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Review Article

Positive Effects of Training for Expectant Mothers- Physical Activity for The Prevention of Pregnancy Related Diseases

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Abstract

Pregnancy is associated with significant physical and psychological changes for expectant mothers, which have many effects on their fitness and physical performance. However, the benefits of regular training outweigh the risks and reduce the likelihood of suffering from pregnancy-induced diseases. Physical activity during pregnancy causes many positive effects. Reduced risk of premature birth, caesarean section and also a positive influence on the risk of gestational hypertensive disorders, gestational diabetes, excessive weight gain are among those positive effects. The American College of Obstetricians and Gynecologists (ACOG) recommends in its guidelines a regular physical activity of about thirty minutes on most days of the week. An energy consumption of 28 MET (Metabolic Equivalent of Task) per week should be aimed for Especially sports such as jogging, cycling and swimming are suitable. Moreover, strength training with free weights and weight machines can be recommended. Sports with a high risk of injury and body contact are not suitable and should be avoid. With the beginning of their second trimester, it is recommended that even un-athletic women start light physical activity. The intensity should be controlled via the heart rate reserve or with a simple scale such as the Borg scale. Physical activity can be continued throughout the pregnancy and re-intensified four weeks after delivery. On this occasion, an increased attention should be paid to the training of the pelvic floor and the abdominal muscles.

Keywords: Expectant Mother; Pregnancy; Prevention; Sport; Training

Introduction

The mindset concerning physical activity during pregnancy has been changed fundamentally over the centuries. The Book of Exodus, a part of the Old Testament, for example states that women who are used to physical labor behave more easily than mistresses who do not work physically. In ancient Sparta, women were encouraged to exercise during pregnancy in order to give birth to sportier descendants [1]. Even in the Roman Empire, physical activity during pregnancy was considered beneficial. However, it seems that this knowledge has been lost over the following centuries [2,1]. Towards the end of the 19th century, a renunciation of exertion during pregnancy was postulated. It was not until 1985 that a first statement on the subject was published by the American College of Obstetricians and Gynecologists (ACOG) generally recommending physical activity during pregnancy [3]. However, these guidelines restricted physical activity to a maximum length of 15 minutes and a general heart rate limit of 140/min [3,4].

The new and amended edition of the ACOG guideline now serves as the basis for most national and international directives [3]. Nowadays, sportive women are not willing to relinquish their active lifestyle during pregnancy. Professional athletes in particular cannot entirely cease their training during pregnancy and aim to continue their exercise routine and professional careers after delivery again. On the other hand, inactive women often develop an increased health awareness during pregnancy with the desire not only to eat healthy but also to follow and continue an exercise routine and a healthy lifestyle [5,6].

Studies conducted to date do not allow for clear conclusions in regards to ideal physical activities during pregnancy but agree on the general benefits of exercise [3,2,5,6]. This makes it difficult to clearly define risks and benefits. However, literature suggests that regular physical activity can reduce the risk of Gestational

Diabetes (GDM) by 30-70% [7,6]. The active lifestyle of mothers increases their fitness and improves body composition resulting in a lower BMI. The prepartal BMI, in turn, correlates with the child's birth weight, a key predictor of the child's health outcomes [8-10]. As a result, one should encourage sportive activities even during pregnancy in order to compensate for the detriments associated with the modern way of life.

Partial Physiological Adaptation

Partial Weight Gain

During pregnancy, the weight gain occurs predominately in the last trimester. The National Academy of Medicine (NAM) has published a BMI-dependent weight-loss chart to determine the ideal weight gain and the health risk to the child (Figure 1).

Preconceptional Body Mass Index (kg/m^2)	Recommended weight gain during pregnancy (kg)	
	Lower limit	Upper limit
< 18.5	12.5	18
18.5 - 24,9	11.5	16
25.0 – 29.9	7.0	11.5
>30	5.0	9.0

Figure 1: BMI-dependent weight-loss chart to determine the ideal weight gain and, in turn, the health risk to the child.

