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RECOMMENDATIONS

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Polish Society of Gynecologists and Obstetricians (PTGiP) and Polish Society of Sports Medicine (PTMS) recommendations on physical activity during pregnancy and the postpartum period

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INTRODUCTION

Regular physical activity during pregnancy brings numerous health benefits for both the mother and her child [1–3]. Such behavior is safe for most patients without specific contraindications to physical activity. Therefore, exercise is currently perceived as a key lifestyle component that supports the normal development of pregnancy and reduces the incidence of pregnancy complications.

Women with uncomplicated pregnancies are advised to engage in at least 150 minutes of moderate-intensity physical activity per week (*e.g.*, brisk walking, swimming, resistance training/body toning exercises, gardening) throughout their pregnancy, accumulated over three or more days per week [3–5]. If failing to achieve this goal they should be encouraged to do any physical activity each day to minimize sedentary behavior [3, 5].

Regular physical activity is associated with improved cardiorespiratory fitness and reduced risk of pregnancy-induced hypertension, preeclampsia, gestational diabetes, and excessive weight gain in healthy pregnant women. Those who engage in regular physical activity are significantly more likely to give birth by vaginal delivery, are less likely to suffer from urinary incontinence or depression and find it easier to return to their pre-pregnancy body weight after delivery [2, 6]. There is also strong scientific evidence that moderate-intensity physical activity during pregnancy is not associated with pregnancy loss, miscarriage, preterm delivery, premature rupture of membranes, neonatal death, low birth weight, perinatal damage to the mother or the incidence of labor induction [2, 5]. In addition, exercise during pregnancy can be a preventive measure for both the mother and her child against chronic conditions such as obesity, type 2 diabetes and cardiovascular diseases [6–9].

Importantly, women become less physically active with every subsequent pregnancy, failing to observe the recommended volumes and frequency. The most common reasons for this are feeling unwell, feeling tired, having too little time available or low motivation to exercise, and being uncertain of whether exercise is safe for the mother and

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child. In addition, women often report that their pregnancy care providers do not offer enough information on physical activity. This may be due to the latter having insufficient knowledge on the subject and their concern that exercise may be detrimental to the mother and fetus [2]. Hence, it is extremely important to adequately educate both pregnant patients and the personnel responsible for pregnancy care provision.

ANATOMICAL AND PHYSIOLOGICAL ADAPTATIONS TO PREGNANCY IN THE CONTEXT OF PHYSICAL ACTIVITY

Pregnancy is associated with anatomical and physiological changes that must be considered when planning physical activity during this period. The most significant anatomical changes are weight gain, anterior displacement of the center of gravity with an increased lumbar lordosis, and a loosening of the ligamentous and articular systems. This puts stress on some joints, including the spine — mainly the lumbar segment and the pelvic girdle — and increases the risk of falling. The latter is the most common cause of injury in pregnant women in the second and third trimesters and can lead to negative health consequences for both the mother and child. The risk of falling is higher in women who do not exercise during pregnancy than in those who do [10]. This is most likely due to a poorer posture, worse balance and longer reaction times in non-exercisers [11]. Therefore, it is important to do such exercises during pregnancy that will help reduce the risk of falling. Engaging in new sports or those that impose high technical requirements is not recommended. Women who, prior to their pregnancy, practiced sports entailing the risk of falling or contact sports should modify their training plans to minimize the possibility of sustaining injury [12].

Approx. 50% of pregnant women suffer from lower back and pelvic girdle pain, often causing them to avoid exercise. Many reports have proven that physical activity reduces the severity of these complaints [9, 10]. During the third trimester of pregnancy, the increased weight and stress on the joints implicates considering non-weight bearing activity, such as aquatic or stationary bicycle exercise [11].

The cardiovascular system begins to change in the fifth week into gestation [4]. The heart rate accelerates by an average of 10–15 beats per minute. Peripheral resistance decreases, which can result in lower blood pressure and in symptoms of hypotension when the patient's position changes suddenly (especially from lying to sitting or standing) or when they are standing without moving for a prolonged time. Exercise should not end abruptly, and it is recommended that the intensity in the final part of the exercise session should reduce gradually [13–16]. In the third trimester of pregnancy, the growing uterus can compress the inferior vena cava, mainly in the supine position. Decreased blood pressure or malaise occurring while in the supine position affects 10% of women [4]. This group should avoid remaining supine for longer periods of time. The available research suggests that exercise in the supine position is not associated with negative consequences for the course of pregnancy or the development of the fetus [17]. Nevertheless, those women who are uncomfortable in this position (either in physical or mental terms) should avoid such activity [4]. Tachycardia, jugular venous distention, slight shin edema, leftward displacement of the apex beat, and systolic heart murmur along the left side of the sternum are physiological occurrences during an examination of pregnant patients lying in the supine position [15].

The fetus produces additional heat that must be removed. In addition, fetal temperature maintenance is dependent entirely on the mother's management of her own temperature. The pregnant woman dissipates heat more easily by way of increased blood flow through the skin, elevated respiratory rate, and more abundant perspiration, which is associated with a resetting of the thermoregulatory center [18]. Elevated temperature (> 39°C) during pregnancy may be associated with abnormal embryogenesis and fetal congenital defects. Its impact on neural tube formation is of particular significance [18]. Recommendations as to the conditions of physical activity, its duration and its effects on fetal temperature are provided in the following chapters.

Diastasis recti abdominis is a separation of the linea alba found in 66–100% of women in the third trimester of pregnancy and 39% of patients 6 months after delivery [19, 20]. To date, there has been no consensus among researchers as to what width of the linea alba should be considered a pathology and require intervention [21, 22]. Recommendations as to abdominal muscle exercise in pregnancy are provided in the following chapters.

ASSESSING THE PREGNANT WOMAN AND FETUS

At her first visit during pregnancy, each patient should be notified about the benefits of physical activity in pregnancy. In the absence of complications or obstetric or general medical contraindications, exercise in pregnancy is safe and desired, while pregnant women should be encouraged to continue or commence safe physical activity. The intensity and type of exercise should be individualized. In order to be able to discuss the scope of safe exercise with the patient, the risks to her pregnancy should be assessed first. Particular caution should be maintained with regard to women with high-risk pregnancy, where the choice of the type and intensity of exercise must be made under the supervision of specialists.

Table 1. Pregnancy risk assessment based on the patient's history and medical examination. (Modified from the perinatal care standard provided for in the Health Minister's Order of 16 August 2018 on the organizational standard for perinatal care. Identification of risk factors for perinatal complications) [26]

The risk factors identified through the patient's medical history taken during pregnancy and prior to delivery include, in particular:
1. Her conditions, in particular cardiovascular diseases, blood hypertension, kidney diseases, neurological diseases, mental and behavioral disorders, liver diseases, diabetes mellitus, coagulation defects, thrombophilia, antiphospholipid syndrome, and obesity
2. Active HIV or HCV infections
3. Status post fertility treatment, at least two consecutive spontaneous abortions, or preterm labor
4. Previous stillbirth or delivery of a neonate with severe birth asphyxia
5. Previous delivery of a neonate weighing more than 4 000 g, or contrary — with a very low or extremely low birth weight
6. Multiple pregnancy
7. Bleeding prior to delivery, status post such complications as placenta previa or placental abruption
8. Status post uterine surgery or surgery of the lower segment of the reproductive system, birth canal injuries, uterine atony, postpartum hemorrhage, convulsions, thromboembolic conditions or uterine inversion
9. Where the pregnant patient is a multigravida of over 40 years old or a multigravida having delivered 4 children
10. Chronic infection (also suspected) in the pregnant woman or a body temperature exceeding 38°C more than once during pregnancy
11. Use of psychoactive substances, medicinal products, alcohol or nicotine during pregnancy and in the period immediately preceding pregnancy
The factors identified during pregnancy and prior to delivery based on an examination include, in particular:
1. Systolic pressure exceeding 140 mmHg and diastolic pressure exceeding 90 mmHg, proteinuria higher than 0.3 g/24 h
2. Weight gain of more than 500 g per week in the last trimester
3. Pyelonephritis
4. Anemia
5. Diabetes mellitus
6. Previous or ongoing vaginal bleeding
7. Blood type incompatibility between the mother and the fetus
8. Inadequacy of the size of the uterus or the size of the baby in relation to the duration of pregnancy (problems in determining the precise due date, fetal growth restriction, fetal macrosomia, polyhydramnios, oligohydramnios, myomas, multiple pregnancy, cephalopelvic disproportion)
9. Threatened preterm labor (premature uterine contractions, incompetent cervix)
10. Abnormal location of the placenta
11. Multiple pregnancy with fetuses in abnormal positions
12. Pregnancy past the 41st week, or uncertain due date

