Exercise Selection and Adaptations During Pregnancy

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Abstract

There are several guidelines supporting the benefits of exercising during pregnancy. Those documents contain very general recommendations on physical activity and exercise during pregnancy, such as general guidelines for health screening and prescription of aerobic exercise and strength training. They also include examples of safe physical activities during pregnancy, such as walking, running, swimming, stationary cycling, aerobics, modified yoga, and Pilates. However, those guidelines contain little information that exercise professionals could use when programming the contents of targeted exercise classes for pregnant women. This chapter addresses the steps for planning, conducting, and monitoring prenatal exercise classes, and explains how to select and adapt the exercises making them safe physical activities during pregnancy.

Keywords

Pregnancy · Exercise · Physical activity · Aerobics · Resistance · Flexibility Functional · Neuromotor · Balance · Posture · Pelvic floor muscle training Breathing · Fitness · Exercise planning

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9.1 Introduction

Scientific research conducted in the last decades has markedly changed the perception of prenatal physical activity. The conservative approach presented in the 1990s, which could significantly limit exercise during pregnancy [1], now appears to be detrimental to the health of women and their children. In current recommendations, prenatal physical activity is considered a necessary condition for normal pregnancy and fetal development. What is more, physical inactivity in pregnancy is a risky behavior [2, 3]. Exercise in pregnancy is not so much a luxury for the few women, but the responsibility of every future mother.

In the light of available research, the current question is not "if," but "how" a woman should exercise in pregnancy. A literature review from a few years ago [4] indicated that publicly available recommendations on prenatal physical activity did not provide answers on which exercises to choose and how they should be performed. Divergent, often unfounded information undermined the safety of certain exercises or modes of physical activity, higher intensities, and training loads. While the guidelines published in the last 5 years are far more progressive, there are still conflicting views in society about exercise in pregnancy. In addition, misguided social pressure may be a reason why pregnant women ill-advisedly reduce their physical activity because of the fear of the child's health [5, 6]. It should be noted that there is no clear scientific evidence that some sports activities or particular exercises are indeed dangerous for pregnancy and fetal development. The classification of the modes of physical activity as "not recommended for pregnant women" is rather due to the excessively cautious attitude. Medical experts who took part in the National Forum on Pregnancy and Sport in 2001 in Sydney advised that "damage to the womb of the kind that could injure an unborn child is usually associated with forces equivalent to those occurring in a car accident. All medical experts agreed that falls and direct contact of the kinds that occur during contact sports were unlikely to cause damage to the womb or the unborn child" [7].

Considering the above, there is no reason for a woman to give up a mode of physical activity or a particular exercise just because she has become pregnant. Certainly, one should minimize the risk of injury, bearing in mind that in pregnancy medical interventions, including the use of certain medications are limited. "Common sense" suggests that pregnancy is not the time to take part in new activities, especially if they are technically difficult. However, if a woman believes that her technical skills provide a sense of security and comfort and she has no medical contraindications, she may continue her current physical activity. An excellent example is a top tennis player Serena Williams who revealed in April 2017 that she was 20 weeks pregnant when she won the Australian Open [8].

The updated guidelines for physical activity are addressed in Chap. 7 by Szumilewicz et al. [9]. Chapter 8 by Santos-Rocha et al. [10] addresses and discusses the current knowledge on exercise testing and prescription for pregnant women. In this chapter, we present the general principles of planning and implementation of prenatal physical activity and suggestions for exercise adaptation. Exercise in pregnancy not only should be safe but also potentially effective for

preventing and relieving typical pregnancy ailments and preparing a woman for childbirth and maternity [4]. We emphasize that the following suggestions do not exhaust the extensive list of exercises that pregnant women can perform. Guidelines for planning and implementing an exercise program for women with pregnancies at risk require a separate evidence-based description.

9.2 Planning, Conducting, and Monitoring of the Prenatal Exercise Sessions

According to the recommendations of World Health Organization [11] and the U.S. Department of Human and Health Services [12], the beneficial effects of exercise in most adults, including special populations and people with chronic conditions are indisputable and the benefits far outweigh the risks. Due to the health benefits of regular physical activity, it is best if it is taken continuously for several months before becoming pregnant, and then throughout pregnancy, postpartum and early motherhood, to smoothly go into lifelong activity until late age.

Unfortunately, after becoming pregnant by the end of the first trimester, many women stop exercising or significantly reduce the training load for fear of miscarriage. In the first trimester, the risk of spontaneous abortion is about 10% [13]. According to the available data, neither the continuation of recreational exercise will increase the risk of miscarriage nor its interruption will lower it [14]. Research indicates that there are no significant differences in the early miscarriage rate between recreational runners, aerobics participants, and physically active, fit controls [15]. It is scientifically justified to think that bounces associated with running or jumping can hinder implantation. Therefore, inter alia due to the alleviation of pregnancy symptoms, prenatal physical activity should be undertaken from the day of conception.

Before starting the exercises, obstetrician–gynecologists and other obstetric care providers should carefully evaluate women with medical or obstetric complications. If no such complications exist [16], both active and inactive women should be encouraged by the medical staff to take up the prenatal exercises. According to current guidelines, women with complicated pregnancies also should continue their normal everyday activity and modify their exercise programs, where necessary (see Chaps. 7 and 9). Close cooperation with qualified prenatal exercise specialists is recommended here. They will plan the right type, intensity, frequency, and duration of exercise (see Chaps. 8 and 10). Both professional groups should educate women and do their best to refute myths limiting prenatal physical activity. By participating in various forms of activity, women should be convinced of their safety and positive impact on the course of pregnancy and child development.

In working with pregnant women, it should be taken into account that the body is additionally burdened by the development of pregnancy, which significantly determines its response to exercise, manifested, among others, in larger fluctuations in heart rate and respiratory rate [17–20]. It significantly alters the management of the intensity of each training session, which sometimes requires extended warm-up. It should also be considered that owing to weight gain, the woman

performing at the same exercise has greater training load in the same unit of time compared to the preconception period [21]. Therefore, reducing the time for physical activity or number of exercise repetition is not always associated with limiting physical effort.

In exercise planning, the exercise positions should be properly selected. An exercise specialist should consider both exercise purpose, external conditions (e.g., outdoor activities, available equipment in the rooms), and, most importantly, the well-being of the woman. To ensure the versatility of muscle work, good blood flow in the woman's body and the attractiveness of exercises, it is good practice to use frequent changes of position. When planning exercises for women in the second and third trimesters, it is worth taking into account that changing positions alone is associated with physical effort and sometimes requires slightly longer time than in non-pregnant women. We have described selected positions for pregnant women in Appendix 1. Nevertheless, a pregnant woman does not have to limit herself to them.

Pregnant women should be informed, not only what is the correct technique of each exercise, but also how to modify it in case of discomfort during its execution. It is good practice to propose various versions of the exercises, considering trimester of pregnancy and its progress, the level of skills and abilities of a woman. Due to continuous morphological, biomechanical, and physiological changes in the woman's body, the same exercises on different days may be differently received in terms of comfort. In exercising, women should take into account both the suggestions of an exercise specialist and signals from their bodies. Especially they should be sensitive to the warning signs that indicate the need to immediately stop exercising (see Chaps. 8, 10, and 16).

To participate in prenatal physical activity, a woman should be well nourished and hydrated according to recommendations for proper nutrition during pregnancy [22]. In each exercise session, one should plan rest breaks, inter alia to refill the fluids, depending on the volume and intensity of the exercise (e.g., 3–4 breaks during a 60-min session). If necessary, a woman should rest more often, according to her own well-being. If she exercises under the supervision of an exercise specialist, she should report any discomfort to this professional, thus enabling proper selection and modification of the physical activity program. A woman should also follow the norms of nighttime sleep and proper rest after the exercise session. The general recommendation is to have rest time during the day equal to the duration of the exercise session [23].

Women should use training clothing and footwear and sports equipment appropriate for the given form of physical activity, the temperature of the environment of the exercise, and its intensity. In addition to paying attention to the increasing abdominal circumference, the same rules apply as for the general adult population. In the case of beginners, in the selection of clothing and equipment, it is recommended to consult a specialist in a given form of physical activity. At the end of pregnancy, an abdominal support and an extra bra may be useful to ensure the greatest possible stabilization for the growing abdomen and sore tender breasts.

The appropriate level of the individual training components should be regularly monitored and evaluated according to the observed progress [23]. The most

Table 9.1 Exercise monitoring card

Exercise monitoring card								
Name and surname:					Date of the first classes			
Date	Form of physical activity*	The duration of exercise	Subjective intensity perception at RPE scale**		Rest time after exercise***	Well-being during or after classes /comments	The reason for absence	Participant's signature
			Aerobic part	Resistance part				
Example	Total body condition class	60–min	7	6	60–min	Good or e.g., backpain after exercise		

[a]You should enter all forms of physical activity, also individually taken, e.g., walking, cycling
[b]A women should use the RPE scale from 0–10 or 6–20, according to exercise specialist's instructions
[c]Rest time after exercises (entered at the next class)

significant effects are typically observed during the first 6–8 weeks of an exercise program [24]. The following is a useful tool to monitor and record a pregnant woman's well-being during and after exercise session (Table 9.1).

9.3 The Structure of the Exercise Session for Pregnant Women

The important purpose of prenatal physical activity is to stimulate the positive development of pregnancy, provide the greatest possible well-being for the future mother, and prepare her for childbirth and postpartum. Therefore, each training session should include several elements. A combination of aerobic and resistance exercises during pregnancy seems to induce the most favorable effect on maternal health during pregnancy [25, 26]. A pregnant woman should also perform flexibility, body posture, neuromotor, and pelvic-floor muscle exercises. Preparation for birth part, including breathing exercises, relaxation, birth visualization and birth position is recommended, as well [27–31].

Prenatal exercise sessions are usually scheduled for 45 to 90 min, depending on the capacity of the women. The recommended structure of the 60–90 min class is as follows:

1. Warm-up (7–10 min).
2. Aerobic exercise, e.g., low or high–low impact aerobics, walking or jogging on a treadmill, stationary cycling (15–20 min).
3. Resistance exercises (including abdominals exercises), postural and neuromotor (e.g., body balance) exercises (10–15 min).
4. Stretching exercises (5–10 min).
5. Pelvic floor exercises (5–10 min).

6. Cool down and preparation for birth exercises, e.g., birth position and breathing exercises (5–10 min) and also relaxation and visualization of pregnancy and childbirth (5–15 min).

Aerobic exercise may be substituted by anaerobic exercise, e.g., in a form of High-Intensity Interval Training (HIIT). Resistance exercises, involving large muscle groups, are usually used in the high-intensity exercise intervals. The prenatal HIIT classes usually are scheduled for 30–60 min. The structure of the prenatal HIIT classes may be as follows:

1. Warm-up (5–7 min).
2. High-intensity exercise intervals alternate with rest breaks (15–20 min).
3. Postural, neuromotor (e.g., body balance) and stretching exercises (5–10 min). These exercises can be performed during the rest break after high-intensity exercise intervals.
4. Pelvic floor exercises (5–10 min).
5. Cool down and preparation for birth exercises, e.g., birth position and breathing exercises (5–10 min) and also relaxation and visualization of pregnancy and childbirth (5–15 min).