Musculoskeletal Adjustments

Due to the increasing size of the uterus during a pregnancy and a weight gain of 15-25%, the body's center of gravity shifts ventrally. The entire musculoskeletal system is influenced by relaxing and estrogens increasing the elasticity of tendons and ligaments. This results in an increased risk of injury due to a changed leverage ratio. At the same time an increased lordosis in the lumbar region with an anterior tilt of the pelvis and an increasing load on the M. erector spine occur [11,6,1]. As a result, back pain is one of the most frequent side effects. In addition, the gait control decreases as a result of the reduced visual feedback caused by the increased abdominal volume, which ultimately results in an increased tendency to fall [6,12,13].

Psychological Adjustments

As a result of the hormonal and physical changes during pregnancy, the psychological mindset of pregnant women is also influenced. This causes women to eventually suffer from mood swings, sleeping disorders and even depression. Moreover, nausea, fatigue and a lack of motivation are common phenomenon's, all of which usually disappear during the first trimester [6,1].

Cardiovascular Adaptations

Hormonal changes, which already begin in early pregnancy, cause a dilatation of the arterioles and the venous vascular system with a significant increase of the circulating blood volume. This increase in cardiac output and stroke volume is mediated by the renin-angiotensin aldosterone system, which is responsible for an increased reabsorption of sodium to reduce diuresis thus increasing the plasma volume [11,14]. In contrast, the mean arterial blood pressure decreases by 5-10 mmHg to its half during the second trimester. This effect results from the decrease in vascular resistance on the one hand, and an increase of the uterine blood flow and placental vascularization on the other hand. The vasodilatation, the increased intra-abdominal pressure and the complicated reverse venous blood flow from the lower extremity to the heart influenced by the uterus can lead to the development of varices and lower limb edema.

This phenomenon in combination with the hormonally induced procoagulatory potential leads to an increased risk for the women to suffer from deep vein thrombosis [15,6].

Respiratory Adjustments

The augmented oxygen demand is regulated by an increase in the respiratory rate and may raise by up to 50% compared to the respiratory minute volume of a non-pregnant woman [8].

Endocrinological Adjustments

The hormonal changes during pregnancy (estrogens, prolactin, cortisol, progesterone) lead to an increased release of insulin as a result of an increasing cellular insulin resistance. These metabolic conditions, which can be referred to as diabetogenesis, and the fact that the body weight further increases, may favor the development of GDM. The child's blood sugar level correlates with the maternal levels and therefore increases the risk of fetal macrosomnia, skeletal malformations and a polyhydramnios. In addition, these children are more likely to develop Diabetes Mellitus (DM) type 2, obesity and hypertension [16,17]. The incidence of GDM in Germany is around 5-10% [18,19]. Approximately 40% of women with GDM develop DM type 2 within four years [20]. Recent studies have shown that women who were born "Large for Gestational Age" (LGA) are at an elevated risk of giving birth to a LGA child. This is independent of their current BMI and could be an explanation for rising obesity rates [21].

Effects of Sports on the Expectant Mother

The beneficial effects of physical activity for the mother to be and the unborn child seem very obvious today. By maintaining the normal routine of exercise during pregnancy the training level is kept constant and in un-athletic women a certain level of basic

fitness can be achieved. A basic fitness level positively influences the progress of the pregnancy, childbirth and postpartum period [6,22]. Besides the described physical advantages, regular exercise during pregnancy also leads to psychological adjustment reactions. It has been reported that physically active women compensate better for physiological changes during pregnancy, that mood changes are less common and that the risk of developing postpartum depression is significantly reduced [11,8,6,23].

Physical Effects

Physical fitness during and post pregnancy is increased through regular physical activity. Physical activity reduces pain during delivery, facilitates childbirth, prevents puerperal discomfort and increases mental activity [24,6]. Excessive weight gain is also reduced and the return to ideal weight is achieved more frequently [25,26]. Additionally, the problem of uterine erosion occurs less often in the years after pregnancy preventing incontinence [8]. Physical activity aims to prevent not only postural damage, but also the development of varicosis and deep vein thrombosis [1]. A direct correlation between physical activity during pregnancy and a higher malformation rate could not be shown so far [11].

Looking at the rate of preterm birth, the risk can be reduced by 12-18% with more than five hours of exercise per week and an energy turnover of 10-16 MET [6,27,28]. It has been shown that moderate and intense training during pregnancy with an inconspicuous course and missing pre-existing risks has no influence on fetal mortality and morbidity [1,29,30]. Highly intense physical activity can lead to an increased catecholamine release leading to irritability of the uterus. This can cause increased uterine contractions especially in the last trimester. However, literature provides no evidence for preterm delivery [1,31,27,28].

