bpm de FC materna) parece benéfica para a mãe e o feto em gestações não complicadas.*

Palavras-chave: *Gestantes; Tolerância ao Exercício; Sistema Cardiovascular; Feto.*

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INTRODUCTION

Pregnancy determines local and systemic adaptive modifications with the main objective of promoting fetal growth and development.[1] These adaptations are physiological and occur in reaction to the presence of the fetus and its tissues, modulated by the growing action of several trophoblastic/placental, maternal, and fetal hormones, immunological factors, and the mechanical action of the gravid uterus.[2,3]

Despite these physiological adaptations, pregnant and non-pregnant women benefit from the regular physical activity.[4] However, a substantial proportion of pregnant women disrupts the practice of regular physical activities and reduce their level of daily life activities (DLAs) when they discover that they are pregnant.[5] Conversely, the practice of regular physical exercise before pregnancy or even during the prenatal period can prevent the development of some diseases such as arterial hypertension (AH), maternal obesity, gestational diabetes, and preeclampsia among others.[4,6,7]

This study aims to evaluate the current knowledge about the physiological alterations during pregnancy, recommendations and guidelines for the practice of regular exercises, and their consequences for the fetus during the gravid cycle.

METHODOLOGY

A systematic review of physiological alterations and physical exercises during pregnancy was conducted. The study included published articles in the MEDLINE and COCHRANE collaboration databases, in journals and between 1980 and the present date. The following terms were used: pregnant, exercise tolerance, cardiovascular system, and fetus.

Physiological changes of pregnancy

Pregnancy determines special alterations in women as the result of caloric, protein, minerals, and vitamins needs imposed by the fetus. The following metabolic and cardiovascular adaptations, which will influence the maternal response to exercise, can be highlighted: increase of blood volume by 40-50% and increase in cardiac output at rest as well as during submaximal exercise in the first two trimesters.[8] The heart rate (HR) increases in 15 beats to compensate for the increase in cardiac output (DC). The peripheral vasodilatation occurs from the beginning of the second trimester. Placental and peripheral vessels become refractory to pressure agents resulting in a tendency towards hypotension.[8] In the third trimester, the cardiac output is smaller, and the possibility of hypotension is greater. The fall in CO also occurs as a function of uterus growth, which compresses the inferior vena cava when in a supine posture, which complicates venous return and reduces CO.

Clinically, it is observed that the cardiovascular system of pregnant women is characterized by a "hyperkinetic state."[9] Metabolically, there is an increase in growth of the uterus and its contents (fetus, placenta, amniotic fluid), breasts, blood volume, and extravascular and intracellularly fluid.[10] There is a tendency to water and sodium retention mediated by decreased plasma osmolarity and increased glomerular filtration rate and hormone action, which favors the appearance of edema in the lower limbs.[10] The needs of proteins, carbohydrates, and lipids increase in about 30% to meet the growing fetus' demands and formation of reserves in maternal tissues.[11] The need for iron, calcium, and folic acid increase and are compensated in part by the increased renal reabsorption capacity of these nutrients[11]. These also occur: relaxation of ligaments due to [embebição gravídica], particularly in the pelvis ligaments;[12] increased vascularization (estrogens); and tonus reduction of muscles responsible for the stabilization of these joints by the actions of progesterone and relaxin.[12] Therefore, these alterations involve various systems and aim to respond to the increasing metabolic and nutritional demands of the fetus (Figure 1).

Practice of physical exercises during pregnancy

The practice of a regular physical activity is no longer a cosmetic procedure but represents a resource widely used by all medical specialties in disease prevention, health promotion, and as an adjunct therapeutic in disease control.[13]

Until a few decades ago, pregnant women were advised to reduce their occupational and physical activities, especially at the end of pregnancy.[14] However, from the last decade, several evidences were observed on the benefits of physical exercises in pregnant women especially those with a healthy pregnancy: improvement of physical capacity, supported effect on body weight control, maintenance of the lean

body mass, thrombosis prevention, improved venous return, reduced incidence of gestational diabetes, and effective contribution facilitating the mechanism of normal labor.[13,15] (Figure 2).