9.3.1 Warm-Up

The main task of the warm-up part for prenatal activities is, as in any other activity, psychophysical preparation for the more rigorous demands of the cardiorespiratory and muscular and conditioning parts of the exercise session. The recommended time is 7–10 min. In warm-up, pregnant woman should pay attention to several elements:

1. Before each activity, the woman should make a self-assessment of her well-being. Even in normal pregnancies, there are occasional discomforts (e.g., dizziness, abdominal pain, and any other pain), which may indicate, for example, fatigue or a beginning of an infection. On such days, it is worthwhile to extend the warm-up, lower the intensity of exercise, or maybe even give up exercises. Observations, however, suggest that moderate physical activity improves the well-being of pregnant women [32, 33]. Therefore, the decision to give up exercise on a given day should not be taken too hastily.
2. It is good to start with the correction of body posture so as not to fix the posture defects in the course of further exercise [34]. Posture exercises improve body awareness [35] and it is likely that women will be more sensitive to signals from their body. This, in turn, can affect the effectiveness and safety of exercise.
3. During warm-up, simple, rehearsal moves should dominate, engaging all large muscle groups. These can be marches or runs, supplemented by arm swings or circulations. Aerobics moves can be used too. When music is used in the warm-up, the recommended tempo is 120–136 beats per minute [36].
4. Already during the warm-up, a woman should consciously activate the pelvic-floor muscles to practice how to prevent the urinary leakage in more intensive exercise in the main part of the exercise class.

5. In the warm-up, pregnant women should perform breathing exercises. First, as in general population, these exercises should help to supply more oxygen during increased muscle work. Secondly, the diaphragm, the major muscle involved in breathing, is like any muscle group and needs time to speed up its work. It is particularly important in the second and third trimesters, when the growing womb hinders the lowering of the diaphragm during inhalation. Thirdly, breathing exercises help a woman reduce discomfort associated with a feeling of breathlessness appearing at the beginning of physical exertion. This feeling is the result of elevated levels of progesterone, which initiates "overbreathing" by increasing the sensitivity of the central chemoreflex control of breathing to carbon dioxide [37]. Although this is often not pleasant for pregnant women, it increases the efficiency of oxygen uptake from the lungs and the elimination of carbon dioxide from the blood of mother and baby [23].
6. Due to continuous changes in the circulatory system throughout the pregnancy, the increase in intensity during warm-up should be gradual. Especially at the very beginning of pregnancy, when the vessels are already relaxed and dilated and the volume of blood has not yet caught up, the heart rate may be extremely high at one's usual intensity [23].
7. At the end of the warm-up, the woman should re-evaluate her well-being and readiness for greater physical effort in the main part of the class. It is also time to consume the fluids.
8. If the class is performed by an exercise professional, it is a good time to present to the participants the target of the main part of the exercise session, as well as provide important training tips, such as the importance of maintaining proper posture, proper breathing, monitoring exercise intensity and well-being, and fluid refills. Exercise professional also reminds women of the warning signs for immediate discontinuation of exercises and customization of exercises to individual capabilities.

Examples of warm-up section:

https://youtu.be/h11NnFDPlfs
https://youtu.be/tq5PwcTBuVE
https://youtu.be/Ca0uL5f2zQ8
https://youtu.be/VlEVuBD1LTk
https://youtu.be/_Hg6Trdhn0M
https://youtu.be/0Vvlojbxmag
https://youtu.be/aR7hJp9MhcI

9.3.2 Aerobic Exercise

According to the current guidelines [3, 11, 12, 38–41], healthy pregnant women should perform at least 150 min per week of moderate-intensity aerobic activity (i.e., equivalent to brisk walking). This activity should be spread throughout the week and adjusted as medically indicated. The guidelines advise that "the pregnant women who habitually engage in vigorous-intensity aerobic activity (i.e., the equivalent of

running or jogging) or who are highly active can continue physical activity during pregnancy and the postpartum period, provided that they remain healthy and discuss with their health care provider how and when activity should be adjusted over time" [3, 11, 42]. Women who did not exercise before pregnancy should be encouraged to do physical activity at least three times a week starting from 15-min sessions, gradually lengthening them [16]. Aerobic exercise for pregnant women can be implemented in various forms, depending on the skills and abilities of women.

Typically, aerobic exercises are those that involve the use of large muscle groups in a repetitive or rhythmic fashion. Examples of aerobic activities include walking, jogging, running, cycling, swimming, and using aerobic-based machines, e.g., stair climber, elliptical machines [34]. Some activities are weight-dependent, meaning that body weight is moved during the exercise (e.g., walking, running). In other activities, body weight is not a factor because the body is supported (e.g., cycling, swimming). These activities are referred to as weight-bearing and non-weight-bearing exercises, respectively. The use of non-weight-bearing exercises may be particularly useful for women at the end of gestation due to the increasing body weight.

According to ACSM, endurance activities have been classified into four groups. Group A includes endurance activities that require minimal skill or fitness to perform, e.g., walking. These activities can easily accommodate individual fitness levels and thus are recommended for all adults, especially for beginners. Based on the review of guidelines on exercise in pregnancy [4], walking was the most frequently recommended form of physical activity for pregnant women (see Chaps. 7 and 9). Group B activities are those that require minimal skill but, in contrast to Group A activities, are typically performed at a more vigorous intensity, like jogging and running. Group B activities are appropriate for those who exercise regularly and who have at least an average level of fitness. Although in some countries jogging and running are considered as appropriate forms of physical activity for women during pregnancy, in other countries, the sight of a running pregnant woman is controversial. It should be emphasized that fears of miscarriage resulting from repetitive bounces typical for more vigorous exercises have not been confirmed in scientific research. Already in the 1980s, Clapp [15] observed that the rate of early pregnancy loss in recreational runners was even lower, although not statistically significant, than in controls (17 vs. 23%, respectively).

Examples of Group C activities are swimming and cross-country skiing. This group reflects activities that have a high relationship between skill and energy expenditure. For example, an experienced swimmer may be able to easily swim at a constant intensity, whereas a person with poor swimming skill would be very inefficient and would struggle to swim at an appropriate and constant intensity to gain cardiorespiratory benefits [34]. Swimming was the second, most frequently proposed exercise in pregnancy [4], mainly due to its non-weight-bearing form. However, due to the risk of genital tract infections in public swimming pools, not all women can participate in water activities. Other forms of movement from group C should be popularized for those pregnant women who regularly took part in them before conception.

Recreational sports like basketball, soccer, tennis, and other racquet sports are classified as Group D activities. These activities are typically vigorous and intermittent. The nature of these activities does not lend themselves to constant, controlled intensity levels. This is even more true when competition is involved. Activities from group D usually are on the list of "not recommended" forms of exercise for pregnant women (see Chaps. 7 and 9), although not much data is available on their potential risk.

We presented the most popular aerobic forms of prenatal physical activity below.

9.3.2.1 Aerobics

In an aerobics class, participants perform movements that work the large muscle groups to promote cardiorespiratory fitness and its benefits. These movements are traditionally dancelike and can be executed while keeping 1 ft on the floor at all times (low impact) or while jumping (high impact). Classes mixing high- and low-impact movements are labeled as high–low (or hi-lo) aerobics. A skilled exercise specialist is able to teach low- or high-impact options of movements in one choreography so that even in group classes, it is possible to adjust the intensity of exercise to the individual needs of the participants [36]. Music sets the cadence and rhythm of the moves [43]. Official guidelines on exercise in pregnancy from different countries advice women aerobics as a form of cardio exercise; however, several older guidelines limited this recommendation to low-impact aerobics [4].

Several authors have observed that low-impact aerobics is safe [44, 45] and beneficial for pregnant women, both for various conditions and parameters of the course of pregnancy [46, 47], and for labor and delivery [48, 49]. Nevertheless, too low intensity in low-impact aerobics may not be sufficient to stimulate the cardiopulmonary system [45] and not produce the desired health effects. Using high-impact movements during group classes gives the opportunity to increase quickly the intensity of exercise. It is especially important for women with high levels of exercise capacity and accustomed to participate in high-intensity classes before pregnancy. Adding jumps or runs during an aerobics class may be an option for such women [50].

There is some scientific evidence that the participation of pregnant women in hi-lo aerobics can lead to health benefits, with no adverse effects on the course of pregnancy or on birth outcomes [50, 51]. It is unsubstantiated belief that runs or jumps can cause miscarriage or premature labor. However, with the development of pregnancy and the growing womb, it may be necessary to limit high-impact movements. Potentially, they can cause an unpleasant bounce of pregnant belly or growing breasts, intensify urinary incontinence or lower back pain. However, the decision to eliminate high-impact movements should be based on the assessment of the well-being of a woman and not be a general rule for exercising during pregnancy.

The recommended music tempo for hi-low aerobics classes is 134–150 BPM (beats per minute) depending on the group's abilities [36]. With the progression of pregnancy and gaining weight, the training workload of a pregnant woman increases, so it may be necessary to use slower music in the third trimester. To get aerobic exercise, during the entire choreography, the woman should be able to

breathe freely and maintain an exercise intensity of 14–16 on the RPE scale from 6 to 20, or 6–8 on the RPE scale from 1 to 10 (see Chaps. 8 and 10). Concerning the level of expertise, Laukkanen et al. [52] reported that intensity management during aerobics classes is generally successful regardless of the participants' prior participation in aerobics. However, in their study, some individuals who were older and/or had less prior participation tended to exceed the targeted heart rate.

The technique of performing aerobics moves does not differ significantly from the technique for the general population. Special attention should be paid to the correct body posture, not to deepen its defects. Perhaps at the end of pregnancy, due to the falling belly, it will be uncomfortable for a pregnant woman to perform the *front knee up* move, which can be replaced by *side knee up* move (see Appendix 2). It is certainly worthwhile to include conscious pelvic-floor muscle contractions at the end of each exercise (e.g., when attaching legs in *step touch* move or before jump or run). To prevent urine leakage during exercise, Bourcier [53] proposed to use "the knack" - a quick, strong, well-timed pelvic-floor muscle contraction before and during physical stress increasing intra-abdominal pressure. Using pelvic floor precontractions in high–low impact classes allowed pregnant women not only to maintain a good quality of life in terms of urinary incontinence but also to improve the electromyographic parameters of the pelvic floor muscles [50].

In aerobics, one should also incorporate upper-body moves to activate the whole body, increase the exercise intensity and improve coordination. The arms can move bilaterally (right and left sides perform the same movement simultaneously) or unilaterally (right and left sides move individually or perform different movements simultaneously) [36]. Some women are afraid to raise their arms above their heads, for fear of miscarriage. This is an unfounded opinion, which unnecessarily limits the range of exercises during the classes. Likewise, there is no justification for avoiding in pregnancy frequent changes in direction or any turns during choreography. Although the center of gravity, balance and coordination are changing in pregnancy, there is no scientific evidence that these changes increase the risk of collapse or collision during aerobics, compared to the general population. As mentioned above, the inclusion of changes in direction and turns in a choreography as well as cadence will depend on participants' level of expertise. However, there should always be an "easier" and "more challenging" option included in the session plan for the cases where there are participants with different levels of fitness and experience in the same group class. We presented examples of aerobics movements for pregnant women in Appendix 2.

9.3.2.2 Step Aerobics

Step aerobics is a classic cardio workout that uses a 10, 15, 20, or 25 cm height bench of approximately 102 cm (length) × 38.5 cm (width) (Fig. 9.1) to step up and down, around the step forward, sideways, and backward, and over the platform, usually combined in choreography. Different patterns of steps can be used to boost heart rate and breathing, as well as lower limb muscles resistance. Core muscles stabilize the trunk. Upper limb movements can also be added. Upbeat music sets the cadence, the number of moves, the rhythm and provides motivation. Exercise

Fig. 9.1 Image of a 15-cm height Step Reebok™ bench

specialists show the moves, appropriate technique, and the progression of choreography. Moves' sequence building is important in order for participants to feel successful. Usually, participants are in a gym, in front of a mirror. However, this equipment can be used at home to follow video classes and exercise to music. If used outdoors, precautions should be taken regarding the type of floor: it must be flat and not slippery. Moreover, if the participant feels tired or she is a complete beginner, she can perform the moves on the floor, i.e., without a bench step (e.g., draw a rectangle on the floor with duct tape). A step aerobics class typically lasts 45–60 min.