The hemodynamic changes during pregnancy are also positively influenced by regular physical activity. Mediated by physiologic compensation mechanisms during aerobic endurance training an increased blood flow to the placenta can be accomplished. This leads to an increase in the arteriovenous oxygen difference and an improved substrate uptake in the placenta [8,32]. The increased blood flow to the placenta also reduces the risk of thrombosis and varicosis [1]. A raise of the body core temperature above 39 ˚C due to physical activity or infection could potentially lead to teratogenic effects as demonstrated in animal experiments. It has however been shown that submaximal efforts can only bring about a mean temperature rise of 1.5 ˚C [31].

Furthermore, the risk of overheating during pregnancy is reduced by physical adjustment processes. These include an increase in blood volume, skin perfusion and respiratory minuscule volume due to a higher respiratory rate and perspiration [32,1].

Consequently, the main risk of physical activity during pregnancy is injuries. While the fetus is still protected by the symphysis during the first trimester, blunt abdominal trauma may directly endanger the fetus from the second trimester onwards eventually resulting in premature labor and placenta abruption [8,5].

Glucose Metabolism

The training of larger muscle groups can reduce pregnancy-induced insulin resistance. Regular exercise improves glucose uptake and increases the organism's sensitivity to insulin [5]. It has been shown that a regular exercise program before and during pregnancy can reduce the risk of GDM by 30-70% [33,34]. Zhang, et al. showed that women benefit the most from strenuous exercise, both before and during pregnancy [32]. In addition, it was found that an intense exercise program can stop the yo-yo effect [35]. Intensive endurance training can increase the proportion of Type I muscle fibers. As a result, the subcutaneous fatty tissue shows a faster reduction. Zavorsky, et al. were able to measure a reduction in body fat from 27% to 22% [36]. It must however be taken into account that sports during pregnancy can result in hypoglycemia after 45 min of submaximal exposure [32].

Hypertensive Disorders

One of the leading causes of maternal morbidity and mortality are gestational hypertensive disorders [37]. In 6-8% of the pregnancies are disrupted by these disorders [38]. Hypertension in pregnancy is defined as a systolic Blood Pressure (BP) ≥ 140 mm Hg and a diastolic BP ≥ 90 mm Hg on two separate measurements which have been tested at least 4-6 hours [38]. Literature describes that exercise in pregnancy leads to a reduction of oxidative stress which improves the endothelial function and results theoretically in a reduction of preeclampsia [39]. Margo-Malosso, et al. showed in their meta-analysis that there is a significant benefit in the risk reduction of gestational hypertensive disorders based on aerobic exercise [27].

Effects On the Fetus

With regards to a normal healthy pregnancy, literature provides no evidence of negative effects of a medium-intensity aerobic exercise program [1]. Under moderate training conditions there is no influence on or only a slight increase in fetal body weight, which is caused by an improved fetal substrate and oxygen depletion [40,8,1]. In contrast, highly intense physical exercise of more than four times a week, especially in the last trimester, can lower the body weight of the newborn by 200 - 400 grams. A reduction in the body fat percentage of the newborn is discussed as a potential cause [1,41].

Competitive Sports and Pregnancy

Competitive athletes often fear a loss of performance and thus the danger of losing one's livelihood therefore deciding to continue their training program or even competitive activity. Such continued

routine requires a close doctor-athlete-trainer relationship, close monitoring and counseling. There is evidence that the endurance and performance of female athletes only decrease slightly when performing adapted basic training [1].

In contrast to aerobic endurance training, a continuation of maximum strength training needs to be seen critically putting the fetus at risk due to an increased intra-abdominal pressure. This causes a reduction of the uterine blood flow and leads to bradycardia and thus to a shortage of the child. However, this effect has not yet been clearly demonstrated [1]. The increased risk of injury during pregnancy due to the changes of the capsular ligament apparatus could not be proven in competitive athletes as they have better muscle strength and coordination [1].