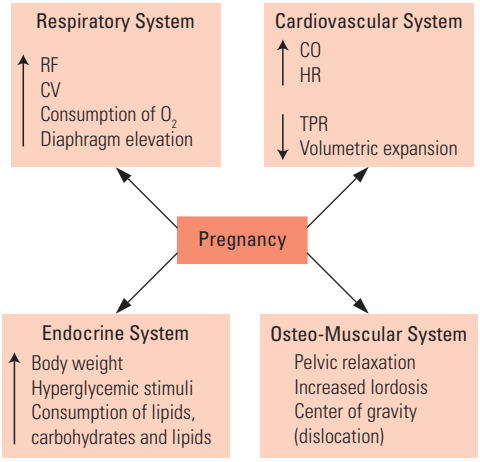

Figure 1 - Main physiological alterations associated with pregnancy. Caption: CO = cardiac output; HR = heart rate; TPR = total peripheral resistance; RF = respiratory frequency; CV = current volume.

It is up to the obstetrician and physiotherapist to indicate regular physical activity during pregnancy, know the pathophysiological mechanisms involved in this practice for mother and fetus, seeking the appropriate orientation and individualized protocol, type, frequency, intensity, and ideal time for the practice of physical exercise. The main effects of aerobic exercise of moderate intensity during pregnancy are: increased cardiac output, reduction and redistribution of blood flow, increased 10 to 20% in O_2 consumption, increased blood volume and heart rate, and reduced peripheral resistance and blood pressure.[15] The fetal heart beat is increased by 10-30 beats per minute (bpm) and returned to basal levels approximately five minutes after the end of aerobic exercises of moderate intensity. The increased CO means that the increased blood flow to the muscle in exercise can occur without compromising the flow in the uterus.[16] However, the practice of high-intensity exercise, i.e. above 80% of the maximum heart rate (HBmax) is not recommended because they can result in increased HR for approximately 30 minutes, which can result in fetal hypoxia.[17] Therefore, strenuous and prolonged exercise should be avoided, even knowing that a healthy fetus can tolerate periods of suffocation with tachycardia and increased blood pressure, because there seems to be a protective mechanism that causes increased blood circulation, increasing O_2 production, and decreasing that of carbon dioxide.[18,19] In addition, high-intensity physical exercises can result in 20 to 30% increase in the risk of preterm labor, reduced growth, and low fetus weight.[17]

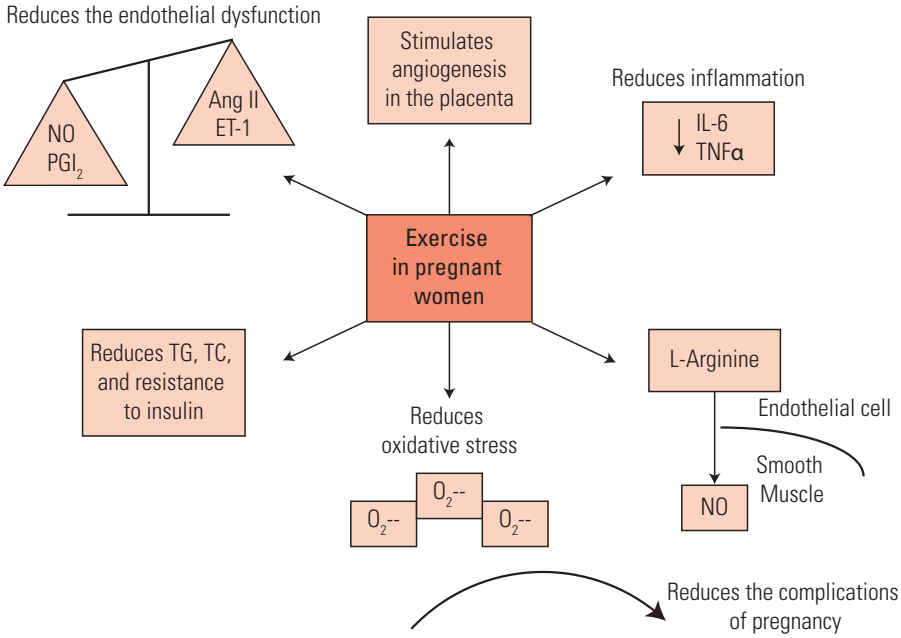

Figure 2 - Main effects of physical exercise during pregnancy. Caption: NO: nitric oxide; PGI2: Prostacyclin; Ang II: Angiotensin II; ET-1: endothelin-1; IL-6: Interleukin-6; TNFα: alpha tumor necrosis factor; TG: triglycerides, TC: total cholesterol; O2--: reactive oxygen species.