HIV — human immunodeficiency virus; HCV — hepatitis C virus

Such pregnancies are classified as either low- or high-risk. The pregnancy risk assessment must follow the perinatal care standards (Tab. 1) [23]. Based on medical history and examination, the obstetrician-gynecologist/perinatologist may issue a pregnancy risk certificate — a template is shown in Figure 1.

The management of an uncomplicated pregnancy in a healthy patient engaged in moderate-intensity sports should not differ in any way from the recommended standard of perinatal care in Poland. However, patients engaged in vigorous sports should have an additional ultrasound done between 28–32 weeks' gestation and the due date. An examination at 35–37 weeks' gestation is suggested to assess fetal growth. Three meta-analyses showed that differences in birth weight were minimal or nonexistent between women who exercised during pregnancy and the non-exercising control group. However, women who continued to exercise intensely during the third trimester of pregnancy were more likely to deliver babies weighing 200–400 g less, although there was no increased risk of fetal growth restriction [24–26].

There is currently no reliable data available on what supervision over pregnant patients engaged in competitive sports should look like. Studies evaluating umbilical artery blood flows, the fetal heart rate and the fetal biophysical profile before and after vigorous exercise in the second trimester, have shown that 30 minutes of vigorous exercise is well tolerated. Therefore, individualized exercise recommendations may be warranted in pregnant women engaged in competitive sports, but only if intensive supervision of fetal well-being, which should primarily include assessment of fetal growth and vascular flows, is ensured. Pregnant women

First name	Last name		Date of birth	PESEL [personal identity number]
Obstetric diagnosis				
Concurrent diseases				
Additional information (past injuries)				
Low-risk pregnancy				
High-risk pregnancy				
Doctor's first and last names			Stamp	

Figure 1. Template of the pregnancy risk assessment certificate issued by the obstetrician-gynecologist/perinatologist — valid until the date of the subsequent appointment scheduled according to the perinatal care standard or an earlier appointment if recommended by the doctor

continuing their competitive sports regime should be aware that there is insufficient data available on the safety of intense physical activity for fetal well-being, the condition of the newborn, and the child's further development and health. Should any signs occur of the risk of preterm labor, vaginal bleeding or placental insufficiency, the pregnant patient should significantly reduce her sport participation.

If there are complications of pregnancy that may constitute an absolute contraindication to exercise during pregnancy (*e.g.*, significant risk of preterm labor or severe preeclampsia, or placenta previa with episodes of bleeding), continuing normal daily activities is permissible, but participation in more strenuous exercise or activities must be given up [4, 15]. Women with relative contraindications (*e.g.*, a history of preterm labor) should discuss the advantages and disadvantages of moderate- to high-intensity physical activity with their obstetrician-gynecologist/perinatologist.

In summary, healthy women with low-risk pregnancy should always be informed about and encouraged to engage in physical activity. In the case of women with complications of pregnancy, the degree of their recommended physical activity should be individually adjusted according to their type of obstetric-medical restriction. In addition, it would be advisable to avoid putting complete ban on physical activity and preventing the pregnant woman from undertaking any physical activity.

Absolute pregnancy-related contraindications to physical activity

In 2020, ACOG experts removed the list of absolute and relative contraindications to exercise during pregnancy. Instead, they recommend consulting a specialist (*i.e.*, an obstetrician-gynecologist, a maternal-fetal medicine specialist, a doctor of another specialty) should there be doubts regarding exercise safety [5, 27]. With concurrent obstetric diseases or general medical conditions, the exercise regimen should be individualized with the safety of the patient and fetus in mind. Limiting activity in the prevention of primary preeclampsia or preterm birth is also discouraged, which was a common practice in obstetric care (Tab. 2).

Table 2. Obstetric conditions requiring specialist consultation to individualize physical activity and ensure safety for the mother or fetus

Incompetent cervix, cervical cerclage, the pessary
Multiple pregnancy at risk of premature birth
Persistent bleeding in the second or third trimester of pregnancy
Placenta previa after 26 weeks' gestation
Threatened preterm labor
Ruptured membranes
Preeclampsia
Intrauterine growth restriction in the current pregnancy

Absolute non-pregnancy related contraindications to physical activity

Pregnant women with chronic diseases may require modification of their physical activity, but not cessation of it. Therefore, in their case, it is necessary to consult their doctor providing prenatal care and determine further management. Conditions of particular significance here are cardiovascular diseases, poorly controlled asthma, diabetes mellitus, hypertension, severe anemia, uncompensated thyroid diseases, malnutrition, morbid obesity, an extremely sedentary lifestyle, and heavy smoking [18].

EXERCISE PLAN FOR PREGNANT WOMEN

The main assumption of targeted physical activity for pregnant women should be to select exercises in such a way that they are not only safe for the mother and fetus but also bring as many health benefits to the women as possible [28]. In order to be able to respond to the needs of all the participants in group classes, different versions of exercise should be proposed considering the trimester of pregnancy and how it has been developing, and the women's level of skills and psychophysical capabilities. They should be informed both of what the correct technique is for each exercise and how to modify it in case of discomfort or a pregnancy-related complaint [29].

For the general population, a health-promoting exercise program includes endurance exercises (usually aerobic), resistance exercises — to increase muscle strength, stretching exercises, and neuromotor exercise training [30]. For pregnant women, pelvic floor training and labor preparation exercises should be added [31–33]. Pregnant patients fall into the healthy adult category, although they are considered a so-called special population [4]. Thus, the planning and implementation of exercise programs for pregnant women should be guided by the same principles as for other adult populations, sometimes perhaps including slight modifications. The bottom line is to select training components appropriately (Tab. 3 [34]):

- frequency (how many exercise sessions per week?);
- intensity (how intense or tiring are the exercises?);
- time (how long does each exercise session last?);
- type of exercise (what exercises are performed?);
- volume (how many individual exercises are performed, most often per week — as a resultant of the intensity, number of sessions and their duration?);
- progression or modification (how to make progress/ /or how to adjust exercise to the course of pregnancy).

Previously inactive women

The exercise program for pregnant women without previous exercise experience should start with low-intensity activities, such as walking or swimming, initially performed in short sessions (*e.g.*, 15 minutes long). It should be gradually extended to reach the minimum level of physical activity recommended for pregnant women, *i.e.*, 150 minutes per week of at least moderate-intensity exercise [4].

Previously active women

According to World Health Organization and American College of Obstetricians and Gynecologists (ACOG) experts, women who were physically active before pregnancy or regularly participated in higher-than-moderate intensity physical activity may continue to do so, provided that the pregnancy is uncomplicated and there is no discomfort during exercise [3, 4].