Training During Pregnancy

As already explained above, the topic of sports, exercise and pregnancy has always been discussed controversially. The first international guidelines addressing exercise during pregnancy were drafted by the ACOG in 1985 and have been updated last in 2016. The guidelines recommend a moderate physical activity of about 30 minutes on most days of the week. There are, however, certain risk factors and chronic conditions that need to be considered (Figure 2 and 3) [3]. In addition to the internal gynecological factors depicted in Figure 2, these risk factors include premature birth in a previous pregnancy, SGA, pre-eclampsia, infections and a tendency to edema [11,6]. In addition, Figure 2 shows two relative contraindications to exercise during pregnancy (Figure 2) [1]. Especially in the first trimester, hot and humid environments should be avoided and attention be paid to a balanced fluid and calorie intake [3,26]. There are specific warning signs that need to be considered that should result in an immediate termination of physical activity (Figure 4) [11,1]. However, these recommendations are not based on a clearly defined moderate training amount or energy consumption level. In a published review, Korsten-Reck, et al. describe a minimum energy consumption of 16 MET per week, that should preferably be kept at 28 MET with an intensity of >60% of the heart rate reserve (Figure 5 and 6) [8,22]. Keeping in line with these premises reduces the risk of GDM, hypertension and preeclampsia [22].

Severe anemia
Unexplained maternal arrhythmia
Chronic bronchitis / nicotine abuse
Misadjusted type I diabetes mellitus
BMI <18 or > 35
Intrauterine growth retardation
Misadjusted hypertension
Orthopaedic limitations
Misadjusted epilepsy

Figure 2: Relative contraindications of aerobic exercise during pregnancy.

Hemodynamically effective heart disease
Restrictive lung diseases
Cervical incompetence
Multiple pregnancy with risk of premature labor
Persistent bleeding in the 2nd or 3rd trimester
Placenta previa after the 24th week of pregnancy
Premature labor activity
Premature rupture of membranes
Gestational hypertension/ Pre-eclampsia

Figure 3: Absolut contraindications of aerobic exercise during pregnancy.

Dyspnoe
Dizziness/ nausea
Chest pain
Weakness
Vaginal bleeding
Premature labor
Decreased child movement
Suspected premature rupture of membranes

Figure 4: Warning signs to immediately stop exercising.

Maternal age (years)	Target zones of heart rate (bpm)
< 20	140 - 155
20 - 29	135 - 150
30 - 39	130 - 145
> 40	125 - 140

Figure 5: Target zones of heart rate for pregnant women during endurance training depending on age.

Intensity		Activity	Duration (hours/week)	Energy consumption (MET)
Easy	2.5 MET <10.4 ml/kg/min	3.2 km/h walking	6.4 – 11.2	16 - 28
Moderate	3 - 6 MET 10.5 - 21 ml/kg/min	4.8 km/h walking	4.5 - 9	16 - 28
Heavy	6 - 7 MET >21 ml/kg/min	7.2 km/h walking 8.0 km/h jogging	4 3.5	28 28

Figure 6: Training of physical activity according to intensity.

The aim of exercise during pregnancy should not be set on improving one's physical performance, but on preserving the existing trainings level. Previously active women can continue their aerobic endurance program without facing any complications during pregnancy. Sportive, inactive pregnant women planning to adapt a healthy lifestyle should not start exercising prior to the second trimester. In the second trimester, the symptoms of early pregnancy are often nausea and fatigue [1]. Consequently, even unsportsmanlike women should slowly increase the intensity of their sports activities. For this purpose, the heart rate zones (Figure 2) and the subjective perception, e.g. on the basis of the so-called Borg scale can be used. In addition, however, physical parameters should also be considered, e.g. the number of child movements with a base rate of ten to twelve per hour [22].

Recommended Types of Sports

Not every type of sport is suitable for a pregnant woman. The election of adequate activities essentially depends on the type of movement and the potential risk of injury [11]. Recommended are aerobic endurance sports with a continuous load such as hiking, walking, jogging, Nordic walking, cross-country skiing, gymnastics and cycling [11,2,22,1]. In addition, swimming has been proven a good choice as it is particularly gentle on the joints and leads to a redistribution of the plasma volume due to the hydrostatic pressure. This causes an increased kidney circulation with an elevated micturition and a reduction of edema [21,1]. It is important to ensure a pleasant water temperature between 20 and 33 ˚C degrees. There are also no objections to a moderate strength training using free weights or machines during pregnancy [42,2,22,1]. Notably, heavy weight training and isometric exercise with maximum load should be avoided as it increases intra-abdominal pressure and causes fetal deficiency. It is however of importance to follow the right breathing technique during strength training. Again, to avoid an intra-abdominal pressure increase, a belly breathing and so-called Vasalva maneuver should be avoided. Beginning with the 28th week of pregnancy, exercises in a supine position should be excluded accounting for a possible vena cava compression syndrome [11,6].