The *Step Reebok*™ program was originally introduced as a low-impact activity (with a medium impact version called Power Step Reebok) since its proponents claimed that ground reaction forces were similar to those of walking [54, 55]. Step classes currently include propulsive movements that have changed the nature of impact of the activity [56]. The objectives of this group exercise are based on the improvement of cardiovascular and muscle efficiency, as well as motor coordination, balance, spatial orientation, body composition, and fun. One important characteristic of Step exercise is the repetition of exercises (or techniques, called "steps") that induce forces of low magnitude (around 1 to 2 BW—body weight) and of high frequency (around 3750 to 4050 times on a 30 min session, using music speed of 125 to 135 beats per minute) [56, 57].

Step aerobics moves range from simple to advanced depending on low- or high-impact, coordination, balance, change in position, speed and combination of choreographed steps. Regarding impact loading, this being a weight-bearing exercise, low-impact moves mean that there is always 1 ft on the bench or ground (e.g., basic step, knee lift, knee repeater, marching, mambo). High-impact moves mean that for a moment both feet are off the ground (e.g., run step, knee hop, jump step, knee leap). Regarding leading leg loading, step moves can be symmetrical or asymmetrical, i.e., the sequence of moves always start with the same leading leg followed by the impulsion leg, or the sequence of moves always starts with alternated leading legs. The Step aerobics low-impact basic moves are the asymmetrical "basic step" (right step up, left step up, right step down, left step down, etc.) and the symmetrical "knee lift" (right step up, left knee lift, left step down, right step down, left step up, etc.). The step aerobics medium-impact basic moves are the asymmetrical "run

step" (right leap step up, left leap step up, right step down, left step down, etc.) and the symmetrical "knee hop" (right step up, left knee lift with hop, left step down, right step down, left step up, etc.). Regarding the dominant leg of each move, instructors must plan a session with a balanced number of asymmetrical moves. This is a very important point of the session since it will influence mechanical load.

Regarding technique, the head should be up, shoulders down and back, chest up, abdominals lightly contracted, and buttocks gently tucked under the hips. Knees and back should never hyperextend at any time. When stepping up, the body should lean from the ankles and not the waist to avoid excessive stress on the lumbar spine. The entire sole of the foot should contact the bench, stepping softly and quietly to avoid unnecessary high impacts. The heel should not land over the edge of the bench to avoid Achilles tendon injury. When stepping down, the step should be close to the bench (no more than one shoe length away) and the heel should contact the floor to help to absorb shock [54].

The class starts with a warm-up, followed by choreographed routines on the step, and a cool down at the end. The intensity can vary from low and medium to high, depending on the type of moves (impact, repeaters, amplitude, overhead upper limb moves, etc.), cadence, choreography, and bench height. This means that a session can be planned with the following objectives of meeting different fitness and skill levels: 1) low to medium intensity, low to medium impact, and easy to follow (i.e., pregnant women, older adults, children, some clinical populations and beginners); 2) medium to high intensity, impact, and complexity (i.e., skilled participants, including pregnant women); and 3) medium to high intensity and impact, but easy to follow (i.e., cross-training for athletes). There are no advantages of adding weights while stepping. The use of ankle and hand weights failed to enhance training adaptations [58]. After the cardio part, the set bench can also be used to perform strength training and stretching exercises. The only contraindications for step aerobics are the conditions of hip, foot, ankle, or knee pain, or recent back and knee injury.

Step aerobics is one of the main trends of activity undertaken by pregnant women [59]. Unfortunately, to our knowledge, only one prospective randomized controlled trial designed to assess the benefits and possible risks of aerobic exercise during pregnancy used step aerobics in the exercise intervention [60]. With a general population of pregnant women, the program should include low to medium impact moves, benches of 10–15 cm height, without too many changes of direction and jumps over the platform, in order to prevent falling or loss of balance. Pregnant women should always maintain visual contact with the platform. On the other hand, each woman feels safer on her own bench and space around it, compared to an aerobics class. It does not require much space and equipment and provides a good cardiovascular, resistance, and neuromotor exercise. Thus, it is a safe and effective exercise to start or continue during pregnancy, as long as intensity (e.g., slower cadence, lower bench) and complexity can be adjusted to fitness and skill level as pregnancy progresses. Important precautions include lowering the bench as the belly grows and the center of gravity changes, drinking water before and during exercise and not overheating. We presented examples of step aerobics movements for pregnant women in Appendix 3 of the present chapter.

Fig. 9.2 Indoor cycling is a non-weight-bearing activity to be performed on: (**a**) a spinning bike; (**b**) a stationary bike; (**c**) a reclined bike

9.3.2.3 Indoor and Outdoor Cycling

Indoor cycling is a non-weight-bearing cardiovascular and lower body resistance exercise. An indoor cycling class typically lasts 45–60 min. Indoor cycling requires a stationary or "spinning" bike (Fig. 9.2a). The position of the saddle must be adjusted to participants' measurements (i.e., when standing beside the bike, the saddle must be at the same plane as the hips; when seated in the saddle, with foot on the pedal at the bottom of the stroke, the knee must be slightly bent; when seated, with the crank arms parallel to the ground, the horizontal distance from the handlebars to the saddle must be set when the knee line intersects the leading edge of the forward crank arm). Intensity depends on the speed, load on the bike, time (duration of the session), and change in position (sit or stand). Other options include a stationary bike (Fig. 9.2b) or a reclined bike (Fig. 9.2c) at a gym or at home.

Outdoor cycling is non-weight-bearing cardiovascular, lower body resistance, and neuromotor exercise. The findings by Skreden et al. [61] indicate that so-called active transportation, including cycling, is one possible approach to prevent excessive weight gain in pregnancy. An outdoor cycling session may last from a very short period to several hours depending on fitness level and comfort. Outdoor cycling requires a regular bike, usually, specific to the road, mountain or urban/fitness (Fig. 9.3a–c). However, there are other types available, such as tandem, touring, tricycle, hybrid, electric, etc., and bikes designed around female anatomy and dimensions. The frame, weight, and dimensions of the bike must be adjusted to participants' size, fitness level, comfort, and training objectives.

The characteristics of the bike will, of course, influence its price. However, the main question to have in mind is technique and a correct fit. Being a repetitive movement, sustained up to several hours, appropriate technique is of particular importance in order to perform effective and safe training, avoiding falls and preventing injuries.

Pregnant women that are regular or competitive cyclists will have very light and expensive bikes. It is very likely that competition and training for racing will need

Fig. 9.3 Outdoor cycling requires: (**a**) a road bike; (**b**) a mountain bike; (**c**) an urban/fitness bike, among other types

to be suspended during pregnancy but athletes may wish to continue to train until the abdomen expands to the point that it is no longer comfortable to cycle, especially if the woman is a road bike athlete. In these cases, switching to a mountain or fitness bike, indoor cycling or using a more comfortable bike that allows a more upright position can be good options, taking into account that most of the body weight shifts onto the saddle, compressing intervertebral disks. Those who are recreational bikers, or use the bike for active commuting, may wish to continue as long as pregnancy progresses. In these cases, mountain bikes and urban/fitness bikes can offer very comfortable equipment regarding size, feminine geometry, suspension, woman's saddle, number of gears, and lightweight equipment. There are many brands on offer from very affordable to very expensive bikes. For those who do not know how to use a bike, starting this activity after the childbearing period may be a better option, unless using a stationary bike or a tricycle. Learning how to use the bike is a very demanding activity regarding balance skills. Pregnant women should avoid falling and trauma situations.

When cycling outdoors, several precautions should be taken:

1. To ensure proper technique: to use proper bike and ensure correct bike fit; feet should be properly placed on the pedals, with or without cycling shoes with a strapless pedal binding system (this system must be fitted to the cyclist' experience level).
2. To adjust the trunk position and the handlebar of the bike (in height and width) as belly grows.
3. To be sure of the condition and maintenance of the tires, brakes, and gears.
4. To know how to fix or replace a flat tire, and how to pump.
5. Always use a helmet.
6. To use a women's saddle, no matter the type of bike.
7. To avoid bad weather (too cold or too hot) and slippery ground.
8. To know the conditions of the weather and ground in advance.

9. To drink water before, during and after exercising (and carry light snacks).
10. To avoid air pollution and car traffic.
11. To be aware of traffic rules and hazards.
12. To use sun protection for skin (lotion) and eyes (glasses). Glasses also protect from dust and bugs.
13. To use cycling routes, lanes, and parks; preferably engage in a cycling group or ride with a partner (either on two bikes or using a tandem).
14. To use proper sportswear: bike or cross-training shoes, breathable shirt and jackets, supportive and comfortable bra, breathable underwear, shorts or leggings with saddle pads (or extra comfortable women's saddle).
15. To use fingerless or full cycling gloves to prevent blisters and to protect skin if the hands contact the ground in case of falling.
16. To avoid riding in the dark and to know how to deal with dogs (e.g., carrying some cookies, shouting back or dismounting and placing the bike between the body and the dog).

Some modifications may occur in accordance with common pregnancy-related symptoms and discomforts. If the pregnant woman has pelvic girdle pain, hemorrhoids, varicose veins in legs, varicose veins in the vulvar area, or vaginal yeast infection, just sitting in the saddle or sitting in the saddle for a long time will be uncomfortable. In some cases, there might be temporary vision changes due to hormonal effects and glasses may not be enough to ensure safety while riding outdoors. Other safety concerns are related to changes in the sense of balance and dizziness (in those cases indoor cycling is the best option).

An indoor or outdoor cycling training includes a warm-up, cardiovascular exercise, lower limb resistance exercises, and a cooldown part with stretching exercises. Any change in the bike will affect muscle activity and pedaling form, which in turn, will affect intensity. Cycling also allows monitoring heart rate, using a heart rate monitor, a GPS (global positioning system), or a smart phone.

Example of warm-up before a cycling session:

https://youtu.be/S6bDBWA7QAE

9.3.2.4 Walking, Jogging, or Running

Walking provides a good cardiovascular and lower limb resistance and core exercise to be performed outdoors (with or without poles) or using a treadmill (Fig. 9.4). Walking briskly requires attention to posture and technique: keeping the head up and looking forward; keeping head straight with chin parallel to the ground; properly blended arms swing with loose shoulders (arm counterbalance leg movements); hip aligned with shoulders avoiding sway back; and proper leg swing and stride length [62].

Walking is the most commonly reported form of exercise during pregnancy [63]. Walking is an affordable exercise that requires no special equipment or facility, and it is very good for beginners and for active women. There is no contraindication from its practice during pregnancy, except recent lower limb injury or pain. Several

Fig. 9.4 Walking can be performed either outdoors (with or without poles) or using a treadmill

clinical trials have used walking as an intervention to assess the effects of exercise on maternal and perinatal outcomes and have found it to be an effective intervention [44, 64–66]. Running is a time-efficient aerobic activity [62], and is a good option for those who were recreational or competitive runners before pregnancy. Those athletes may wish to continue their training, although some adaptations may be needed, regarding intensity and impact. There have been several experimental trials [15, 67, 68] on the influence of regular running on maternal and/or fetal health, and no adverse effects were observed.

One important characteristic of walking and running is the repetition of strides (loading cycles) of low impact (inducing ground reaction forces of low magnitude, i.e., 1–2 BW) or medium impact (i.e., 2–4 BW), with high frequency (around 3570–5710 steps) during a 30-min session, at speeds of 5 km/h (~83 m/min) to 8 km/h (~133 m/min), respectively (assuming that the mean stride length of a woman is ~70 cm). There may be some changes needed as the belly grows, regarding the speed, balance, and gait pattern. Moreover, there are factors that may lead to cease running and substitute it for walking or other activities. These include joints and ligaments more vulnerable to strains or sprains, augmented pelvic pressure and urinary frequency, especially during the third trimester.

Proper stretching exercises both before and after a walking or running session are helpful to prevent injuries. When walking, hiking, or running outdoors, several precautions should be taken:

1. To ensure proper posture, technique (arm and leg swing), and breathing.
2. To avoid bad weather (too cold or too hot) and slippery ground.
3. To get familiar in advance with the conditions of the weather, trails, and ground, as well as bathroom facilities.
4. To avoid steep ascent or descent.
5. To drink water before, during, and after exercising.
6. To avoid air pollution and car traffic.