Table 3. Elements of recommended physical activity for pregnant women (based on Santos-Rocha et al. [34])

Type of exercise	Intensity	Duration/volume	Frequency	Progression or modification
Endurance exercises				
Exercises that activate large muscle groups in a rhythmic and continuous manner, for example: walking, riding a stationary bicycle, dancing, aerobics, aquatic exercise. Many previous activities can be continued during pregnancy, with some modifications Contact sports carrying a high risk of abdominal injury are not recommended. Similarly, sports entailing a high risk of falling are not recommended Underwater diving is not recommended during pregnancy, either	At least moderate to high, monitored using, for instance, the Borg Rating of Perceived Exertion (RPE)*, the talk test** or heart rate values*** Women with no or very limited previous exercise experience are advised to start with low-intensity exercise and gradually increase intensity to reach the moderate level Women with previous exercise experience can participate in vigorous physical activity, provided that the pregnancy develops normally and is monitored continuously There is no conclusive data on the impact of maximum effort activity or exercises at more than 90% of the maximum heart rate on pregnancy	At least 30 min of moderate-intensity exercise per day, up to a total of at least 150 minutes per week or 75 minutes of high--intensity exercise per week Previously inactive women should start with low-intensity exercise, extending duration gradually from 15 to 30 minutes per day	Previously sedentary women: up to 3 days per week Previously very active women can continue their training programs with the same frequency, provided that the pregnancy develops normally Previously active women: 3–5 days per week, even every day	The patients should avoid activities that pose a risk of falling or injury

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Table 3 cont. Elements of recommended physical activity for pregnant women (based on Santos-Rocha et al. [34])

Type of exercise	Intensity	Duration/volume	Frequency	Progression or modification
Resistance exercises				
A variety of stationary machines, weight-bearing and non-weight bearing exercises, and bodyweight exercises are well tolerated during pregnancy Exercises involving large muscle groups are recommended	For most pregnant women, appropriate intensity will be one that allows multiple submaximal-effort repetitions (*e.g.*, 8–10 or 12–15 repetitions) to be performed until moderate fatigue At the end of the set of repetitions the woman should feel comfortable and have no pain	1 set for beginners 2–3 sets for intermediate and advanced exercisers It is recommended that the basic program include 8–10 exercises for different muscle groups	2–3 non-consecutive days per week	After 16 weeks' gestation, when exercising in the supine position, it should be assessed whether there is compression of the inferior vena cava — in this position the patient may feel uncomfortable, dizzy or weak A safe alternative is to modify the position of the exercise so that instead of lying on her back the patient should assume a lateral recumbent, sitting, or standing position
Weightlifting or intense isometric exercises with a large number of repetitions should be performed with special care, due to the lack of conclusive scientific data on their safety in pregnancy				
Stretching exercises				
A set of active or passive static or dynamic stretching exercises for each musculotendinous junction	The given stretching exercise should be continued until tension or slight discomfort is felt Exercise should not be perceived as painful	In static exercises, the position should be maintained for 10 to 30 seconds (up to 60 seconds) 2–4 repetitions for each exercise	At least 2–3 to 7 days per week	Excessive strain on the joints should be avoided
Neuromotor exercise training				
Exercises developing motor skills, *e.g.*, balance, agility, coordination, gait), proprioceptive training, and all-around exercise regimes (*e.g.*, pilates, yoga, Tai Chi)	Balance training intensity refers to the degree of difficulty of the positions or technical elements being practiced No recommendations for the minimum intensity (and volume) of neuromotor exercise during pregnancy have been developed	20–30 to 60 minutes per day	At least 2–3 to 7 days per week	They can be included in daily activities In the event of a risk of falling or other safety concerns, the patient should exercise under supervision
When doing neuromotor exercises, one should avoid positions that are uncomfortable or pose the risk of losing balance or falling				
Pelvic floor training — see text below				
Comprehensive pelvic floor muscle training should include both conscious contraction and conscious relaxation exercises	The minimum effective intensity (and volume) of pelvic floor exercises has not been determined	10 to 30 min per day	1 to 7 days per week	Can be performed anywhere, anytime, every day Should be included in any pregnancy exercise program
Proper technique for performing pelvic floor muscle exercises should be ensured, and a specialist contacted if necessary				
A variety of pelvic floor muscle exercises should be performed to improve the speed, strength, endurance and coordination of the pelvic floor muscles and to engage both the fast- and slow-twitch muscle fibers				

*The woman can assess her exertion using the 20-point Borg rating (Tab. 4), *e.g.*, as moderate-intensity between 13 and 14 (somewhat hard), or as high-intensity from 17 onwards (very hard) [5, 35]; **Another simple way to assess and monitor exercise intensity is the 'talk test' [36]. If during her activity the pregnant patient can comfortably hold a conversation but cannot sing her exertion is most probably moderate (so-called aerobic); ***Women with previous experience in heart rate monitor use can continue gauging their exercise intensity in this way, although they need to remember that the resting heart rates in pregnancy are often higher than their pre-pregnancy values. The heart rate ranges for individual exertion scopes were borrowed from Canadian recommendations, while the results were obtained in studies of healthy pregnant populations [18] (Tab. 5)

Table 4. 20-Point Borg Rating of Perceived Exertion [35]

Number	Effort
6	No exertion at all
7	Very, very light
8	Very, very light
9	Very light
10	Very light
11	Fairly light
12	Fairly light
13	Somewhat hard
14	Somewhat hard
15	Hard
16	Hard
17	Very hard
18	Very hard
19	Very, very hard
20	Maximum exertion

Table 5. Heart rate ranges recommended for physical activity during pregnancy [18]

Pregnant woman age	Intensity	Range of heart beats per minute
< 29	Low Moderate High	102–124 125–146 147–169
30+	Low Moderate High	101–120 121–141 142–162
Moderate intensity (40–59% HRR)		
High intensity (60–80% HRR)		

HRR — heart rate reserve

PELVIC FLOOR MUSCLE TRAINING FOR THE PREVENTION OF UROGYNECOLOGICAL DYSFUNCTIONS

Pregnancy and childbirth affect the strength of the pelvic floor muscles, urinary system function, urination, and the women's quality of life [37]. Pelvic floor muscle training (PFMT) is an important element of preparing a pregnant woman both for changes occurring in her body as a result of adaptation to pregnancy and for childbirth. Women who do not show symptoms of pelvic floor muscle dysfunction should be trained in the proper exercise of this muscle group and receive clear and accurate instructions on PFMT, best included in a comprehensive health-promoting exercise program. On the other hand, women with incontinence or other pelvic floor dysfunctions, or patients unable to contract their pelvic floor muscles consciously, should be referred for specialist clinical diagnosis by a specialist in the area of her particular dysfunction (*e.g.*, a gynecologist, urologist, proctologist, *etc.*), and subsequently for functional diagnosis and rehabilitation by a urogynecological physiotherapist [38].

Pelvic floor muscle training during pregnancy and after labor can prevent and treat urinary incontinence. The literature on the subject recommends a training protocol compliant with the principles of strength training, emphasizing contractions close to maximal and lasting at least 8 weeks. Notwithstanding, numerous research papers claim that there is a need for further high-quality randomized trials, especially in postpartum women, to determine the effectiveness of the actions taken. Given the prevalence of urinary incontinence in women and its effect on participation in exercise, PFMT should generally be included as a routine part of women's exercise programs. Several systematic reviews and Cochrane reviews implicate there is high-quality evidence of the effective preventive and therapeutic impact of pelvic floor muscle training in urinary incontinence and pelvic organ prolapse in the lesser pelvis [39]. In addition, intense pelvic floor muscle training during pregnancy prevents urinary incontinence both during pregnancy and after labor. Pelvic floor muscle strength improves significantly after intense pelvic floor muscle training [40, 41]. It is worth mentioning, however, that there is no evidence of the effectiveness of exercise regimens other than pelvic floor muscle training in relieving the symptoms of urinary incontinence [42]. According to available studies, pelvic floor muscle training clearly does not prevent damage to the perineum. Further research is needed to examine various protocols and interventions in this area. However, the largest study of pelvic floor muscle training reported a significant reduction in the duration of the second stage of labor, while this intervention also reduced the incidence of urinary incontinence [43]. In summary, pelvic floor muscle exercises used during pregnancy increase the strength of the pelvic floor muscles, prevent the exacerbation of urinary system symptoms, and affect the quality of life of pregnant women [37]. With concomitant dysfunction in the pelvic floor area, pelvic floor muscle exercises should be conducted by a urogynecological physiotherapist.