Aerobic exercises should include activities that are comfortable for pregnant women to execute such as those that work large muscle groups, continuously and rhythmically, and improve the cardio respiratory state. Although there are no standardized protocol of specific exercises during the gestational period, the most recommended are: walking, pedaling on ergonomic bikes, hydro-gymnastics and swimming because, besides the ease in quantifying intensity and time, there is no doubt that these are healthy during the gestational cycle if carried out at least three times per week, with a maximum duration of 60 minutes.[20]

Pregnant women who were sedentary before pregnancy should start exercising in the second trimester and gradually increase aerobic exercises of moderate intensity until reaching 30 min of continuous activity.[20] According to Longo and Zavorsky (2011), the intensity of the exercise should be 60% of the reserve HR considering maternal HR according to age. However, a maternal HR over 140 bpm should be avoided.[21]

In relation to the BORG scale, this should be between 12 and 14, and the calorie expenditure should be 16-metabolic equivalents (METS)/week, which corresponds to a walk of 3.2 km/h in 6.5 hours per week, for example.

Complementing the aerobic work, the program of physical activity for pregnant women should include exercises that promote strength and flexibility aimed to balance torso lumbar, abdominal, and pelvic floor muscles that are, in general, shortened by the gravid posture.[7] Thus, muscular endurance exercises with eight to 10 exercises involving large muscle groups in the upper and lower limbs, with three sets of 10-12 repetitions and resistance of up to 3 kg must be included for pregnant women at least three times a week.[22] The uncomfortable back pain from the physical and physiological alterations during pregnancy are alleviated, providing improved posture.

Conversely, some exercising modalities such as weightlifting, jumping, pushups, and trunk extensions of great range motion, and contact physical activities that lead to easy imbalance and possible fetal trauma should be avoided by pregnant women.[21] Similarly, exercises performed in the supine posture, lasting over 30 minutes, after the 16th week of pregnancy may result in CO reduction and symptomatic hypotension due to compression of the inferior vena cava.[21] These restrictions are imposed by changes in the maternal body biomechanics and the resulting instability in her musculoskeletal kinetic chain. Thus, the main alterations that occur in pregnancy are protruding abdomen, rib cage expansion, diaphragm rise, swing gait, lumbar hyperlordosis, and alterations from deviation in the center of gravity, loss of balance, projection of shoulders forward, less stability of knees and ankles joints, increased body weight, increased breasts, tension in the spine and hips, increased pressure on the pelvic floor muscles, and nerve compressions.[21]

In relation to the fetal response to the effects of exercises, it seems that fetuses of pregnant women who practice regular physical exercise with moderate intensity tolerate labor better than those of sedentary pregnant women (Table 1).[23]

Table 1 - Evaluation of several studies that included exercises with pregnant women and evaluated their effect on maternal well-being and fetal vitality through cardiotocography

Study	Studied group	Type of exercise	Fetal response
Clapp JF 3rd [24], 1985.	Normotensive pregnant women (20-32 weeks). Non randomized	Treadmill with variable intensity for 20 min	Significant increase of post-exercise FHR
Watson *et al* [25]., 1991	13 normal sedentary pregnant women (25-30 weeks of gestation). Non randomized	Ergonomic bike and swimming. Maximum effort (1 time) of 0-30 minutes	Significant reduction of FHR after exercise with bike and significant increase of FHR during exercise (10-20 min) in both studied modalities
Sasaki *et al* [26]., 1993	17 normotensive pregnant women (35-38 weeks). Non randomized	Swimming (375-750 meters) during 33-41 min	Significant increase of post-exercise FHR vs. pre-exercise
Asai *et al* [27]., 1994	48 normotensive pregnant women in the second and third trimesters (16 and 39 weeks). Non randomized	Ergonomic bike for 30 min (Submaximal HR)	Significant increase in FHR during exercise. Exaggerated increase of FHR (tachycardia) observed in 6 cases and significant reduction of FHR in 2 cases when the maternal HR was over 160 bpm
Asakura *et al* [28]., 1994	21 normotensive pregnant women in the third trimester (34-40 weeks). Non randomized	Dance (65% of HRmax for 30 min)	Significant increase in FHR during exercise
Manders *et al* [29]., 1997	12 sedentary normotensive pregnant women (29-32 weeks). Non randomized	Test on ergonomic bike (53%-99% HRmax). Strenuous exercise for 30 min	Increasing FHR until 30 minutes post-exercise. 2 cases of fetal bradycardia (80-99% of HRmax) associated with the absence of fetal and respiratory movements