7. To avoid hiking at high altitudes due to reduced oxygen levels.
8. To use sun protection for skin (lotion), head (cap), and eyes (glasses).
9. To use eyes protection (glasses) against dust and bugs.
10. To use walking lanes and parks.
11. Preferably to engage in a walking/running group.
12. To use proper sports shoes: walking, running or cross-training shoes that provide comfort, ankle support, cushioning, and shock absorbing features.
13. To use comfortable socks with extra padding to prevent friction and blisters.
14. To use proper sportswear (and underwear): breathable shirt and jacket, pregnancy supportive bra, seamless and breathable underwear, shorts or leggings.
15. To ensure frequent rest and water breaks if exercising for a long time.

9.3.2.5 Water Exercise and Swimming

Water exercise is also a commonly reported form of exercise during pregnancy [63], very good for beginners and for active women (Fig. 9.5). Water exercise and swimming take the weight off the joints while exercising. It has been shown that water exercise is safe [69, 70] and beneficial for pregnant women [46]. In the study by Vallim et al. [71], a great majority of pregnant women considered that the practice of water aerobics had benefitted them in some way.

Most water workouts are done in the shallow end of the swimming pool and participants stand in chest-deep water. They can also stand in shoulder-deep water to perform other upper body exercises keeping the arms under water. It is a low-impact exercise, and the buoyancy of the water is supporting the body weight. Different patterns of lower limbs and upper limbs moves performed in the water can be used to boost heart rate and breathing, as well as muscular resistance and flexibility. Core exercises (abdominals and back muscles) may include lunges, side leg lifts,

Fig. 9.5 Water exercise is a popular activity among pregnant women

etc., or exercising with legs and arms at the same time. Upper limb moves may include underwater bicep curls, etc. Lower limbs exercises may include water walking, water jogging, jumping jacks, squats, high knee kicks, and underwater kicks and jumps. Pelvic floor exercises can be performed by incorporating them in other stretching or strengthening exercises. Pool noodles, paddles, barbells, balls, kickboards, aqua joggers, foam weights and other specific equipment can also be used for added resistance.

Upbeat music sets the cadence, the number of moves, the rhythm, and provides motivation. Workout intensity can be increased by doing more repetitions of each move, increasing speed, or using some equipment to increase resistance. An advanced class might include underwater interval training. Classes also are performed in outdoor pools where and when the weather allows. Usually the exercise specialist, placed in the dock of the swimming pool, shows the exercises putting emphasis on technique and breathing. A water exercise class typically lasts 45–60 min.

Swimming is also a popular exercise among pregnant women, recommended in several guidelines (see Chaps. 7 and 9). A swimming class may include adaptation to water environment exercises, arms' exercises, legs' exercises, technique exercises, assisted or resisted exercises, breathing exercises, and backstroke, freestyle (crawl), breaststroke and butterfly styles of swimming (including flip turns). Some small equipment can also be used to focus the exercise only on the arms or lower limbs (kickboard, pull buoys or another flotation device), increase resistance (hand paddles) or propulsion (swim fins) of the swimming exercises. The selection of exercises for each session will depend on the level of experience, skill, and fitness. Butterfly stroke is the most demanding regarding technique and effort. Each swimming stroke has a specific arm and movements' technique and performance, but general aspects of swimming include efficient movement of the body through the water, keeping the strokes long and relaxed, and trying to get as much distance as possible with each stroke (and increase speed).

As pregnancy progresses, some lower back movements will probably become difficult or painful (butterfly and breaststroke) and the expanded abdomen will create more resistance (drag) in the water (butterfly, breaststroke, and freestyle) making body alignment in water more difficult as well. The same reason applies to flip turns. Thus, the speed work usually performed by competition swimmers should be postponed until after the childbirth. Moreover, the hormonal changes provoking the relaxation of hip and pelvic joints may promote discomfort during the frog kick of breaststroke. For the same reason, the neck movements of the breaststroke and freestyle (assuming that the participant breathes alternately to the right and left sides or every three-arm strokes) may also become uncomfortable. The alterations of spine alignment may also interfere with backstroke. Nevertheless, the best technique is the one that the pregnant woman is able to perform correctly and without pain and discomfort, and is more motivated to practice.

A swimming session can last 30–60 min. However, a short interval of 10–15 min can be added to a regular water exercise session, especially when the pregnant women are able to swim backstroke.

A water aerobics class or a swimming training includes a warm-up, cardiovascular exercise, muscular resistance exercises and a cooldown with stretching exercises. When swimming or practicing water exercise, several precautions should be taken:

1. To ensure proper posture, technique, and breathing regarding water exercises and swimming strokes.
2. To avoid too cold or too hot water.
3. To ensure the hygienic conditions of the pool.
4. To ensure that the swimming pool is supervised regarding safety and emergency conditions.
5. To drink water before, during, and after exercising.
6. To use skin (lotion) and eyes (glasses) sun protection when exercising in outdoor pools.
7. To avoid jumping into the pool or diving activities.
8. To use proper and comfortable maternity swimwear.
9. To use proper water goggles (to protect from irritation), swim cap (to protect hair from damage), and maternity swimwear with bra support included.
10. To ensure the availability of bathroom facilities.
11. To avoid sharing a lane with other swimmers (because of potential shocks).
12. To avoid swimming alone when exercising outdoors in a lake, river, or sea.

9.3.3 High-Intensity Interval Training (HIIT)

High-intensity interval training (HIIT) has become the second most popular mode of exercise in the European fitness trends [72]. There is a variety of HIIT protocols: they are based on short work intervals (<60 s to 8 min) of vigorous (70%–90% maximal heart rate or 14–16 of the 6–20 RPE Borg's scale) to high intensity (≥90% maximal heart rate or ≥17 of the 6–20 RPE Borg's scale) interspersed with active (40%–70% maximal heart rate or 8–13 of the 6–20 RPE Borg's scale) or passive (cessation of movement) recovery periods (of 1–5 min) [73].

The effectiveness of HIIT programs on a number of health indicators has been proven in various populations, including populations with cardiac or metabolic disorders [74], elderly people with dementia [75] and cancer patients [76]. Given the significant benefits of HIIT programs, both in terms of the impact on metabolic changes and the impact on the psyche of participants, they should also be implemented for women in the perinatal period. To date, only trace data on the benefits of HIIT in pregnancy have been published [77, 78].

Studies in rats by Songstad et al. [18] showed that females responded well to HIIT throughout pregnancy. The program consisted of performing five training sessions per week, consisting of ten 4-min intervals with an intensity of 85–90% of the VO_{2max}. The authors did not record the side effects of such an HIIT program on pregnancy and fetal development. Interestingly, the HIIT program modified some of the genes associated with oxidative stress in fetal livers and hearts. This indicates

that adaptive mechanisms to intense physical exertion can be activated already in the fetal period.

Based on the research conducted on athletes, it is known that performing three to five submaximal running intervals, with an intensity of up to 90% VO_{2max}, did not adversely affect the fetal heart rate [19]. Temporary bradycardia appeared when their mother exceeded 90% VO_{2max} exercise intensity. Fetal parameters quickly normalized after the mother stopped exercise. Ong et al. [20] analyzed the effectiveness of a one-time interval session in a group of women in the third trimester, with an average level of activity before and during pregnancy. They observed that adding six 15-s intervals of subjectively maximum intensity to traditional moderate-intensity continuous training increased its energy expenditure by 28%. In addition, based on the PACES scale [21], the authors found that intensive intervals increased women's satisfaction with doing exercises. The studies by Salvesen et al. [14] have shown that high-class athletes performing near-maximum physical exercise in pregnancy gave birth to healthy newborns.

Nagpal et al. [79] noted, that due to the popularity of HIIT in general women population and the lack of evidence-based information and guidelines, pregnant women may inquire about HIIT on their own through online searches. The purpose of the study by Nagpal et al. was to systematically search and critically evaluate online resources that women may access when seeking guidance on how to participate in HIIT during pregnancy. Based on this study outcomes, publicly accessible online information on HIIT during pregnancy has been shown not to adhere routinely to evidence-based safety recommendations for prenatal exercise. The authors concluded that further research on HIIT during pregnancy and public dissemination of findings is required. There are a few projects already on the HIIT during pregnancy registered in the ClinicalTrials registration [80–82], but the study outcomes have not been yet published. Therefore, for now, women can participate in HIIT on the same terms as other special populations, taking into account the recent guidelines on physical activity during pregnancy.

The current recommendations do not set an upper limit for the intensity of physical effort in the perinatal period [3]. Women who regularly do intensive exercise can continue their physical activity during pregnancy and after delivery, provided that they remain healthy and that the pregnancy or delivery is normal. Although there is no scientific evidence, HIIT programs appear to be more appropriate for women who were active before pregnancy, as they are more likely to tolerate high-intensity exercise well during pregnancy. As any other exercise program, prenatal HIIT should be implemented gradually, starting with lower intensity. After a HIIT class, pregnant women should feel well and be motivated to train again.

An example of a prenatal HIIT can be a program of 3 sessions a week, in a duration of each session of 60 min. High-intensity intervals (approx. 85–90% of the maximum exercise capacity) should be planned as the main part of the training (15–20 min), e.g., 4 exercises, 3–4 series each. The high-intensity exercises will be performed for 30–60 s, alternating with a 30–60 s rest break, in the ratio of exercise time to rest 1:2, 1:1 or 2:1, according to the individual capabilities of the participant and taking into account the training progression and stage of pregnancy [82].

9.3.4 Resistance, Postural, and Neuromotor Exercises

9.3.4.1 Resistance Exercises

So far, there is sparse knowledge on strenuous strength training in the general pregnant population and there have been no studies on its effects in pregnant elite athletes [83]. According to Bø and coauthors [83], women who are considering heavy strength training in pregnancy should understand that the Valsalva maneuver used during weight training precipitates a rapid increase in blood pressure and intra-abdominal pressure [84–86] and therefore potentially may temporarily decrease blood flow to the fetus. The consequences of this process for the fetus development remain unknown. Heavy-strength training potentially may lead to pelvic floor disorders. Therefore, IOC experts [86] advised, the pelvic floor muscles should be contracted before and during heavy lifting to counteract the impact on the pelvic floor from increased intra-abdominal pressure. Research is needed to explain the above issues.

Nevertheless, in pro-health resistance training with a light-to-moderate load of free weights or weight machines (Fig. 9.6a–d), researchers have observed no adverse health

Fig. 9.6 Resistance training can be performed: (**a**) with body weight; (**b**) with load of free weights; (**c**) with stability ball; or (**d**) with weight machines

effects during pregnancy [26, 67, 87, 88]. Prenatal exercises strengthening particular body parts can improve both their appearance and functionality specific to pregnancy and motherhood. The fear of adverse effects of resistance training such as inadequate blood flow to the fetus during exercise was not supported by scientific research [26].

Resistance exercises for pregnant women follow the same training rules as for the general adult population. When applying the principle of training progression, one should consider the increase in body weight (at the end of pregnancy, it may be over a dozen kilograms). Additional body weight should be considered in exercises with body resistance. For example, it will be important in doing squats, but it will not matter in straightening the legs with the resistance of the machine in supine position. Keeping the same number of repetitions in exercises with body resistance until the end of pregnancy should be treated as training progress.

In the selection of the training load (also external load in the form of e.g., dumbbells, resistance bands, medicine balls, the resistance of machines), the individual level of fitness of the woman and her well-being during and after the exercises must be taken into consideration. There is no (and probably will not be) a maximum load allowed during pregnancy either in absolute values, e.g., in kilograms, or relative, e.g., in the percentage of maximum capabilities. There is no scientific basis for women to reduce workload in exercise simply because they became pregnant. It is good practice to self-assess the load. It is optimal when during the whole series of exercises, the woman maintains a free breathing rhythm, and during the last repetition in the working muscle group, she feels a noticeable tension and fatigue. Exhalation is performed during muscle work / muscle contraction, inhalation while muscles are relaxed. Until the determination of the impact of Valsalva maneuver (increased exhalation against closed airways) on the course of pregnancy, it is rational to limit it in both exercises and daily activities.