LABOR PREPARATION EXERCISES, INCLUDING BREATHING AND BIRTHING POSITION EXERCISES

According to scientific reports, skillful breathing and relaxation techniques, explained to and practiced by pregnant women early-enough, can positively affect their sense of self-efficacy and control over labor. They are also likely to reduce the need for pharmacological support, in particular the use of epidurals, and to affect the experience of labor pain. However, there are no valuable scientific reports showing

the effects of these interventions in relation to the improvement of neonatal outcomes. In addition, the role of providing relevant information and focusing on breathing and relaxation techniques in antenatal education is emphasized in research [44]. Regarding breathing, the most frequently suggested techniques are slow and deep breathing during contractions in the first stage of labor and breathing while pushing in the second [45].

As regards the conduct of active delivery, including the use of birthing positions, it is important that non-weight bearing positions that reduce stress on the sacral region (kneeling, four-point kneeling, lateral recumbent position, squatting, delivery in a birthing chair or stool) shorten the second stage of labor [46]. In the second stage of labor, these positions may also reduce the incidence of operative delivery, instrumental delivery, cesarean section, episiotomy, and severe perineal injuries and severe pain, and shorten the duration of the active pushing phase in the second stage of labor. However, these positions may increase the incidence of mild perineal injury [47].

There is no clear agreement among researchers, however, whether the upright or lying birthing positions are beneficial or detrimental to the patient regarding serious or less serious perineal injury. In turn, labor in the lateral recumbent position or with the use of four-point kneeling correlates with higher incidence of complete perineal protection [48]. Researchers have raised the need to leave certain freedom to the patient in childbirth and encourage her to choose her comfortable childbirth position spontaneously [46].

PHYSICAL ACTIVITY IN PREGNANCY FOR OBESE WOMEN — SPECIAL RECOMMENDATIONS

An obese pregnant patient carries an increased risk of complications of pregnancy, labor and puerperium. In this group, hypertension, diabetes mellitus, fetal macrosomia, cesarean section, perineal damage and poor wound healing are observed more often than in pregnant women with normal body mass index (BMI). For these patients, weight gain limitation during pregnancy is of particular importance. The higher the BMI, the lower the desired weight gain should be. Physical activity decreases as BMI increases, and thus it is extremely important that the pregnant woman should be encouraged to participate in any of the forms of physical activity recommended during pregnancy. For obese pregnant patients, exercise is best commenced with 15-minute sessions, gradually extending their duration to 30 minutes to reach the minimum recommended level of physical activity. The best advantages are derived from daily adherence to exercise. Aquatic exercises tend to be popular with obese pregnant women as they help reduce the feeling of their body weight and the stress associated with exposing their own body to the group's view. Moderate-intensity physical effort is recommended to avoid tachycardia and fatigue in pregnant women with obesity [4, 5, 14, 27].

ABDOMINAL MUSCLE EXERCISES

Properly selected and performed abdominal muscle exercises are known to diminish the risk of postural disorders and back pain. What is more, strong abdominal muscles strengthen the abdominal prelum, and thus support the pushing mechanism necessary during natural labor [43]. There is no consensus on which abdominal muscle exercises are most effective in preventing or treating diastasis recti abdominis. Until a standard for the prevention and therapy of diastasis recti abdominis is established, pregnant and postpartum women are recommended to perform abdominal exercises applying the correct technique requiring that abdominal muscle contractions be accompanied by an exhalation, the correct body position (including proper trunk stabilization) be maintained, and a conscious contraction of the pelvic floor muscles be performed [49].

Preventive consultation with a specialist is recommended in order to assess the pathological separation between the rectus abdominis muscles and perhaps individualize the exercise regime. Ultrasound is one of the best methods to assess the separation between the rectus abdominis muscles, which can be combined with a standard ultrasound examination assessing how pregnancy is developing.

SYMPTOMS REQUIRING CESSATION OF PHYSICAL ACTIVITY

Symptoms that require immediate cessation of exercise and an appointment with a doctor include:

- chest pain;
- inexplicable shortness of breath before effort;
- dizziness or headache, feeling faint;
- muscle weakness;
- pain in the calf, accompanied by its swelling and possibly redness;
- sudden swelling of the ankles, hands or face;
- bleeding or a leak of amniotic fluid from the birth canal;
- decreased fetal movement sensation;
- uterine contractions, lumbar or pelvic pain (signs indicating preterm birth) [4].

PHYSICAL ACTIVITY FOR WOMEN WITH COMPLICATED PREGNANCY — LIMITED BED REST RECOMMENDATIONS

Bed rest has historically been regarded as a 'remedy for all pregnancy-related ailments. According to current fact-based medical knowledge, routine bed rest is not recommended. The negative health consequences of this practice have

been reported, among them the risk of venous thromboembolism, bone demineralization and deterioration of the pregnant woman's fitness, as well as negative psychosocial effects affecting not only the mother but also the entire family. There are no studies documenting improvements in outcomes in women at risk of preterm birth prescribed with reduced activity, including bed rest. Based on the available evidence from Cochrane reviews, it is believed that recommending bed rest to treat pregnancy complications may be considered as an unethical approach [50–52].

POSTPARTUM ACTIVITY

In the first hours after labor, the mother should be instructed on how to exercise to assist her postpartum convalescence and, in the absence of medical contraindications, perform lower extremity edema exercises as part of antithrombotic prophylaxis that includes activating the distal parts of the legs, exercises preparing for regaining a full upright position, those that facilitate regaining and maintaining the correct body posture, and breathing and functional exercises, including for instance instruction in lifting and putting her baby back to bed. It is recommended that simple exercises should be done while still in the hospital. These are, *e.g.*, hand, arm, trunk, hip and foot circles, and exercises for individual parts of the body in the supine position on the bed. The selection of these exercises, as well as their intensity and range of motion, should consider how the labor progressed, whether there were any complications thereof, and whether the postpartum woman has any functional and health limitations, *e.g.*, ones related to cesarean section, episiotomy or perineal tear.

In order to prevent pelvic floor muscle dysfunction, in the absence of medical contraindications the patient should commence exercising this muscle group as soon as possible [5, 31]. The woman is allowed to continue to exercise the pelvic floor muscles with the same volume, frequency and intensity as those recommended for pregnant patients, if there are no contraindications related to how the labor progressed or associated with the surgical treatment of the perineum that she received [53]. Women with no previous pelvic floor muscle exercise experience should receive appropriate instruction in how this should be done. A preventive appointment with a urogynecological physiotherapist is recommended to exclude dysfunction of this muscle group and individualize the exercise regime. Ideally, the first consultation assessing the pelvic floor with a qualified specialist should take place in the maternity ward before leaving the hospital following childbirth, and subsequently continue in the postpartum period and, if necessary, also after its completion.

If there are no medical contraindications after returning from the hospital following childbirth, the woman should gradually return to physical activity in order to accumulate a minimum of 150 minutes of moderate-intensity exercise per week as soon as this becomes possible [4]. The time to commence the exercise, as well as its intensity and frequency, are determined by the woman's well-being and health [54]. As a rule, those women who were active during pregnancy will be quicker to return to their pre-pregnancy or antenatal activity levels compared to those who did not exercise during gestation. Due to the high probability of pelvic floor muscle dysfunction, including in particular stress urinary incontinence, it is recommended that in the first 4–6 weeks after childbirth the mother should participate in the so-called low biomechanical load activities, such as walking, Nordic walking, dancing, inline skating, cycling (after the perineum has healed), and resistance exercises. The patient's return to more dynamic forms of activity that entail running or jumping, such as jogging, running, tennis and team games, should be adjusted to how the postpartum convalescence is progressing, and be contingent upon full recovery of pelvic floor and abdominal muscle function, as well as complete healing of the C-section or episiotomy or other perineal wound.

