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RESEARCH ARTICLE

Physical Activity During Pregnancy: Physiological Considerations and Practical Guidelines

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ABSTRACT

Physical activity is a crucial element in preventing and coping with several chronic conditions. Many women become aware of their health issues as they plan pregnancy or become pregnant and consult their physician regarding limitations and recommendations in this situation. This review intends to endow the consulting general practitioner and obstetrician, as well as midwives with the background knowledge for this encounter. It details the physiological changes of pregnancy with regards to physical activity and deals with the range of allowed activities and the major risk groups who should be given special concern. In general, the best judge of a woman's ability to perform physical activity is her subjective feeling of appropriateness of a given effort.

Keywords: Physiology of pregnancy; Physiology of Exertion; Borg Scale

Introduction

Physical activity is a crucial element in preventing and coping with chronic conditions, such as cardiovascular disease, diabetes mellitus, and obesity. It was also documented to reduce the prevalence of some malignancies (1). In general, physical activity should become part of healthier lifestyle for people living in industrialized countries and exposed to all sorts of temptations for a less cautious conduct regarding their health. Naturally, women become aware of their health issues as they plan pregnancy or become pregnant. Some women come up with the intention to establish active lifestyle during the new pregnancy, hence approaching their physician regarding the advisability of certain activities, whereas others are concerned whether continuation of their current lifestyle and sport activity would be harmful or beneficial to their new or planned fetus. Dipietro et al (2) on an extensive review and meta-analysis found that moderate-intensity physical activity reduced the risk of excessive gestational weight gain, gestational diabetes, gestational hypertensive disorders, and symptoms of postpartum depression, antenatal anxiety, and depressive symptomology.

This review intends to endow the consulting general practitioner and obstetrician, as well as midwives with the background knowledge for this encounter. It details the physiological changes of pregnancy with regards to physical activity and deals with the range of allowed activities and the major risk groups who should be given special concern. In general, physical activity is highly recommended during pregnancy, whether as a newly established routine or as continuation of previous active habits.

Physiological Changes During Pregnancy

Herein we review the changes in those systems which are relevant to physical activity.

The Cardiovascular System

The leading changes during pregnancy are expansion of plasma volume, increased cardiac output, decreased peripheral resistance, and increased uteroplacental blood flow, reaching the maximal rate of change during weeks 24-28. These changes materialize due to placental secretion of the hormones estradiol, progesterone, human chorionic gonadotrophin (hCG) and relaxin, as well as the growth factors vascular endothelial growth factor (VEGF) and placental growth factor (PlGF) and the local effect on uterine blood vessel architecture towards expansion and dilatation (3). The resultant change in calculable indices is increase of preload and decrease in afterload. At the primary clinical setting this leads to a reduction of blood pressure by 5-10 mmHg during the first and second trimesters of pregnancy, which returns to normal during the third trimester [4]. A related process, taking place most pronouncedly during the second trimester is the increase in erythrocyte production, caused by an increase of erythropoietin in the kidneys. Altogether these changes culminate in the delivery of nutrients and oxygen to the placenta and the fetus in turn. All these operate up to the level of moderate physical activity and even boosted by it, as a result of muscle squeezing and overall increased cardiac output, accompanied by better extraction of oxygen from the placental bed to the fetus [5]. The combination of pregnancy and physical activity was shown to increase the maximal oxygen consumption (VO2Max) by 5%-10% [6]. An additional adaptation, which increased by physical activity is an increase in the proliferation rate of placental cells, allegedly induced by increased exchange rate across the placenta(7).

Core Body Temperature Regulation

The vasodilation in the skin, concomitant to the central cardiovascular changes is a significant aid in heat dispersion, in turn preventing fetal exposure to relative hyperthermia. Thus, when a pregnant woman performs her activity in thermoneutral environment her gestationally-adapted cardiovascular system can maintain a core temperature that is protective to the fetus(7, 8 9, 10). In 40 women at 25.4 weeks of gestation who performed low impact

physical activity, no increase of core body temperature was recorded and despite some decrease in oxygen saturation during peak effort, no reduction below 95% was recorded(10). In a longitudinal study at weeks 8, 15, 22, 36 and postpartum using ergometric bicycles at an exertion level of 85% age predicted maximal heart rate, it was recorded that core body temperature decreased from pre-pregnancy to the puerperium (after birth) as the result of lower difference between minimal and maximal core body temperature(11). Caution should be exercised in extrapolation to the first trimester, since no studies tested women performing physical exertion during this sensitive phase of gestation. A recent meta-analysis by Ravanelli at al.(12) of 12 publications reporting 347 exercising pregnant women, found that the highest recorded core temperature was 38.9°C and the end-trial mean temperature was 38.3°C, a good 0.7°C below the hypothetical teratogenic level. Addressing more extreme environmental conditions Smallcombe et al.(13) tested 30 women of whom half were pregnant during 2nd and 3rd trimesters at 32°C with 45% humidity for 45 min at moderate-intensity exercise, once with weight bearing and once without it. The highest core temperature they found at the end of exercise was 37.93°C with a small difference at the end of exercise between pregnant and non-pregnant women. An additional element of core temperature regulation, sweating, was concomitantly tested by this group. Whole-body sweat loss was not different for pregnant women during weight bearing effort but was lower for the pregnant women during non-weight bearing exercise. They concluded that even at these relatively extreme environmental conditions, pregnant women are safe performing protracted physical activity at moderate intensity.