In 60-min sessions, after 30 min of aerobic exercise, the organization of 8–9 exercises strengthening main muscle groups in 2–3 sets of 12–24 repetitions fits very well. This is of course only a suggestion. Depending on the training goals and fitness of the woman, exercises can be performed at endurance and strength intervals, in the form of circuit training and others. There is no scientific basis to exclude specific training methods or techniques due to pregnancy. Special attention should be paid to the technique of exercise, including body posture, in order not to increase lordosis in the lumbar region. There are typical rules for teaching new exercises, from known to unknown and from simple to complex. There is no scientific basis to exclude technically difficult exercises from a training session if a woman is able to do them properly and does not experience discomfort while performing them.

It should be taken into account that in everyday activities the back muscles of a pregnant woman do intensive work to balance the abdominal mass [89]. Therefore, in the last weeks of pregnancy, it may be necessary to modify, exclude, or limit the range of the exercises for the spinal erectors. Leg muscles also work hard in locomotion. One must keep this in mind when planning an exercise program. We presented examples of resistance exercises in Appendix 4. Because abdominal and pelvic floor muscles are of particular importance for the course of pregnancy, we described them separately.

9.3.4.2 Pilates Mat

Pilates is an exercise technique which focuses on body–mind balance, muscle strengthening, flexibility, muscle control, posture, breathing, and the power center of stabilization [90]. The equipment required for a Pilates class may vary from a single mat, small and big balls, to specific machines called "reformer." The exercises are usually done in a specific order, one right after another, starting from a standing position, to other positions such as knees and hands, seating and laying positions. The movements have names, like the "100," the "Swan," the "Criss-Cross," the "Elephant," etc. Regarding intensity, Pilates can be very easy or very demanding, depending on the difficulty of the movements. The movements are usually performed in slow motion requiring precision and control to enhance muscle resistance and flexibility. This resistance and neuromotor exercise are a great addition to an aerobic program. Usually, the exercise specialist shows the exercises putting a strong emphasis on technique and breathing. Due to precision and control of movements, the supervision of movements by a qualified exercise professional is helpful even with experienced participants.

It is a safe and effective exercise to start or continue during pregnancy, as long as intensity (e.g., the amplitude of movements, repetitions, sustained time and position, lying positions) and complexity (muscles involved, resistance and flexibility required) can be adjusted to fitness and skill level as pregnancy progresses. However, pregnant women may need to avoid certain Pilates moves if they do not feel comfortable (i.e., head down, lying backward, etc.). Usually, participants are in a gym, in front of a mirror. However, a mat can be used at home to follow video classes if the participant is experienced and is able to use the appropriate technique. If the mat is used outdoors, precautions should be taken regarding the type of floor: it must be flat and not slippery. Although these exercises could have interesting intersections with pregnancy musculoskeletal adaptations, there are insufficient data in the literature to assess the effect on pregnant women.

A Pilates class typically lasts 45–60 min. However, short periods of 10–15 min of Pilates exercises can be included in a complete prenatal exercise session. A recent back or knee injury may be contraindications for Pilates exercise program. However, Pilates would be a good choice if the pregnant woman has low back pain.

9.3.4.3 Abdominals Exercises

Owing to, inter alia, the growing uterus, changes in the curvature of the spine and the effect of pregnancy hormones, abdominal muscles are heavily stretched [91]. As a result, almost 70% of all pregnant women experience lower back pain [92]. To minimize this risk, the ACOG [16] recommends the strengthening of abdominal and back muscles. Strong abdominal muscles also play an important role in the pushing process necessary during natural delivery. Although this still requires scientific evidence support, abdominal muscles maintained in good condition throughout pregnancy are more likely to recover quickly after delivery.

Despite the many obvious advantages of abdominal muscle exercises, this is a controversial topic. The reason for this phenomenon may be opinions appearing in the society that the abdominal muscles exercises during pregnancy can lead to

miscarriage or a more painful childbirth [93]. Even a significant part of exercise professionals are convinced that women should not exercise abdominal muscles in pregnancy [94]. It should be emphasized that so far, no studies have been published that could confirm the allegedly negative impact of abdominal muscle exercises on the course of pregnancy, childbirth, or development of a child.

The most important principles recommended for the implementation of abdominal muscle exercises during pregnancy are as follows:

1. When selecting the exercises for abdominal muscles, the stage of pregnancy should be taken into account. A large uterus will certainly hinder the abdominal muscle shortening during contraction. A growing fetus takes up space in the abdominal cavity. Therefore, in the high pregnancy, it is rational to limit the movements which additionally will reduce it, like in crunches. Nevertheless, it is the uncomfortable feeling of a woman in a given exercise that should be an indicator for its elimination or modification. Creating the so-called list of abdominal muscle exercises forbidden in pregnancy seems to have no scientific justification.
2. During exercise, one must remember to breathe properly; exhalation should be performed with muscle contraction, inhalation - when relaxing.
3. After a series of exercises to strengthen the abdominal muscles, it is recommended to relax them by conscious abdominal breathing (the abdomen protrudes as the diaphragm is lowered). The ability to move quickly from the state of tension to the relaxation of the abdominal muscles seems to be useful during delivery.
4. Due to the increase in lumbar lordosis during pregnancy, special attention should be paid to lay down on the back with the legs straightened as a starting position for exercise, e.g., in raising straight legs. In such exercises, the lumbar spine should be stabilized by shortening the abdominal muscles throughout the entire period of motion.
5. The supine position should be individually considered for a woman. Jeffreys et al. [95] observed that in women after 28 weeks of gestation, performing 60- to 90-s periods of abdominal crunches and leg exercise at moderate/high intensity (Borg's rating of perceived exertion 14 ± 1) in supine position, uterine blood flow decreased. However, the uterine blood flow decrease in those women was twice larger during 5-min rest in the supine position. There is still no scientific evidence that such temporary decrease in uterine blood flow has any negative influence on the course of pregnancy, fetus development, and its well-being. Based on systematic review by Mottola et al. [96], there was insufficient evidence to ascertain whether maternal exercise in the supine position is safe or should be avoided during pregnancy.
6. Exercises from the front or side plank positions are recommended mainly for advanced women. For women who are trying to perform planks for the first time in advanced pregnancy, there may be a problem with the correct technique and the risk of excessive deepening of the lumbar lordosis. It is then recommended to perform the exercise in a more upright version with the support on the forearms on a chair.

7. It is recommended to activate pelvic floor muscles in abdominal muscle exercises. This may prevent unwanted urine leakage during increasing intra-abdominal pressure.
8. Owing to the permanent stretching of the abdominal muscles by the growing uterus, it seems justified to limit the exercises stretching this muscle group. An alternative in this regard is to perform abdominal breathing.
9. Attention should be paid to the occurrence of prodromal uterine contractions (Braxton-Hicks contractions). Although they are not dangerous, if they are intense, they can cause tension in the abdominal area [97]. The Braxton–Hicks contractions may make women anxious and discourage them from being physically active [6]. Although it has not been proven scientifically, when prodromal uterine contractions strongly interfere with the pregnant woman, it is rational on the given day to limit the contraction stimuli by giving up exercises strengthening the abdominal muscles and replacing them with breathing and relaxing exercises.
10. Bearing in mind the fact that in some societies strengthening abdominal muscle exercises are unfoundedly labeled dangerous [94], exercise professionals and obstetrics care providers should pay special attention to educating women in this area.

Both before and during the exercise program, pregnant women should control the condition of their abdomen in terms of diastasis recti abdominis (DRA). It is a separation of the two rectus abdominis muscles along the *linea alba*, which appears in 66 to 100% of women in the third trimester [91]. The etiology of this condition is not clear. In the light of the available scientific evidence, there are no grounds to argue that intense exercises to strengthen abdominal muscles before conception or during pregnancy increase the risk of abdominal muscle separation. On the other hand, no reliable data are available, confirming whether diastasis recti abdominis can be prevented or treated with abdominal or other exercises during pregnancy. In one study, the researchers found that the acute response on inter-rectus distance (IRD) produced by drawing-in exercise was a widening of the IRD in postpartum, while the abdominal crunch exercise induced an acute narrowing response of the IRD in pregnancy and in postpartum [98].

Diastasis recti abdominis test should be performed as follows: lying back, legs bent, head and shoulder blades raised (as in abdominal crunch). One should check along the *linea alba* if there is no space between the abdominal muscles. The test is positive (diastasis recti abdominis is diagnosed) with palpation of ≥ 2 finger-breadths 4.5 cm above, at, or 4.5 cm below the umbilicus [99, 100]. A woman with a positive test requires consultation with a doctor or physiotherapist. To date, there is no consensus on whether to measure the distance along the *linea alba*, or on the cut-point for diagnosing the condition [91]. According to the study [101], evaluating the normal width of the *linea alba* in first-time pregnant women, the researchers found: during pregnancy at the 35–41 week of gestation, the 20th and the 80th percentile corresponded to 49–79 mm below the umbilicus, 54–86 mm at 2 cm above the umbilicus and 44–79 mm at 5 cm above the umbilicus. At 6 months postpartum,

the 20th and the 80th percentile corresponded to 9–21 mm at 2 cm below the umbilicus, from 17 to 28 mm at 2 cm above the umbilicus and from 12 to 24 mm at 5 cm above the umbilicus.

Although there is not much evidence on preventive or therapeutic exercises of DRA for pregnant women, there are some small experimental studies performed in postpartum women.

It is worth taking a look at an interesting, though small, study conducted in the USA by Walton et al. [7]. Two groups of women after giving birth followed one of the two training programs for 6 weeks. One program, the so-called traditional, included: abdominal crunches, posterior pelvic tilts, pelvic floor muscle contractions (Kegels), and Russian twists. In the second experimental program, the abdominal crunches were replaced with planks. Additionally, both groups used abdominal bracing, which was defined as using a large towel or sheet secured around the abdominal section for each patient. A statistically significant reduction in DRA was observed in both groups: 2.01 cm through the "abdominal crunch program" and 1.65 cm through the "plank program." Therefore, in this study, crunches were slightly more effective. What is more, both programs significantly reduced back pain problems reflected by a lower ODI score—Oswestry Disability Index (but not statistically significant, which could have resulted from the small study group).

The high effectiveness of both exercise programs carried out by Walton et al. [102] could result, inter alia, from the use of external "abdominal bracing." Confirmation of this assumption can be a randomized controlled trial (RCT) in postpartum women, published in 2019 by the international team Thabet et al. [103] from Egypt, Saudi Arabia, and Australia. For 8 weeks, one group of postpartum women performed traditional abdominal muscle training included: static abdominal contractions, posterior pelvic tilts, reverse sit-up exercises, trunk twists, and reverse trunk twists. Their DRA decreased by an average of 2.5 cm. The experimental group performed the same exercises, and additionally: mechanical support by abdominal bracing, abdominal breathing, pelvic floor muscle contractions, planks, and isometric abdominal muscle contractions. In this group, the DRA decreased by an average of 8.30 cm. Both programs were significantly effective in reducing the DRA, but the experimental one statistically significantly more ($p = 0.0001$). Once again, the effectiveness of the comprehensive impact has been proven.

There is no reason not to use the abdominal exercises mentioned above also during pregnancy. Before the results of high-quality research are available, for abdominal muscle exercises in pregnant women diagnosed with abdominal muscle separation, it is worth introducing rules based on movement biomechanics analysis:

1. Limit or completely eliminate exercise positions, in which the trunk is parallel to the floor and the uterus rests on the front wall of the abdomen as in a hammock, for example, front plank, supported kneeling.
2. Limit the range of trunk rotation and lateral flexion not to intensify mechanically the separation of the abdominal muscles.
3. Shorten the range of motion or eliminate exercises in which a bulge appears along *linea alba*.