After returning from the hospital, women in an uncomplicated postpartum period can gradually return to resistance exercises they participated in prior to pregnancy. It is recommended to do sessions of at least 5 to 10 minutes between 3 to 5 times per week. The sessions are supposed to be performed alternately (it is wrong to limit oneself to, for example, abdominal muscle exercise). The exercises are to be performed in sets, starting from 1–2 sets of, *e.g.*, 4–6 repetitions, increasing to 2–3 sets of, *e.g.*, 12–16 repetitions. Any progression of difficulty and volume will depend on the characteristics of the patient's physical activity during pregnancy, as well as her well-being and individual needs.

If the woman had a C-section, the recommendation is that the exercise program should be individualized, preferably with the support of a physiotherapist, considering the size of the wound and how it has been healing. The program should start with low-intensity exercises and with a very small range of motion, so that no discomfort or pain is caused in the area of the post-operative wound. Exercise intensity, volume and range of motion should be gradually increased, depending on the woman's well-being.

The exercise sessions for breastfeeding mothers must consider their lactation needs and the child feeding times. It is recommended that the baby should be fed, or milk extracted before physical activity is undertaken to avoid breast soreness during dynamic movements. The woman should ensure she wears an appropriate supportive bra and follows proper hygiene of her breasts, also by using nursing pads. Physical activity, including its intense forms, has no adverse effect on the quantity and quality of breast milk [55].

HIGH-INTENSITY PHYSICAL ACTIVITY FOR PREGNANT WOMEN WITH PREVIOUS HIGH-INTENSITY EXERCISE EXPERIENCE AND FOR PROFESSIONAL ATHLETES

We do not establish separate recommendations for intense exercisers, since there are no large studies available exploring their case. Rather, the only source at hand is scientific reports, which is why the decision is always up to the doctor providing prenatal care, the coach, and the pregnant athlete herself. We make sure to carefully emphasize for which activities there is insufficient data to ensure full safety, as it is in the case of, for instance, weights in strength sports. Our recommendations on these issues are consistent with those of other world societies.

Female athletes, especially those involved in endurance sports, exercise at least 10 times longer per week (700–800 minutes of at least increased-intensity training) than specified in the recommendations for pregnant women who do not exercise on a professional basis. In addition, their training regimes often include at least 2 strength exercise sessions, or 100–120 minutes, per week [56].

The most active period in a female athlete's sports career often coincides with her best reproductive years. Therefore, it frequently becomes necessary to reconcile the expectations and objectives she will have in both these areas. A prolonged sports career requires an adaptation of the training plan allowing the athlete to successfully compete during pregnancy, as long as that is found to be safe, then give birth to a healthy child, and finally return to full competitive activity after labor.

The available literature presents a number of well-documented data on endurance training for pregnant women. There is little data on strength training, though.

Basic recommendations are presented below.

Avoid hyperthermia — body temperature above 39°C

Only 25% of the energy consumed by muscles is used for their effective contraction, while the remaining 75% is a by-product in the form of heat that the body needs to dissipate (through perspiration) to prevent hyperthermia. The latter is especially dangerous in the first six weeks of pregnancy (while the woman may be unaware of being pregnant) when the neural groove forms and converts into the neural tube. During this time, body temperature ≥ 39°C poses a risk of nervous system defects (such as myelomeningocele) [57–62].

One should:

- limit duration of swimming sessions to 45 minutes if water temperature is ≤ 33.4°C;
- limit high-intensity physical activity at up to 90% VO_{2max} to 35 minutes if the ambient temperature is 25°C with 45% humidity;
- limit sitting up in a bath (40°C) or hot and dry sauna at temperatures up to 70°C, with humidity up to 15% to no more than 20 minutes.

High-intensity effort at > 90% of maximum exercise capacity

There is no clear evidence in the available literature on whether high-intensity workout at > 90% of the maximal aerobic capacity (VO_{2max}) or the maximum heart rate (HR_{max}) is safe for the mother and fetus. Studies conducted on female athletes have shown that performing three to five submaximal running intervals, with an exertion level of up to 90% VO_{2max}, had no adverse effect on fetal heart function. Temporary bradycardia and a decreased uterine artery pulsatility index were found in fetuses whose mothers exceeded the exertion level of 90% VO_{2max}. However, fetal parameters quickly normalized after the mother interrupted her exercise [63]. In another paper, Anderson et al. assessed maternal-fetal flows and fetal heart rate in a single interval training session with an exertion level of 80–90% of the maternal maximum heart rate. The fetal parameters remained normal throughout the session [64]. Ong et al. [65] analyzed the effectiveness of a single interval session in a group of women in the third trimester engaged in an average level of activity before and during pregnancy. They observed that adding six 15-second intervals of perceived maximum exertion to traditional continuous moderate-intensity training increased its energy expenditure by 28%. In addition, the authors found that the intense intervals increased the women's exercise satisfaction [65]. Despite the growing body of evidence of the health benefits to be derived from well-planned and monitored high-intensity physical activity in pregnancy [66], the safe training intensity threshold is unknown [67–69]. It is not known how brief, frequently repeated bradycardia and reduced placental flow affect the fetus, which is why special care should be taken until the studies that are currently ongoing can confirm the safety of exercise with an intensity of more than 90% of the mother's maximum exercise capacity.

Training volume adjustment to the stage of pregnancy (and time since labor)

According to clinical data, a pregnant competitive athlete's training intensity (in any trimester) that does not exceed > 90% of her maximum exercise capacity during pregnancy is safe for the mother and fetus. The first trimester of gestation (with the mother not always aware of her pregnancy) is the one where the mother has physiologically

the greatest exercise capacity. Many female athletes have achieved their best results in the first weeks of pregnancy — either when they were unaware of their status (athletes with menstrual disorders) or when their pregnancy was scheduled for doping purposes (female athletes from the GDR). In cases of expected and planned pregnancy, female athletes tend to reduce their training load (volume) to, for example, 80% of the pre-pregnancy values, with particular attention to avoiding hyperthermia. Most female athletes return to their training regime already during the postpartum period. The training load should increase gradually after childbirth [55, 62–70].

Suggestions for training volume adjustment in pregnancy:

- first trimester = up to 80% of the pre-pregnancy values;
- second trimester = up to 90% of the pre-pregnancy values;
- third trimester = up to 50% of the pre-pregnancy values.
- suggestions for training volume adjustment after labor:
- first quarter after labor (0–3 months) = up to 40–50% of the pre-pregnancy values;
- second quarter after labor (4–6 months) = up to 90% of the pre-pregnancy values;
- third quarter after labor (beyond 6 months) = full training volume from before pregnancy.

The above values of training loads are only proposals. The female athlete will adjust the training to her health status, the way her pregnancy and labor progressed, her capacity, her well-being, and the competition timetable [71–73].

Strength training load adjustment during pregnancy

During strength training, especially bench pressing, blood pressure increases significantly, with systolic pressure reaching up to 300 mmHg, diastolic pressure up to 150 mmHg, and intra-abdominal pressure up to 150 mmHg [74]. There is little evidence to indicate how these changes in blood pressure can affect the well-being of the pregnant female athlete and the course of her pregnancy, and whether they pose any potential risk. Prevett et al. studied a group of 679 pregnant women who continued weight-lifting training with at least 80% of their maximum load [75]. Their pregnancy complication rates were not different from those of the average population of pregnant women. In the light of the available studies, the length of strength training and the numbers of repetitions need not be limited. However, in individual cases, it will be necessary to reduce the external load applied, also considering the weight gained in pregnancy. The alternative is to use resistance bands instead of weights. To date, there is no accurate data available determining the safe load values in strength training for pregnant women [56–70].