Furthermore, the lifestyle sports enjoying a growing interest such as yoga and pilates are recommended during pregnancy. Yoga and pilates lead to an enhanced increased body control, intensified strength and elasticity without the risk of damaging joints. Pilates is possible in any stage of pregnancy also as a beginner in this exercise method [43].

Unsuitable Sports

All team sports and combat or contact sports can be classified as high risk activities for pregnant women. Body contact implies a risk of abdominal trauma with fetal injury. Also, sports associated with a higher risk of falling such as horseback riding, climbing and alpine skiing should be refrained from. Additionally, leisure sports with abrupt changes of direction such as tennis, squash and table tennis should not be continued as these negatively influence the laxer musculoskeletal system. Attempts should also be made to avoid altitudes over 2500 meters and extreme climatic conditions [11,2,22,1].

Postpartum Phase

Recent studies have shown that the birth process of female athletes is not always protracted. However, there is the possibility of a prolonged expulsion phase, whereas the entire birth process is shorter. In addition, female athletes better compensate with pain during childbirth, which in combination with an improved body feeling, significantly reduces the duration of birth [11,22]. Studies also show an uncomplicated course of the puerperium in athletic mothers. This has reasons such as a superior physical constitution as well as a much lower rate of mental illness and postpartum depression [2,6,1,33]. The resumption of sportive activities can take place four weeks after delivery with an inconspicuous childbed. A focus should be set on the training of the pelvic floor muscles. Training should be started slowly and consistently and be carried out over a total of six months. Another focus area is the diastasis recti, which continuously regresses under constant training.

Overall, the tendon, ligament and muscle apparatus must be slowly restored [22]. The resumption of the original scope of

training varies individually and should be adjusted in agreement with the respective trainer and the supervising gynecologist, especially in the case of competitive athletes [22]. Breast feeding mothers need to increase their drinking volume once more when taking an intensive exercise program to meet the additional fluid requirements. It must also be kept in mind that one can expect an acid mother's milk caused by an increased level of lactate [6,22].

Conclusion

Sport in pregnancy has been seen controversially for centuries. Taking into consideration studies published over the last thirty years, physical activity even appears constitutional while continuing competitive sports - with certain restrictions - seems possible during pregnancy. With an inconspicuous course of pregnancy, the benefits of a sporty lifestyle clearly outweigh the risks. Meanwhile, it is recommended that even unsportsmanlike women take on mild aerobic physical activities starting with the second trimester to reduce the risk of GDM, pregnancy-induced hypertension, and excessive weight gain [11,1,44,27,26,34].

Especially overweight and obese people benefit from a combination of exercise and diet during pregnancy to prevent metabolic complications [22,26]. A sports program should be of a duration of at least 30 minutes and carried out on three days a week. For a maximum effect, a MET of 28 a week is recommended [22,36]. The ACOG has summarized in its guidelines a number of suitable and unsuitable sports. It may be necessary to switch to a different type of sport than previously practiced [1,2]. Recommended sports are e.g. jogging, cycling and swimming (Table 1). Competitive athletes should refrain from competitions, adjust their training schedule accordingly and require special medical supervision [2,6,22,1]. The fact that physical activity has beneficial effects and even an intense physical activity such as interval training combined with weight training is not obsolete, should be communicated and stressed by physicians, gynecologists and pediatricians, as well as midwives and coaches [6,22].

Recommended Sport		Unsuitable Sport	
Hiking	Walking	Rowing	Horse riding
Jogging	Nordic walking	Tennis/ Squash	Golf
Cross-country skiing	Aerobic	Climbing	Inline-Skating
Cycling	Swimming	Full contact sport	Ballsports
Moderate resistance training		Athletics	Marathon/ Triathlon
		Diving	Gymnastics

Table 1: Overview of recommended and unsuitable sports during pregnancy.

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