Fig. 9.7 Using hands in the abdominal exercises in the prevention of the diastasis recti abdominis

4. Pay particular attention to exhalation during the abdominal muscle contraction to minimize intra-abdominal pressure.
5. Utilize the work of the hands to mechanically bring the abdominal muscles toward the *linea alba* (Fig. 9.7), especially in places where their separation has been observed. One can use a towel or a sweatshirt, as well.

The validity of the above recommendations should be confirmed by experimental research. We presented examples of abdominal exercises, also in the presence of diastasis recti abdominis in Appendix 5. See Chaps. 6 and 12 for further explanation on this topic.

9.3.4.4 Postural Exercises

Proper posture can alleviate many of the muscular and skeletal discomforts, especially back pain [104]; improve breathing efficiency [105, 106] as well as improve one's self-confidence [106]. In pregnancy, postural exercises are particularly important due to various biomechanical changes in the musculoskeletal system [107]. The growing uterus and breasts intensify women's tendency to protrude the belly and pull the shoulders forward.

Postural exercises should be a regular element of prenatal classes. It is recommended to perform them at the beginning of each exercise session and to repeat them a few times throughout the session, especially before those exercises, in which incorrect technique could consolidate postural defects. Postural exercises can be performed in standing, sitting, kneeling, and lying positions. In addition to the immediate effect of the posture correction, they should increase the body awareness and promote a habit of proper body alignment in everyday activities. A mirror is a good tool for giving feedback for postural exercises.

The correct posture in the standing position should be performed as follows:

- Feet slightly apart, the body weight rests in the middle of the feet, avoiding excessive heel load.
- Legs straightened in the hip and knee joints (avoiding hyperextension), knees are over the feet, hips over the knees.
- The pelvis is set in a neutral position, avoiding excessive tilts backward or forward.
- Arms straight down along the body.
- Abdominal muscles activated.
- Chest "open," but not too far forward.
- Shoulder blades pulled back, without causing non-physiological backward movement of the shoulders.
- Shoulders lowered, maintained at the same level.
- Spine elongated.
- The head in the extension of the torso, not tilted back, the chin should not be extended forward.
- The back of the head, shoulder blades, and buttocks should be in one plane.

We present examples of flexibility exercises for pregnant women in Appendix 6.

9.3.4.5 Neuromotor Exercise

A special place should be occupied by neuromotor exercises, e.g., balance and coordination exercises [34] (Fig. 9.8). Although the center of gravity changes during pregnancy, women who continue previously practiced form of activity are able to perform exercises requiring a high level of balance. Coordination exercises are typically included, e.g., in a step aerobics or dance session. Balance exercises can be included as a part of other sessions, e.g., Pilates session, aerobics, and resistance training session.

The balance-enhancing activities are those, which include:

- Narrowing the base of support.
- Perturbation of the ground support.
- Decrease in proprioceptive sensation.
- Diminished or misleading visual inputs.
- Disturbed vestibular system input.
- Increased compliance of the support surface.

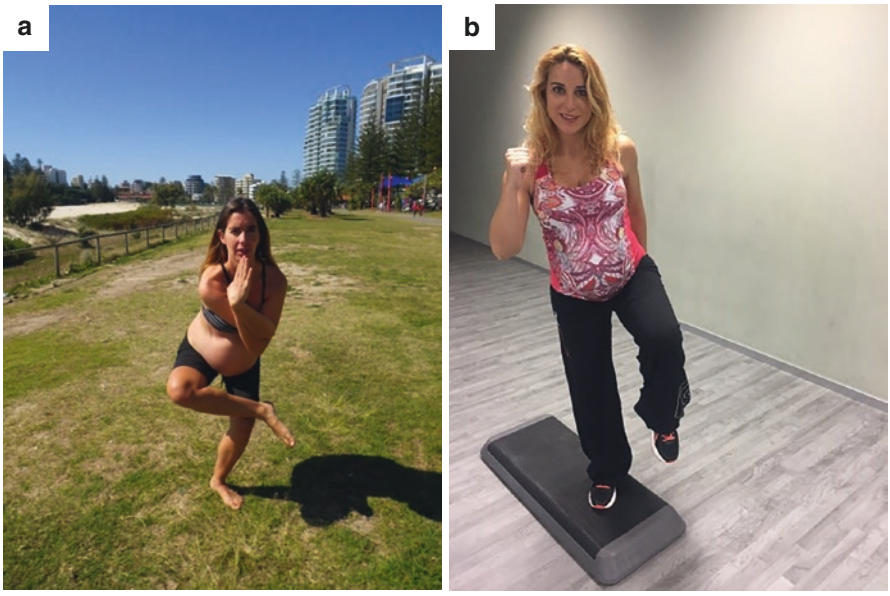


Fig. 9.8 Exercises requiring balance (**a**) and coordination (**b**) skills are examples of neuromotor exercises

- Movement of the center of mass of the body away from the vertical.

General techniques for neuromotor exercise can include following elements:

- Narrowing the base of support for the body.
- Displacing the center of mass to the limits of tolerance.
- Removing or minimizing contributions of visual, vestibular, and proprioceptive pathways to balance.

The validity of the above recommendations should be confirmed by experimental research. We presented examples of balance exercises for pregnant women in Appendix 7.

9.3.5 Flexibility Exercises

Flexibility (stretching) exercises should be part of a comprehensive exercise program, inter allia to reduce muscle tension and soreness, increase relaxation, improve range and ease of moves, and prevent injury [34, 108]. There are negligible scientific data on changes in the level of flexibility during pregnancy. Price et al [60]. observed that the sit-and-reach flexibility scores did not vary significantly between exercising pregnant women and sedentary control group. Their intervention circuit sessions ended with 5 min of hamstring, quadriceps, and calf stretching. No study participants reported injuries related to the exercise regimen. In studies analyzing

various aspects of prenatal exercise programs including stretching exercises [44, 45, 47, 48], also no negative impact on musculoskeletal system was indicated. Therefore, the opinion that due to the action of pregnancy hormones that increase tissue relaxation, prenatal stretching exercises can be dangerous, leading to "excessive stretching of the muscles" is unfounded. With the current state of knowledge, the selection and execution of stretching exercises in pregnancy should be guided by the same principles as for the general adult population. It should only be remembered that the large belly will limit the trunk flexion. Stretching exercises should be performed in positions recommended for pregnant women (see Appendix 1). Due to the large weight load in standing positions, it is advisable to perform stretching exercises in the sitting, kneeling, and lying positions.

An interesting research issue is the use of abdominal stretching exercises during pregnancy. As the fetus grows, the abdominal muscles remain in permanent stretching until the day of delivery. The negative effect of this may be the separation of the abdominal muscles (see Chap. 12). Therefore, approaching it logically, one should concentrate on the stimuli compensating the effect of pregnancy development, i.e., limiting the stretching of the abdominal muscles by the proper selection of position and intensification of exercises that relax this muscle group, e.g., by abdominal breathing. Nevertheless, there is no evidence that stretching exercises for abdominal muscles during pregnancy may intensify or reduce the feeling of unpleasant tightness or expansion of the abdomen or predispose to the diastasis recti abdominis.

Stretching exercises are a good tool to regulate the intensity of activities. Their performance in the main part immediately after exercises strengthening a given muscle group effectively reduces the intensity and extends the break time. Therefore, this solution is proposed for beginners with a lower level of performance. In turn, for advanced women, it will be more reasonable to perform strengthening exercises directly after each other and to leave stretching for the final part. Before performing a stretching exercise, one must remember to relax the whole body, especially the muscle group being stretched and to breathe deeply and calmly [34].

During pregnancy, it is worth paying special attention to stretching:

1. The anterior (hip flexors) and medial (hip adductors) compartments of thigh muscles in preparation for a natural birth.
2. The hamstrings and hip abductors, in the prevention of the piriformis syndrome (pain and/or numbness in the area of the buttock radiating down the buttock and the leg, resulting from the compression of the sciatic nerve around the piriformis muscle).
3. The back muscles to lower their excessive tension and soreness caused by balancing the posture with the growing belly.
4. The muscles of the chest and the anterior shoulder girdle that have a tendency to shorten during pregnancy.

We present examples of flexibility exercises for pregnant women in Appendix 8.

9.3.6 Pelvic Floor Muscle Exercises

Pelvic floor muscles stabilize the body, support pelvic organs, and determine the quality of sexual life [109, 110]. Systematic reviews have shown that pelvic-floor exercises should be recommended for prevention and treatment of urinary incontinence [111–113], a chronic health complaint occurring in 14 to 69% of European women [114]. Pregnancy and vaginal birth are the causal factors for pelvic floor disorders [115], which relate to symptoms of urinary or anal incontinence, pelvic organ prolapse, sensory or emptying abnormalities of the lower urinary tract, defecation dysfunction, sexual dysfunction, and pelvic floor pain syndromes. Although adults of all ages should exercise pelvic floor muscles, it is particularly important in pregnancy.

Correct contraction of pelvic floor muscles in exercise training is described as contracting and inward lifting of the muscles around pelvic openings while keeping outer abdominal, gluteal, and hip adductor muscles relaxed [116–119]. In recent studies, the proportion of women who were unable to correctly activate the pelvic floor on initial exam varied from 14 to 53% [119–122]. Only two-thirds are confident that they were doing pelvic-floor exercises correctly [123] while at least one in five may have had misplaced their confidence [121]. That is why good instructions how to exercise pelvic floor muscles are essential [120–122]. Some authors recommend biofeedback sessions to learn the technique of contracting pelvic floor muscles [124–126].

Various pelvic floor muscle exercises and training protocols [127, 128] have been published, but none of them has been considered a gold standard. However, in the implementation of pelvic floor muscle exercises, it is worth taking into account the following principles:

1. The first stage is the location of the pelvic floor muscles. A woman must be convinced that she is operating the right muscles. A typical mistake is to activate synergistic muscles (e.g., abdomen, buttocks, and thighs) or pushing (strain) of the pelvic floor muscles by increasing intra-abdominal pressure, often while inhaling [129]. Examples of exercises on the location of pelvic floor muscles and the ability to isolate them in a conscious contracting are presented in Appendix 9. When specialized equipment is available to assess the activation of pelvic floor and synergistic muscles, the use of a 1–4 score scale (Table 9.2) to evaluate the technique of pelvic floor muscle contraction is recommended [119].
2. In order to properly locate it, it is worth using specialist equipment providing biofeedback [126] and visualization (e.g., imagining the feeling of tightening a vaginal

Table 9.2 Technique scores for pelvic floor contractions [119]

Score	Score description	Pelvic floor muscles	Synergistic muscles
4	Correct technique	Activated	Not activated
3	Incorrect technique	Activated first in order	Activated after pelvic floor
2	Incorrect technique	Activated but not first in order	Activated before pelvic floor
1	Incorrect technique	Not activated	Activated

tampon or a small balloon). The so-called pee-stop exercise is controversial. Undoubtedly, it gives excellent feedback on both the location of the pelvic floor muscles and on their strength (e.g., the urinary stream can be weakened of completely stopped). On the other hand, there are not scientifically proven views that such an action may cause a urinary retreat from the lower urinary tract contributing to infections and it may interfere with the micturition mechanism. In fact, there is one study by Chesnel et al. [130] who reported that the urine stream interruption during a single micturition increases the post-void residual volume and translates into less efficient micturition. However, to date, there are no studies confirming the harmful, long-term effects of this exercise in healthy women. Until reliable data are available on the subject, it seems rational to use "pee-stop" exercise sporadically as a kind of self-assessment but not as a basis for regular training.