Nutrition and feeding

During pregnancy, starting from the second trimester, the demand for calories and proteins increases:

- in the second trimester, the intake of an additional 10 g/d of proteins and 300 kcal/d (compared to the pre-pregnancy values) is recommended;
- in the third trimester, the intake of an additional 15 g/d of proteins and 450 kcal/d (compared to the pre-pregnancy values) is recommended.

In addition, from the beginning of pregnancy, folic acid and vitamin D should be provided as supplements and the iron balance should be controlled (or iron supplemented, if needed). Exercising pregnant women can and should breastfeed. With proper nutrition, intensive training does not reduce the amount or impair the quality of their milk. The recommended nutrition throughout the breastfeeding period is the same as in the third trimester of pregnancy [62, 76].

Training under hypoxic conditions

There is no data on the safety of altitude training for competitive female athletes. Canadian experts recommend that women living in lowland areas (*i.e.*, below 2,500 m above sea level) should avoid physical activity at high altitudes (> 2,500 m above sea level) [4]. A review of the literature shows that most of the research on physiological responses under altitude conditions has so far concerned pregnant women leading a sedentary or hardly active lifestyle [77]. Therefore, there is a need for research that will allow for establishing recommendations for competitive female athletes regarding altitude training both under natural (in mountainous areas) and simulated (normobaric hypoxia) conditions.

SUMMARY

Physical activity during pregnancy is associated with benefits for both the mother and the developing fetus. In the absence of medical and obstetric contraindications, physical activity during pregnancy does not carry risks and should be performed regularly throughout the entire period of pregnancy. Some modifications to the exercise routine may be necessary to account for the pregnancy adaptations of the woman's body and the needs for the fetus. Physical activity is also crucial for the woman's health after labor. It is necessary that women be motivated to continue or commence physical activity during pregnancy and in the postpartum period. This is the responsibility of doctors, midwives, coaches, and physiotherapists. Cooperation with qualified instructors, coaches, and pregnancy and postpartum physiotherapists is recommended so that specialized exercise programs can be pursued in an effective manner. Both exercising and non-exercising pregnant patients should undergo routine gynecological and obstetric follow-ups in accordance with the accepted standards.

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Conflict of interest

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REFERENCES

1. Díaz-Burrueco JR, Cano-Ibáñez N, Martín-Peláez S, et al. Effects on the maternal-fetal health outcomes of various physical activity types in healthy pregnant women. A systematic review and meta-analysis. Eur J Obstet Gynecol Reprod Biol. 2021; 262: 203–215, doi: 10.1016/j.ejogrb.2021.05.030, indexed in Pubmed: 34058612.
2. Yang X, Li H, Zhao Q, et al. Clinical practice guidelines that address physical activity and exercise during pregnancy: a systematic review J Midwifery Womens Health. 2022; 67(1): 53–68, doi: 10.1111/jmwh.13286, indexed in Pubmed: 34841649.
3. WHO. WHO guidelines on physical activity and sedentary behaviour. World Health Organization, Geneva 2020.
4. Mottola MF, Davenport MH, Ruchat SM, et al. 2019 Canadian guideline for physical activity throughout pregnancy. Br J Sports Med. 2018; 52(21): 1339–1346, doi: 10.1136/bjsports-2018-100056, indexed in Pubmed: 30337460.
5. Physical activity and exercise during pregnancy and the postpartum period: ACOG committee opinion, number 804. Obstet Gynecol. 2020; 135(4): e178–e188, doi: 10.1097/AOG.0000000000003772, indexed in Pubmed: 32217980.
6. Dipietro L, Evenson KR, Bloodgood B, et al. 2018 Physical Activity Guidelines Advisory Committee*. Benefits of physical activity during pregnancy and postpartum: an umbrella review. Med Sci Sports Exerc. 2019; 51(6): 1292–1302, doi: 10.1249/MSS.0000000000001941, indexed in Pubmed: 31095086.
7. Nagpal TS, F Mottola M. Physical activity throughout pregnancy is key to preventing chronic disease. Reproduction. 2020; 160(5): R111–R118, doi: 10.1530/REP-20-0337, indexed in Pubmed: 32805707.
8. https://www.who.int/publications/i/item/9789240015128.
9. Yang X, Li H, Zhao Q, et al. Clinical practice guidelines that address physical activity and exercise during pregnancy: a systematic review. J Midwifery Womens Health. 2022; 67(1): 53–68, doi: 10.1111/jmwh.13286, indexed in Pubmed: 34841649.
10. Barraco RD, Chiu WC, Clancy TV, et al. EAST Practice Management Guidelines Work Group. Practice management guidelines for the diagnosis and management of injury in the pregnant patient: the EAST Practice Management Guidelines Work Group. J Trauma. 2010; 69(1): 211–214, doi: 10.1097/TA.0b013e3181dbe1ea, indexed in Pubmed: 20622592.
11. Brewin D, Naninni A. Women's perspectives on falls and fall prevention during pregnancy. MCN Am J Matern Child Nurs. 2014; 39(5): 300–305, doi: 10.1097/NMC.0000000000000064, indexed in Pubmed: 25137078.
12. Bø K, Artal R, Barakat R, et al. Exercise and pregnancy in recreational and elite athletes: 2016/2017 evidence summary from the IOC expert group meeting, Lausanne. Part 5. Recommendations for health professionals and active women. Br J Sports Med. 2018; 52(17): 1080–1085, doi: 10.1136/bjsports-2018-099351, indexed in Pubmed: 29895607.
13. Davenport MH, Marchand AA, Mottola MF, et al. Exercise for the prevention and treatment of low back, pelvic girdle and lumbopelvic pain during pregnancy: a systematic review and meta-analysis. Br J Sports Med. 2019; 53(2): 90–98, doi: 10.1136/bjsports-2018-099400, indexed in Pubmed: 30337344.
14. Bagwell JJ, Reynolds N, Smith JoA, et al. An exploratory analysis of gait biomechanics and muscle activation in pregnant females with high and low scores for low back or pelvic girdle pain during and after pregnancy. Clin Biomech (Bristol, Avon). 2022; 97: 105705, doi: 10.1016/j.clinbiomech.2022.105705, indexed in Pubmed: 35763890.
15. RANZCOG. Exercise in Pregnancy The Royal Australian and New Zealand College of Obstetricians and Gynaecologists 2020.
16. Kazma JM, van den Anker J, Allegaert K, et al. Anatomical and physiological alterations of pregnancy. J Pharmacokinet Pharmacodyn. 2020; 47(4): 271–285, doi: 10.1007/s10928-020-09677-1, indexed in Pubmed: 32026239.
17. Mottola MF, Nagpal TS, Bgeginski R, et al. Is supine exercise associated with adverse maternal and fetal outcomes? A systematic review. Br J Sports Med. 2019; 53(2): 82–89, doi: 10.1136/bjsports-2018-099919, indexed in Pubmed: 30337348.
18. Dervis S, Dobson KL, Nagpal TS, et al. Heat loss responses at rest and during exercise in pregnancy: A scoping review. J Therm Biol. 2021; 99: 103011, doi: 10.1016/j.jtherbio.2021.103011, indexed in Pubmed: 34420641.
19. Benjamin DR, van de Water ATM, Peiris CL. Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: a systematic review. Physiotherapy. 2014; 100(1): 1–8, doi: 10.1016/j.physio.2013.08.005, indexed in Pubmed: 24268942.
20. Mota P, Pascoal AG, Carita AI, et al. Normal width of the inter-recti distance in pregnant and postpartum primiparous women. Musculoskelet Sci Pract. 2018; 35: 34–37, doi: 10.1016/j.msksp.2018.02.004, indexed in Pubmed: 29494833.
21. Boissonnault JS, Blaschak MJ. Incidence of diastasis recti abdominis during the childbearing year. Phys Ther. 1988; 68(7): 1082–1086, doi: 10.1093/ptj/68.7.1082, indexed in Pubmed: 2968609.
22. Bø K, Hilde G, Tennfjord MK, et al. Pelvic floor muscle function, pelvic floor dysfunction and diastasis recti abdominis: Prospective cohort study. Neurourol Urodyn. 2017; 36(3): 716–721, doi: 10.1002/nau.23005, indexed in Pubmed: 27037746.
23. https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001756/O/D20181756.pdf.
24. Kramer MS, Kramer MS. Regular aerobic exercise during pregnancy. Cochrane Database Syst Rev. 2000(2): CD000180, doi: 10.1002/14651858.CD000180, indexed in Pubmed: 10796173.
25. Lokey EA, Tran ZV, Wells CL, et al. Effects of physical exercise on pregnancy outcomes: a meta-analytic review. Med Sci Sports Exerc. 1991; 23(11): 1234–1239, indexed in Pubmed: 1837326.
26. Leet T, Flick L. Effect of exercise on birthweight. Clin Obstet Gynecol. 2003; 46(2): 423–431, doi: 10.1097/00003081-200306000-00021, indexed in Pubmed: 12808392.
27. ACOG. Physical activity and exercise during pregnancy and the postpartum period. The American College of Obstetricians and Gynecologists (ACOG). 2015; Committee Opinion No. 650.
28. de Castro R, Antunes R, Mendes D, et al. Can group exercise programs improve health outcomes in pregnant women? an updated systematic review. Int J Environ Res Public Health. 2022; 19(8), doi: 10.3390/ijerph19084875, indexed in Pubmed: 35457743.
29. Szumilewicz A, Worska A, Rajkowska N, et al. Summary of guidelines for exercise in pregnancy — are they comprehensive enough for designing the contents of a prenatal exercise program? Current Women s Health Reviews. 2015; 11(1): 3–12, doi: 10.2174/1573404811011509142008838.
30. Garber CE, Blissmer B, Deschenes MR, et al. American College of Sports Medicine. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011; 43(7): 1334–1359, doi: 10.1249/MSS.0b013e318213fefb, indexed in Pubmed: 21694556.
31. Davenport MH, Nagpal TS, Mottola MF, et al. Prenatal exercise (including but not limited to pelvic floor muscle training) and urinary incontinence during and following pregnancy: a systematic review and meta-analysis. Br J Sports Med. 2018; 52(21): 1397–1404, doi: 10.1136/bjsports-2018-099780, indexed in Pubmed: 30337466.
32. Miquelutti MA, Cecatti JG, Makuch MY. Developing strategies to be added to the protocol for antenatal care: an exercise and birth preparation program. Clinics (Sao Paulo). 2015; 70(4): 231–236, doi: 10.6061/clinics/2015(04)02, indexed in Pubmed: 26017787.
33. Akca A, Corbacioglu Esmer A, Ozyurek ES, et al. The influence of the systematic birth preparation program on childbirth satisfaction. Arch Gynecol Obstet. 2017; 295(5): 1127–1133, doi: 10.1007/s00404-017-4345-5, indexed in Pubmed: 28303340.
34. Santos-Rocha R, Corrales Gu, Szumilewicz A, Pajaujiene S. Exercise testing and prescription in pregnancy. In: Santos-Rocha R. ed. Exercise and Physical Activity During Pregnancy and Postpartum Evidence-Based Guidelines. 2 ed. Springer Nature Switzerland AG, Cham, Switzerland 2022: 219–274.

35. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982; 14(5): 377–381, indexed in Pubmed: 7154893.
36. Persinger R, Foster C, Gibson M, et al. Consistency of the talk test for exercise prescription. Med Sci Sports Exerc. 2004; 36(9): 1632–1636, indexed in Pubmed: 15354048.
37. Kahyaoglu Sut H, Balkanli Kaplan P. Effect of pelvic floor muscle exercise on pelvic floor muscle activity and voiding functions during pregnancy and the postpartum period. Neurourol Urodyn. 2016; 35(3): 417–422, doi: 10.1002/nau.22728, indexed in Pubmed: 25648223.
38. Woodley SJ, Hay-Smith EJ. Narrative review of pelvic floor muscle training for childbearing women-why, when, what, and how. Int Urogynecol J. 2021; 32(7): 1977–1988, doi: 10.1007/s00192-021-04804-z, indexed in Pubmed: 33950309.
39. Martín-Rodríguez S, Bø K. Is abdominal hypopressive technique effective in the prevention and treatment of pelvic floor dysfunction? Marketing or evidence from high-quality clinical trials? Br J Sports Med. 2019; 53(2): 135–136, doi: 10.1136/bjsports-2017-098046, indexed in Pubmed: 29038216.
40. Mørkved S, Bø K. Effect of pelvic floor muscle training during pregnancy and after childbirth on prevention and treatment of urinary incontinence: a systematic review. Br J Sports Med. 2014; 48(4): 299–310, doi: 10.1136/bjsports-2012-091758, indexed in Pubmed: 23365417.
41. Mørkved S, Bø K, Schei B, et al. Pelvic floor muscle training during pregnancy to prevent urinary incontinence: a single-blind randomized controlled trial. Obstet Gynecol. 2003; 101(2): 313–319, doi: 10.1016/s0029-7844(02)02711-4, indexed in Pubmed: 12576255.
42. Jacomo RH, Nascimento TR, Lucena da Siva M, et al. Exercise regimens other than pelvic floor muscle training cannot increase pelvic muscle strength-a systematic review. J Bodyw Mov Ther. 2020; 24(4): 568–574, doi: 10.1016/j.jbmt.2020.08.005, indexed in Pubmed: 33218562.
43. Gomes Lopes L, Maia Dutra Balsells M, Teixeira Moreira Vasconcelos C, et al. Can pelvic floor muscle training prevent perineal laceration? A systematic review and meta-analysis. Int J Gynaecol Obstet. 2022; 157(2): 248–254, doi: 10.1002/ijgo.13826, indexed in Pubmed: 34270799.
44. Leutenegger V, Grylka-Baeschlin S, Wieber F, et al. The effectiveness of skilled breathing and relaxation techniques during antenatal education on maternal and neonatal outcomes: a systematic review. BMC Pregnancy Childbirth. 2022; 22(1): 856, doi: 10.1186/s12884-022-05178-w, indexed in Pubmed: 36402944.
45. Heim MA, Makuch MY. Breathing Techniques During Labor: A multinational narrative review of efficacy. J Perinat Educ. 2023; 32(1): 23–34, doi: 10.1891/JPE-2021-0029, indexed in Pubmed: 36632511.
46. Berta M, Lindgren H, Christensson K, et al. Effect of maternal birth positions on duration of second stage of labor: systematic review and meta-analysis. BMC Pregnancy Childbirth. 2019; 19(1): 466, doi: 10.1186/s12884-019-2620-0, indexed in Pubmed: 31801479.
47. Zang Yu, Lu H, Zhao Y, et al. Effects of flexible sacrum positions during the second stage of labour on maternal and neonatal outcomes: A systematic review and meta-analysis. J Clin Nurs. 2020; 29(17-18): 3154–3169, doi: 10.1111/jocn.15376, indexed in Pubmed: 32531856.
48. Edqvist M, Blix E, Hegaard HK, et al. Perineal injuries and birth positions among 2992 women with a low risk pregnancy who opted for a homebirth. BMC Pregnancy Childbirth. 2016; 16(1): 196, doi: 10.1186/s12884-016-0990-0, indexed in Pubmed: 27473380.
49. Szumilewicz A, Santos-Rocha R. Exercise selection and adatations during regnancy. In: Santos-Rocha R. ed. Exercise and Physical Activity During Pregnancy and Postpartum Evidence-Based Guidelines. 2 ed. Springer Nature Switzerland AG, Cham, Switzerland 2022: 275–361.
50. Sosa CG, Althabe F, Belizán JM, et al. Bed rest in singleton pregnancies for preventing preterm birth. Cochrane Database Syst Rev. 2015; 2015(3): CD003581, doi: 10.1002/14651858.CD003581.pub3, indexed in Pubmed: 25821121.
51. Aleman A, Althabe F, Belizán J, et al. Bed rest during pregnancy for preventing miscarriage. Cochrane Database of Systematic Reviews. 2005; 2010(10), doi: 10.1002/14651858.cd003576.pub2.
52. da Silva Lopes K, Takemoto Yo, Ota E, et al. Bed rest with and without hospitalisation in multiple pregnancy for improving perinatal outcomes. Cochrane Database Syst Rev. 2017; 3(3): CD012031, doi: 10.1002/14651858.CD012031.pub2, indexed in Pubmed: 28262917.
53. Szumilewicz A, Kuchta A, Kranich M, et al. Prenatal high-low impact exercise program supported by pelvic floor muscle education and training decreases the life impact of postnatal urinary incontinence: A quasiexperimental trial. Medicine (Baltimore). 2020; 99(6): e18874, doi: 10.1097/MD.0000000000018874, indexed in Pubmed: 32028397.
54. Santos-Rocha R, Szumilewicz A. Exercise rescrition and adatations in early ostartum. In: Santos-Rocha R. ed. Exercise and Physical Activity During Pregnancy and Postpartum Evidence-Based Guidelines. 2 ed. Springer Nature Switzerland AG, Cham, Switzerland 2022: 363–395.
55. Cary GB, Quinn TJ. Exercise and lactation: are they compatible? Can J Appl Physiol. 2001; 26(1): 55–75, doi: 10.1139/h01-004, indexed in Pubmed: 11173670.
56. Sundgot-Borgen J, Sundgot-Borgen C, Myklebust G, et al. Elite athletes get pregnant, have healthy babies and return to sport early postpartum. BMJ Open Sport & Exercise Medicine. 2019; 5(1): e000652, doi: 10.1136/bmjsem-2019-000652.
57. Chambers CD. Risks of hyperthermia associated with hot tub or spa use by pregnant women. Birth Defects Res A Clin Mol Teratol. 2006; 76(8): 569–573, doi: 10.1002/bdra.20303, indexed in Pubmed: 16998815.
58. Davenport MH, Yoo C, Mottola MF, et al. Effects of prenatal exercise on incidence of congenital anomalies and hyperthermia: a systematic review and meta-analysis. Br J Sports Med. 2019; 53(2): 116–123, doi: 10.1136/bjsports-2018-099653, indexed in Pubmed: 30337347.
59. Graham J. Update on the gestational effects of maternal hyperthermia. Birth Defects Research. 2020; 112(12): 943–952, doi: 10.1002/bdr2.1696.
60. Dervis S, Dobson K, Nagpal T, et al. Heat loss responses at rest and during exercise in pregnancy: A scoping review. Journal of Thermal Biology. 2021; 99: 103011, doi: 10.1016/j.jtherbio.2021.103011.
61. Smallcombe JW, Puhenthirar A, Casasola W, et al. Thermoregulation during pregnancy: a controlled trial investigating the risk of maternal hyperthermia during exercise in the heat. Sports Med. 2021; 51(12): 2655–2664, doi: 10.1007/s40279-021-01504-y, indexed in Pubmed: 34165763.
62. Ravanelli N, Casasola W, English T, et al. Heat stress and fetal risk. Environmental limits for exercise and passive heat stress during pregnancy: a systematic review with best evidence synthesis. Br J Sports Med. 2019; 53(13): 799–805, doi: 10.1136/bjsports-2017-097914, indexed in Pubmed: 29496695.
63. Salvesen KÅ, Hem E, Sundgot-Borgen J. Fetal wellbeing may be compromised during strenuous exercise among pregnant elite athletes. Br J Sports Med. 2012; 46(4): 279–283, doi: 10.1136/bjsm.2010.080259, indexed in Pubmed: 21393257.
64. Anderson J, Pudwell J, McAuslan C, et al. Acute fetal response to high-intensity interval training in the second and third trimesters of pregnancy. Appl Physiol Nutr Metab. 2021; 46(12): 1552–1558, doi: 10.1139/apnm-2020-1086, indexed in Pubmed: 34433004.
65. Ong MJ, Wallman KE, Fournier PA, et al. Enhancing energy expenditure and enjoyment of exercise during pregnancy through the addition of brief higher intensity intervals to traditional continuous moderate intensity cycling. BMC Pregnancy Childbirth. 2016; 16(1): 161, doi: 10.1186/s12884-016-0947-3, indexed in Pubmed: 27417194.
66. Szumilewicz A, Santos-Rocha R, Worska A, et al. How to HIIT while pregnant? The protocol characteristics and effects of high intensity interval training implemented during pregnancy – a systematic review. Baltic Journal of Health and Physical Activity. 2021; 14(1): Article-1, doi: 10.29359/bjhpa.14.1.01.
67. Holt EL, Holden AV. A risk-benefit analysis of maintaining an aerobic-endurance triathlon training program during pregnancy: a review. Science & Sports. 2018; 33(5): e181–e189, doi: 10.1016/j.scispo.2016.09.010.
68. Sigurdardottir T, Steingrimsdottir T, Geirsson R, et al. Do female elite athletes experience more complicated childbirth than non-athletes? A case–control study. Br J Sports Med. 2018; 53(6): 354–358, doi: 10.1136/bjsports-2018-099447.
69. Beetham KS, Giles C, Noetel M, et al. The effects of vigorous intensity exercise in the third trimester of pregnancy: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2019; 19(1): 281, doi: 10.1186/s12884-019-2441-1, indexed in Pubmed: 31391016.
70. Kimber ML, Meyer S, McHugh TL, et al. Health outcomes after pregnancy in elithe athletes: a systematic review and meta-analysis. Med Sci Sports Exerc. 2021; 58(10): 1739–1747, doi: 10.1249/MSS.0000000000002617, indexed in Pubmed: 33560776.
71. Bø K, Artal R, Barakat R, et al. Exercise and pregnancy in recreational and elite athletes: 2016/2017 evidence summary from the IOC expert group meeting, Lausanne. Part 5. Recommendations for health professionals and active women. Br J Sports Med. 2018; 52(17): 1080–1085, doi: 10.1136/bjsports-2018-099351, indexed in Pubmed: 29895607.
72. Solli GS, Sandbakk Ø. Training Characteristics During Pregnancy and Postpartum in the World's Most Successful Cross Country Skier. Front