The Respiratory System

The gestationally induced changes in the respiratory system culminate in an increased rate of gas exchange and maintenance of the acid/base balance in both mother and fetus. Lung ventilation increases 50% by the end of pregnancy, attributable mostly to the increased sensitivity of CO2 receptors in the central nervous system that is caused by the elevated progesterone levels. Additionally, the oxygen dissociation curve from hemoglobin shifts to the right and downwards, which allows easier release of oxygen to the perfused tissues(14), enabling in turn higher oxygen consumption by fetal organs. All the above changes are compatible with better coping with the demands of physical activity.

Despite shortness of breath that many women experience during pregnancy, attributable not only to progesterone's effect but also to the increased volume of the uterus and the resultant elevation of the diaphragm, the elevation and widening of the ribcage compensate for these and respiratory capacity remains stable and even increases(15). Furthermore, physical activity during pregnancy elevates the threshold beyond which the contribution of the anaerobic metabolism surpasses the aerobic one and growth exponentially. The latter in turn delays the appearance of fatigue(16).

Altogether, the combination of changes in the cardiovascular and the respiratory systems allows the healthy pregnant woman to indulge physical activity in which the aerobic element is dominant. However, all these changes weaken the reliance on heart rate as an indicator for the adequacy of effort since heart rate is increased at the outset. As a practical substitute for this serves the Borg Scale, which relies on the subjective rating of perceived exertion (RPE). The level that is recommended to pregnant women is 13-14 on this scale.

Fetal Response to Maternal Physical Activity

Experiments in rodents revealed that anaerobic conditioning of the pregnant female results in litters with better aerobic capacity and general physical fitness. Specifically, the maternal programing affected the fetal cardiac output, macrovascular compliance, and oxidative skeletal muscles capacity. A measurable effect was also noted on the vasodilatory ability of the vascular endothelium. On the histological level, Liu et al.(17) found that the density of capillaries in fetal muscles was not affected by

maternal physical conditioning but the mitochondrial count and the overall level of the oxidative enzymes of the Krebs cycle was increased, resulting in better oxygen extraction (grater A-V O2 difference). A study on 12 women who were diagnosed with uteroplacental insufficiency during weeks 22-26 and were put to work on ergometric bicycles for intervals of 5 minutes at heart rate of up to 90% of age predicted maximum heart rate, disappearance of end diastolic flow was noted in 4 fetuses, but no change of fetal cardiac output (18). Fetal heart rate of less than 110 BPM might indicate fetal compromise. Interestingly enough, studies on fetal response to mild maternal exertion for up to 30 min during the 2nd and 3rd trimesters, found slight to moderate increase of fetal heart rate (15). Another study (6) in women at weeks 33-38 of their pregnancy who underwent gradual exertion study also found an increase of 10-15 BPM in fetal heart rate. In the latter study it was also recorded that after cessation of exertion it took an average of 14 minutes for return to baseline of 14 min. During this study no case of fetal bradycardia was observed. When tested by other researchers, high intensity, prolonged exertion can lead to transient decrease in fetal heart rate with it attendatd reduced overall supplies to the fetus(19).

Type of Maternal Physical Activity During Pregnancy

Until relatively recently the common belief held that pregnant women who wish to benefit their cardiovascular and respiratory systems should better stick to aerobic, long duration physical activity. It is now already accepted that moderate-to-vigorous resistance exercise does not jeopardize the health of healthy pregnant women and the fetus during pregnancy, but appears to be appropriate for healthy pregnancy(20, 21, 22).

Physical Activity, Fetal Growth, and Premature Delivery

Duncombe et al.(23) reported that women who perform regular physical activity do not suffer from higher rate of miscarriage and do not tend to deliver earlier or later than their due date. Women who train at high levels of intensity before pregnancy and continue during it did not have higher rates of miscarriage or heart defects in the fetuses, but in those training on the olympic level (90% of maximal age predicted heart rate) there might be some restriction of fetal size(24). Guillemette et al.(25) on a wide scope meta-analysis found that large observational studies did not show an effect of training on clinically relevant offspring outcomes. The smaller numbers reported by RCTs followed the same lines, to indicate no deleterious effect of physical activity during pregnancy. Regarding the combination of resistance training with aerobic training Perales et al.(26) reported a meta-analysis of 61 RCTs that indicated a benefit of the combination on maternal cardiorespiratory fitness, but no consistent effect on fetal outcome. Examining the effect of excessive body mass Perales et al.(27) also found that it can offset the cardiometabolic benefits of gestational exercise. Overall, the group led by Barakat, who performed several studies on the effects of combined resistance and aerobic exercise during pregnancy concluded that (28) for many aspects, whether in healthy pregnant women of those with gestational and pre-gestational pathologies, physical activity is beneficial.