3. A complex training for pelvic-floor muscles should be focused both on their contraction and relaxation [116]. Contractions are to improve, among others, supporting functions for pelvic organs and continence. Relaxing exercises are helpful for the correct process of micturition, defecation, and delivery.
4. In the pelvic floor muscle exercises, the proper breathing technique should be maintained – the same as in the case of exercises of other muscle groups: exhalation is performed during contraction and inhalation during relaxation [34].
5. One should start from simple exercises (e.g., short contractions, the so-called quick flicks), gradually moving to more complex tasks (e.g., several-second holds at different rates) [131].
6. It is important to have a comprehensive impact on the motor skills of pelvic floor muscles, improving their speed, strength, endurance, and muscular coordination, and engaging both fast and slow twitch muscle fibers [132].
7. Exercises should start with an isolated form, i.e., when the pelvic floor is taut the rest of the body should be relaxed. According to Bø and Mørkved [129], the simultaneous activation of large synergistic muscles may mask the awareness and strength of pelvic floor muscle contraction.
8. Due to the low intensity of the isolated pelvic floor muscles exercises, they should be planned for the end of the exercise sessions.
9. Gradually, it is useful to incorporate pelvic floor muscle exercises in exercises that condition other muscle groups, e.g., abdomen, buttocks, and thighs. Thanks to this, in one exercise session, one can get more training stimuli for pelvic floor muscles [129, 132].
10. Conscious activation of pelvic floor in marching, running, or aerobics movements is a more difficult stage, but may be helpful to prevent urine leakage during these activities [50, 51].
11. An important task is to implement a conscious habit of contracting the pelvic floor muscles in daily activities, against the increase of the intra-abdominal pressure, e.g., before lifting heavy objects, before coughing, laughing, sneezing, etc. [131].

See Chaps. 6 and 12 for further explanation on this topic.

9.3.7 Cool-Down

The cool-down should be a part of every exercise session [36], also for pregnant women. Its main role is to calm the body systems after intense physical effort. It is good when after this part the respiratory rhythm and the heart rate return to the level close to pre-exercise values [34]. In the cool-down, the woman should assess her well-being and the intensity and difficulty of the exercises. If they were conducted by an exercise professional, there should be a summary and motivation for the next exercise sessions. It is also time to ask questions and provide professional information to build women's beliefs about the safety and benefits of prenatal exercise. In the cool-down, it is recommended to perform stretching exercises, according to the exercises carried out in the main part. It is also a great time to do exercises to prepare women for natural labor and delivery.

Natural birth, i.e., a birth without any medical intervention, is the best end of the pregnancy for the mother and the baby, both from the psychophysical and the social point of view [133]. Methods of childbirth other than physiological should be used only when justified [134]. Preparation for natural birth should be one of main goals of the future mothers, their families, and the healthcare system during antenatal education course [31]. Regular participation in the prenatal exercise program can significantly support this goal.

The onset and course of delivery are significantly influenced by the interaction of hormones, including an appropriate production of oxytocin. Its secretion can be affected by too high catecholamine levels, specific to the state of threat [133]. Russell et al. [135] observed among strenuous exercising athletes that catecholamines elevated by exercise may interact with female hormones. Magann et al. [136] found that heavy physical exercise in military training during pregnancy significantly increased the risk of induction or augmentation of labor with oxytocin and longer first stages of labor resulting in total longer labors. It is likely that the direction of women's mind to the aggressive, non-maternity tasks, reduced their psychological and physical readiness for the birth, manifested in disorders in its initiation and progression. Research by Magann et al. [136] may be evidence that not only the quantity but also the quality of prenatal exercise are important in order to get their positive impact on pregnancy and childbirth.

Both for hormonal balance, as well as for mental and physical preparation of women for childbirth and motherhood there are proposed, inter alia, birth positions, breathing exercises, relaxation, and visualization [27–31]. The cool-down part usually takes 5–10 min, but when planning visualization, it is worth prolonging it for an additional 15–20 min.

9.3.7.1 Birth Positions

According to the global trend of promoting natural birth, it is important to prepare a woman for the so-called use of birth positions. There is not one universal, most convenient birth position. The choice of position by the woman, the way of breathing

or movement should be completely intuitive and may change with the progress of labor [137, 138].

Many women thinking about childbirth have a picture of childbearing in the so-called classic position or lithotomy position, i.e., lying on your back with legs gaping, raised up. However, this position is the least favorable from the point of view of labor physiology and biomechanics of movement, because a woman has to push the child against the force of gravity [137, 138]. In vertical (or up-right) positions, the force of gravity supports the maternal effort of pushing, facilitates proper descent of the child into the birth canal and cervical dilation. Thanks to this, the time of delivery may be shortened and the necessity of using labor augmentation is reduced. In turn, the kneeling positions with the flexed trunk and the lying positions reduce the pressure of fetal head on the perineum area. They are particularly helpful in the first stage of delivery, when the laboring woman should not push because the cervix is incompletely opened, and also in long deliveries when the woman lacks the strength to maintain her vertical position. The use of different birth positions decreases perineal injury. In addition, it positively affects the psyche of the woman giving birth: it reduces the sense of anxiety, encourages active participation in childbirth, and increases the satisfaction with its course [139, 140].

To fully take advantage of the various birth positions, physical preparation for them is necessary. Some require strengthening or stretching of specific muscle parts. When planning prenatal physical activity, birth positions should be treated as one of the functional exercises and performed in each session, in accordance with generally accepted principles of teaching movement and training progression. The educational aspect is also important here. It is likely that a woman who has learned various birth positions during pregnancy, both theoretically and practically, will try to use them during the delivery. The study by Miquelutti et al. [30] showed that women who during antenatal education received instructions to adopt the vertical positions, comparing to controls, spent significantly more time in the upright positions and considered them more comfortable than the horizontal positions.

Recommended principles of performing birth positions in prenatal classes are as follows:

1. Exercises of birth positions can be performed as cool-down exercises at the end of the training session. They can also be included as relaxation or stretching exercises between a series of exercises strengthening various muscle groups.
2. In all birth positions, the coccyx bone should be maximally bent backward and pelvis tilted anteriorly to increase pelvic dimensions.
3. The whole body of a woman, and in particular the pelvic floor muscles, abdominals, thighs and buttocks, should be maximally relaxed, which is to build the ability to relax during painful contractions.
4. It is good to do breathing exercises in the birth positions, which helps to build the ability to breathe properly during delivery.

5. Birth position exercise may be accompanied by rhythmic pelvis movements to the front and back or up and down, which during the delivery may reduce the pain. This technique is particularly effective when it is combined with a rapid respiratory rhythm (e.g., pant breathing).
6. It is recommended to maintain birth positions by min. 20–30 s to get the right training stimulus (e.g., for muscle stretching).

We present examples of birth position exercises in Appendix 10.

9.3.7.2 Breathing Exercises

Breathing exercises bring many health benefits, including a reduction in the level of stress [141] and in the muscle fatigue [142] and an improvement in function of the circulatory system [143]. They are particularly recommended for pregnant women as, among others they may compensate for physiological and biomechanical changes in breathing pattern induced by pregnancy and increase the amount of oxygen transported to the fetus [144]. Owing to breathing exercises, a woman can reduce discomfort associated with a feeling of breathlessness appearing at the beginning of physical exertion. Breathing exercises are particularly important in the second and third trimesters, when the growing womb hinders the lowering of the diaphragm during inhalation.

Breathing exercises are an important element of preparation for delivery [29, 30]. Boaviagem et al. [145] observed that 6-week stress management program including relaxation breathing and progressive muscle relaxation twice a day contributed to the reduction of perceived stress and increased the sense of control in pregnant women. Abdominal breathing or the so-called belly breathing technique is advocated to improve the excursion of the diaphragm [146]. In the study by Amola et al. [147], 4-week training of diaphragmatic breathing exercises relieved dyspnea and improved pulmonary functions and capacity during third trimester of pregnancy. In addition, appropriate breathing techniques help to cope with pain during delivery [148] and protect against perineal damage during labor [149]. It may increase the efficiency of child displacement during childbirth.

Research indicates that the occasional use of breathing exercises does not bring the desired effect. In the study by Bergström et al. [150], four 2-h sessions with training in breathing and relaxation techniques during natural childbirth preparation did not decrease the use of epidural analgesia during labor, nor did it improve the birth experience or affect parental stress in early parenthood in nulliparous women, compared with a standard form of antenatal education. Boaviagem et al. [145] in turn have shown that breathing techniques offered to women during the first period of labor were not effective to control anxiety, pain, fatigue, and maternal satisfaction.

The above studies suggest that in order to achieve the effectiveness of breathing exercises and the possibility of their use during labor, it is necessary to perform them systematically throughout pregnancy [151]. Breathing exercises perfectly blend in

prenatal exercises, both in the cool-down part and in rest breaks between the series of strengthening exercises. The easiest way to do it is in a sitting position, which provides space in the chest and abdominal cavity, and facilitates relaxation of the abdominal muscles and observation of their work. One can treat breathing exercises performed in other positions, for example lying on the back or side, as a functional exercise. In most exercises, inhaling is done through the nose, exhaling through mouth and nose. We present examples of breathing exercises in Appendix 11.

9.3.7.3 Visualization of Pregnancy and Birth

In mental visualization training, one uses imagination to program the mind to perform in a particular situation in the best possible manner. Such exercises performed systematically and repeatedly lead to the development of neuronal connections between muscles and the central nervous system. Mental visualization training is commonly used in elite sports training and rehabilitation [152]. Visualization is increasingly becoming an important element of preparation for childbirth [31, 151]. The randomized control study by Rakhshani et al. [153] on yoga-based visualization and relaxation in high-risk pregnancy has shown significantly better uteroplacental and fetoplacental blood flow velocity in the yoga group compared to the control group. Ricchi et al. proved that women who had practiced visualization in their antenatal classes had a higher likelihood of taking advantage of the visualization exercises during the labor [151].

During visualization, a woman can imagine the proper development of a child during pregnancy and/or the delivery process. These ideas have a positive effect on the hormonal balance, reduce the level of anxiety, and build a positive attitude to delivery, including faith in their own strength to give birth to a child. Although the impact of visualization has not yet been well researched, certainly exercises of this type are a good form of rest after physical exercise. Women should take a comfortable position, preferably lying on their side or on the back, if in this position the pressure of the uterus does not cause discomfort. It will be useful to cover the body, due to the significant reduction in body temperature after intense physical exercise in the main part. They can use ready-made materials with a recorded voice or create pictures themselves. It is important that they evoke positive emotions and do not perpetuate fear. Depending on the organizational possibilities, the visualization may last from several to between 10 and 20 min.

9.4 Further Research

Owing to the fact that many unjustified ideas limit prenatal physical activity (like the need to wait up to 12–13 weeks of gestation to start exercising, the need to avoid raising hands above shoulder level or abdominal exercises, etc.), it is necessary to conduct research in this area and disseminate the findings. It seems reasonable to classify the forms of physical activity as safe for pregnancy or not on the basis of multidimensional research analysis, not just on implied opinions. Certainly, there is a lack of scientific data on how strenuous, high impact and/or technically complex

activities can influence the course of pregnancy, labor and delivery, and child development and how one can reduce their potential risks.

Insufficient information is available on flexibility exercises for pregnant women. A particularly interesting issue is whether the stretching exercises of the abdominal muscles predispose pregnant women to the diastasis recti abdominis or reduce its prevalence. It is also worth investigating whether any prenatal exercise program (including or excluding specific exercises) can have a preventive or therapeutic effect on the separation of the abdominal muscles in pregnancy. The validity of the recommendations for DRA prevention presented in this chapter should be confirmed by experimental research, as well. It is also interesting to evaluate the possibility of alleviating other pregnancy and puerperal symptoms and complications through specific exercise programs.

No information is available on neuromotor exercises for pregnant women. A particularly interesting issue is whether balance and coordination exercises included in a prenatal program would be effective in preventing falls.

There is a need for more experimental studies confirming the effectiveness of exercises preparing for birth (including various breathing techniques, birth position exercises, relaxation, and visualization) in improving the delivery outcomes.

We also notice a heterogeneous way of reporting exercise programs and a lack of information regarding the validity of experimental studies using "prenatal exercise programs" described as a complex intervention in the context of healthcare [154]. A particularly interesting issue is validating such programs before a pilot, feasibility, or a protocol study is performed. It would be helpful in understanding whether or not, which and how the exercise program was effective.