Physiol. 2018; 9: 595, doi: 10.3389/fphys.2018.00595, indexed in Pubmed: 29875693.
73. Almquist NW, Sandbakk Ø, Solli GS. Performance-related physiological and haematological changes during pregnancy and postpartum in a well-trained cyclist performing endurance training. Front Physiol. 2022; 13: 762950, doi: 10.3389/fphys.2022.762950, indexed in Pubmed: 35615680.
74. MacDougall JD, Tuxen D, Sale DG, et al. Arterial blood pressure response to heavy resistance exercise. J Appl Physiol. 1985; 58(3): 785–790, doi: 10.1152/jappl.1985.58.3.785.
75. Prevett C, Kimber ML, Forner L, et al. Impact of heavy resistance training on pregnancy and postpartum health outcomes. Int Urogynecol J. 2023; 34(2): 405–411, doi: 10.1007/s00192-022-05393-1, indexed in Pubmed: 36331580.
76. Dewey KG. Energy and protein requirements during lactation. Annu Rev Nutr. 1997; 17: 19–36, doi: 10.1146/annurev.nutr.17.1.19, indexed in Pubmed: 9240917.
77. McManis BG. Integrative Review of Exercise at Altitude during Pregnancy. Int J Environ Res Public Health. 2021; 18(17), doi: 10.3390/ijerph18179272, indexed in Pubmed: 34501869.