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Table 1 - Evaluation of several studies that included exercises with pregnant women and evaluated their effect on maternal well-being and fetal vitality through cardiotocography

Estudo	Grupo de Estudo	Tipo de exercício	Resposta fetal
Brenner *et al* [30]., 1999	14 sedentary normotensive pregnant women (exercise group) and 6 normotensive pregnant women and sedentary (control group). Training in the second trimester (27 weeks) and third trimester (37 weeks). Randomized	Ergonomic bike (beginning with 14 min up to 25 min) 3 x week with training FHR of 145 bpm. Submaximal test at 27 weeks and later at 37 weeks	Significant increase of FHR during exercise. Modest reduction of FHR after exercise, with increasing FHR in both tests. There was no significant reduction in FHR in some period
Rafla *et al* [31]., 1999	133 normotensive pregnant women and 44 high risk pregnant women (diabetes, PE, and IUGR) (third trimester). Non randomized	test of 5 min on the ergonomic bike	There was no significant change of FHR betweenpre- vs. post-exercise. 10 cases of high risk pregnant women, FHR reduced in the post-exercise
MacPhail *et al* [32]., 2000	23 active normotensive pregnant women (third trimester). Non randomized	Maximum test protocol in ergonomic bike	Increasing FHR in 20 min post-test compared to 20 min pre-test.
Petrikovsky *et al* [33]., 2001	Healthy, full-term. Non randomized	Aerobic, up to 140 bpm; treadmill or bike for 30 min.	Without significant changes in FHR, however, increase in intrauterine pressure.
Mainread *et al* [34]., 2002	228 primiparous and non-smokers. Sedentary and physically active	Aerobics, 3 to 4 times a week. Strenuous program	No fetal distress, variations in FHR after exercise without correlation with the type of childbirth
Kennely *et al* [35]., 2002	258 normotensive pregnant women with different levels of physical activity (33-38 weeks). Non randomized	Incremental exercise test symptom-limited	Increasing FHR pre-exercise vs. post -exercise, however, with no correlation with FD or delivery type
Ertan *et al* [36]., 2004	33 normotensive pregnant women and 10pregnant women with IUGR (third trimester). Non randomized	Ergonomic bike (1.25 Watts/ kg maternal weight) moderate intensity for 30 min	Without significant change in FHR post-exercise vs. pre-exercise in both groups
Chaddha *et al* [37]., 2005	35 normotensive pregnant women (22-26 weeks). 23 pregnant women with normal doppler and 12 pregnant women with increased uterine arteries PI (> 1.45). Non randomized	5 min test on bike, Rate of 10% -15% of max work expected for 30 min	In the 23 normotensive pregnant women with normal doppler There was no FHR alteration post-exercise vs. pre-exercise.
Silveira *et al* [38]., 2010	133 sedentary pregnant women. Non randomized	Aerobic, moderate intensity, in hot water	Without significant changes on FHR and FM in pre-exercise and post-exercise
Barakat *et al* [39]., 2010	26 sedentary normotensive pregnant and 26 active normotensive pregnant women in the third trimester. Randomized	20 min in ergonomic bike (60% of HRmax) for 30 min	There was an increase in FHR in both groups comparing pre- vs. post-exercise
Salvesen *et al* [40]., 2011	6 elite athletes pregnant women (olympic-level) at 23-29 weeks. Non randomized	Test on treadmill (racing) at 60-90% of VO2 max	FHR remained in normal values (110-160 bpm) when the maternal HR remained below 90% of HRmax. On the other hand, there was fetal bradycardia in intensity over 90% of maternal HRmax

FHR: fetal heart rate; HRmax: maximum heart rate calculated by age; FM: Fetal movements; VO2 max: maximal oxygen uptake; PI: pulsatility index; FD: fetal distress; PE: preeclampsia; IUGR: retarded intrauterine growth.

CONCLUSIONS

The studies achieved by this review reveal the need for further evaluations with larger samples based on clinical trials with randomization of study groups by evaluating maternal-fetal well-defined outcomes. Therefore, the specific recommendations in relation to the practice of physical exercises in pregnant women can acquire a level of recommendation based on high degree of evidence. The evaluation of training with aerobic and resistance activity, on alternate days and with moderate intensity, appears to be beneficial to mother and fetus in pregnancies without complications.

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