Physical Activity and Diabetes Mellitus During Pregnancy

Diabetes mellitus is the most common pathology during pregnancy, whether pre-gestational or gestational(29). Its prevalence as a general pathology is increased in the industrialized countries, in line with the trend of body mass index (30), reaching 14% worldwide. Women who adhere to regular physical activity are at a lower risk of developing gestational diabetes, compared to inactive pregnant women(31). Furthermore, when diabetes accompanies pregnancy, whether before conception or that which is induced by pregnancy, physical training reduces the specific complications of diabetes in pregnancy(32, 33). This effect is attributable to

several elements: increase of muscle diameter, increase of glucose transporter IV density on muscle cell membranes, reduction of intra-abdominal fat, and increased muscular sensitivity to insulin's effect(34). Although the ideal mix and dosing of physical activity during pregnancy, it is clear that it dose-dependently reduces the occurrence of gestational diabetes by 50%(35, 36, 37). Researchers postulated that this may result from a stimulation of placental growth and associated uterine vascularity, in turn reducing oxidative stress. The further beneficial effect of higher intensity training is supported by a study by Flack et al.(38).

Physical Activity and Hypertensive Disorders During Pregnancy

Hypertensive disorders of pregnancy, including gestational hypertension and pre-eclampsia, occur in up to 10% of pregnancies and are associated with increased life-long cardiovascular risk (39). In a large study Arvizu et al 40) studied 842 women with preeclampsia and 905 women with gestational hypertension and found that physical activity before pregnancy was related to a lower risk of hypertensive disorders of pregnancy (relative risk 0.75). In a large meta-analysis Davenport et al (41) found that exercise reduced odds of gestational diabetes mellitus to 0.62, odds of gestational hypertension to 0.61 and odds of preeclampsia to 0.59, compared with no exercise. Whether physical activity and training during pregnancy can prevent GH and PE, remains to be established, but no doubt that the state of mind of women during pregnancy provides a unique opportunity to preach the benefits of this lifestyle alteration 39; 2).

How should look a reasonable program of training for a pregnant woman?

The goal of a reasonable program of physical activity for a pregnant woman should take into consideration her current status of activity and her past experience with physical activity. A pregnant woman who wishes to begin physical activity program while already pregnant should consult a physician, whether a general practitioner or an obstetrician, and should be initially followed by an experienced guide, who should familiarize her with the principles of the Borg scale. The initial step in these circumstances should be done in a training room on power machines that allow wide range of motion with low to moderate resistance. At the next stage weightlifting with free weights can be introduced gradually to achieve synchronization of the active muscles, in turn improving balance and gait. The above notwithstanding, low back pain is a frequent companion of pregnancy. Putting an emphasis of strengthening core torso muscles can prevent this and can improve birthing experience, as physically stronger women cope better with the demands of the final stage of birth(42). In addition, a general strengthening of torso musculature involves a significant improvement in the function of the pelvic floor, in turn improving continence during pregnancy and after birth(43).

At the outset it should be noted that some women who stuck to extreme levels of activity went even all the way to participate in Marathon events. Yet, this is by no means the rule. The recommended level is 3-4 times a week on alternating days to allow optimal recovery(44). It is advisable to train all major muscle groups on each training day and not to alternate between lower and upper body muscles. New commers should begin from one set at a time and advance to two and three later. Recovery between sets should span about two minutes, to allow return of heart rate to baseline. Exercise should be in all three dimensions and includes various instrumentation, such as rubber bands, cables and free wights, and machine trainers.

As joint laxity is increased during pregnancy, load should be attenuated. Hence, only 70% of repetition maximum is allowed, i.e. 10 repetitions for each set. Doing this, the load will be challenging but would not bring to absolute fatigue. A specific concern is not to reach the level of load that would lead the training woman to perform the Valsalva maneuver as this reduces venous return and can affect

uterine blood supply. A specific instruction session should be dedicated to teaching the trainee to exhale during effort. Each push should be slow to moderate, lasting about 2 sec for shortening and 3 sec for elongating. It is important to move between the sets and not to sit idly, which might lead to lowering of blood pressure and cardiac output.

Some specific points for training routines. Each training session should begin with 5-10 light aerobic warming up and should be concluded with a comparable light relaxing motion period. As joints are laxer during pregnancy, exercise should not include efforts in the form of ballistic efforts or weightlifting at extreme load. Lifting weight above head is prohibited beyond the first trimester as it may challenge the lumbar spine, which is already strained by the gestation-associated increased lordosis. In addition, supine exercises should be shorter than 1-3 min during the 3rd trimester, as this jeopardizes venous return to the heart and the consequent reduced uterine blood supply. Finally, all exercises and transition from place to place should be done at a pace that considers the pregnant woman's altered balance and motion abilities.

Conclusion

This short review aimed to briefly present the maternal physiological changes during pregnancy and the impact of physical activity on both mother and fetus. It concluded with practical guidelines and recommendations, useful for the primary physician caretaker to advise his/her patients.

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