9.5 Conclusion

This chapter addresses the steps for planning, conducting, and monitoring prenatal exercise classes, and explains how to select and adapt different forms of exercises to achieve their maximum safety and efficiency. With the current state of knowledge and scientific rejection of the existing myths associated with the alleged harmful effects of physical activity on the course of pregnancy, birth, and fetal development, prenatal exercises can be more and more diverse and available to women with different needs.

Appendix 1: Exercise Positions for Pregnant Women

Standing Position (Fig. 9.9)

Execution: feet apart to the width of the hips, buttocks slightly contracted, abdominal muscles activated (shortened), pelvis in neutral position, relaxed knees, straight back, shoulders blades depressed and retracted, head in the spine extension. The modification is standing upright with various foot settings (e.g., parallel, outside).

Fig. 9.9 Standing position

Recommendations: The best position for body posture correction. Half-squats, squats, and lunges are performed from this position. Exercises for other muscle groups with equipment (e.g., dumbbells) or without may be performed. Standing position should be used in such activities, where it is impossible or contraindicated to sit or lie down (e.g., in outdoor exercises or directly after aerobic classes when the heart rate is still high).

Contraindications and remarks: In some guidelines, there is the recommendation to avoid motionless standing [155]. Carvalho et al. [156] noted that maintaining the **standing** position for a long time worsened low back pain in 27.2% of pregnant women in the third trimester. Although there is no clear scientific evidence, it seems that owing to the force of gravity. The standing position is inappropriate for women with pubic symphysis [157].

Sitting Positions (Figs. 9.10 and 9.11)

Execution: Sit-downs can be done in different versions: with straight legs or bent legs, with legs in parallel or in a straddle. The back is straight, the shoulders blades depressed and retracted, the head is in the extension of the spine.

Fig. 9.10 Sitting positions on the ground

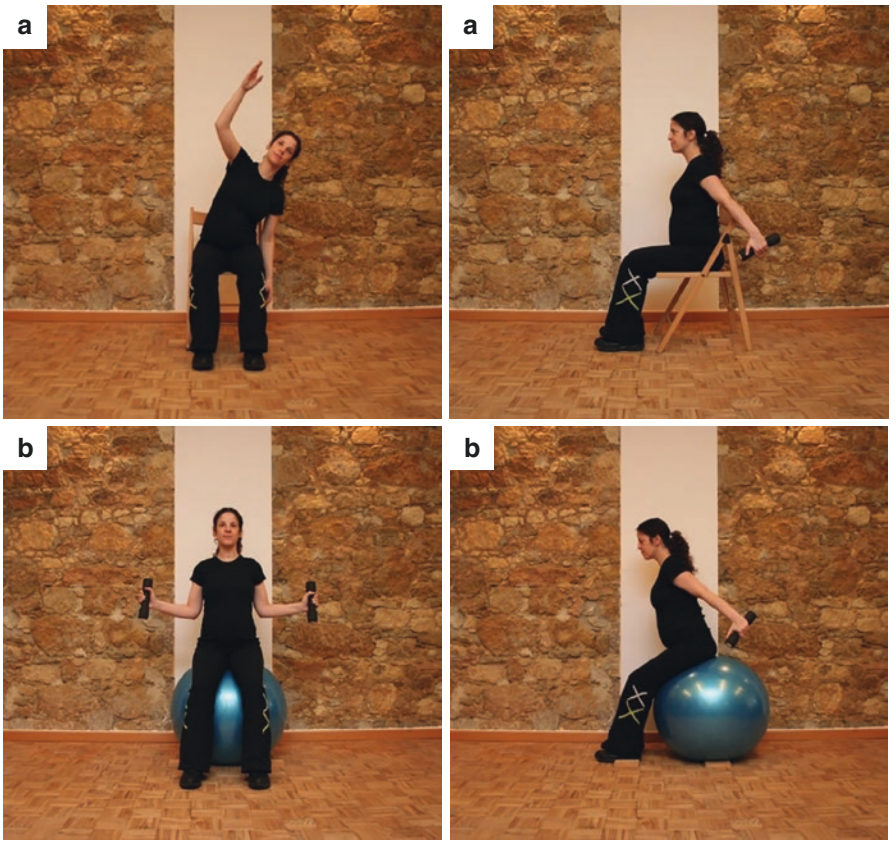


Fig. 9.11 Sitting positions: (**a**) on the chair; (**b**) on the stability ball

Recommendations: Sit-downs, whether on the floor in a chair or on a stability ball are a very good alternative for women who for some reason should not do exercises in standing positions. Due to the fact that the torso is still upright, they are suitable for the posturing exercises of the upper body. They are a good starting position for exercising arm muscles, torso, front legs, with equipment (e.g., dumbbells, exercise bands) or without, and for breathing exercises.

Vertical Kneeling Position (Fig. 9.12a)

Execution: Thighs are parallel, in natural spacing, buttocks slightly contracted, abdominal muscles activated (shortened), pelvis in neutral position, the back is straight, shoulders blades depressed and retracted, head in spine extension.

Recommendations: Kneeling is a good alternative for women who for some reason should not do exercises in standing positions. It is a good position for the posturing exercises of the upper body and the starting position for muscle training of the arms and torso with equipment (e.g., dumbbells) or without.

Contraindications and remarks: Not recommended for people with injuries or painful knees and in the case of worsening back pain in this position.

Kneeling Sit-Down Position (Fig. 9.12b)

Execution: Thighs are parallel, in natural spacing or apart, buttocks resting on the feet, the back is straight, shoulders blades depressed and retracted, the head is in the extension of the spine.

Recommendations: Kneeling sit-down position is a very good alternative for women who for some reason should not do exercises in standing positions, especially for those with back pain (the hip flexion reduces lumbar lordosis). Due to the fact that the torso is still upright, they are suitable for the posturing exercises of the upper body. They are a good starting position for exercising the muscles of the arms and torso with equipment (e.g., dumbbells) or without and for breathing exercises. The performance of kneeling alone is an exercise stretching the quadriceps muscles, anterior muscle group of the lower leg and foot.

Contraindications and remarks: Not recommended for women with injuries or painful knees. Kneeling sit-downs can be problematic for women with excessively shortened and tight quadriceps and / or flexors of the foot. Change position if leg numbness occurs.

Supported Kneeling Position (So-Called On All Fours) On Forearms or Hands (Fig. 9.12c)

Execution: The weight of the body rests evenly on the knees and hands, thighs, and arms are arranged in parallel, in natural spacing, hips over the knees, shoulders over the hands, active elbow joints, straight back, back and abdominal muscles activated, head in the spine extension.

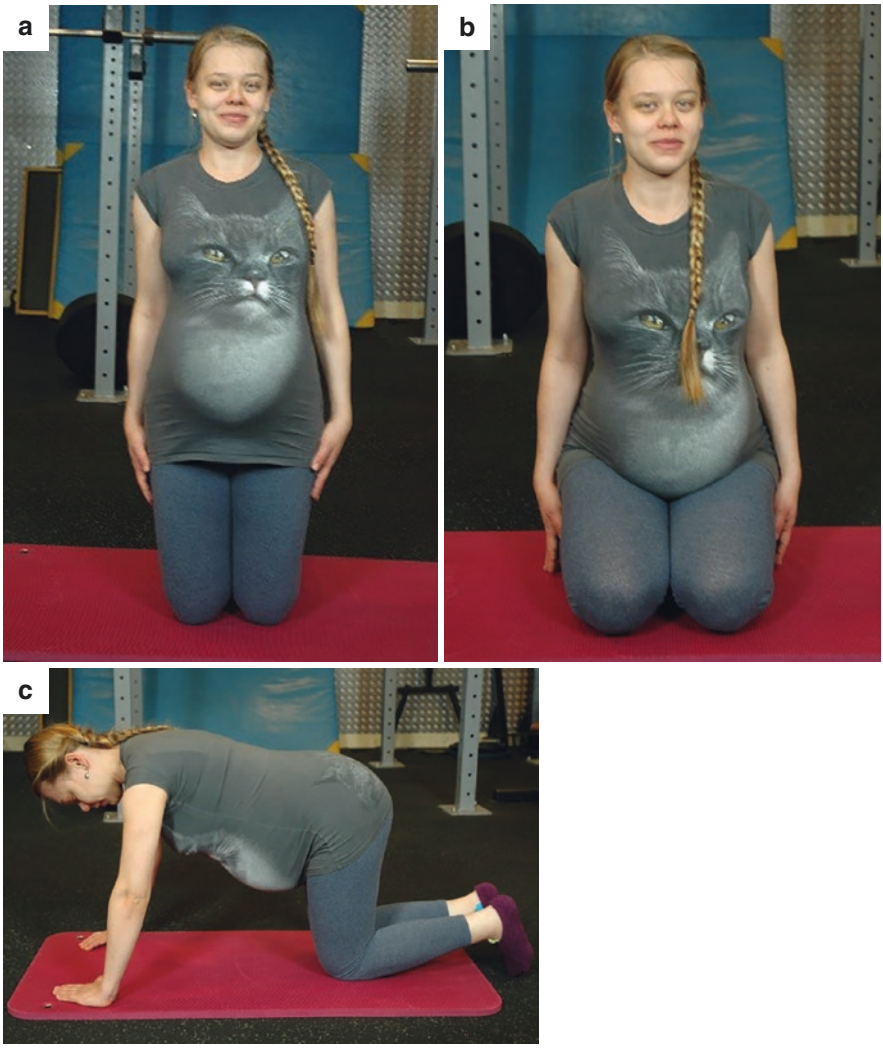


Fig. 9.12 Kneeling positions: (**a**) vertical kneeling position; (**b**) kneeling sit-down position; (**c**) supported kneeling position

Recommendations: When the abdominal and back muscles are properly activated, the position of the supported kneeling may be a good position for the exercise of the hamstrings and gluteus muscles, posterior muscles of the trunk, shoulders, and neck and also chest muscles (various versions of push-ups).

Contraindications and remarks: Although there is no scientific evidence, taking into account the force of gravity, this position may deepen the diastasis recti abdominis (heavy uterus rests on the abdominal muscles as in a hammock, weakened abdominal tissue due to uterine pressure may be further separated). Therefore, the position in the supported kneeling should be used in moderation in asymptomatic

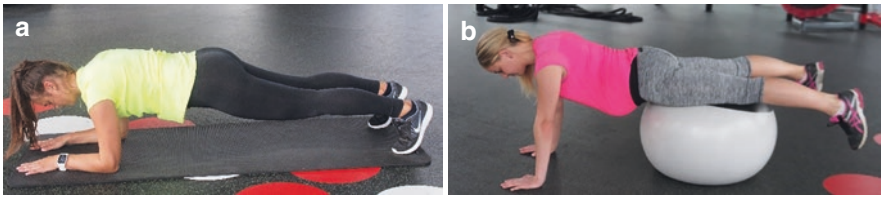


Fig. 9.13 Frontal plank position: (**a**) on the forearms; (**b**) with legs supported on the stability ball

women. In women with confirmed separation of the rectus abdominis muscles, it seems reasonable to completely exclude this position. For a wider use of the supported kneeling for prenatal exercises, one can support the abdomen on a stability ball or big bean bags.

Frontal Plank Position (Fig. 9.13)

Execution: The weight of the body rests evenly on the feet and hands (or forearms), and the arms are parallel, in natural spacing, the shoulders over the hands, active elbow joints, straight back, trunk muscles activated, head in spine extension.

Recommendations: A position directed to advanced women who used it before pregnancy. It can be a good position for the exercise of the chest muscles (various versions of push-ups), hamstrings and gluteus muscles, posterior muscles of the trunk, shoulders and neck.

Contraindications and remarks: Although there is no scientific evidence, taking into account the force of gravity, this position may deepen the diastasis recti abdominis (heavy uterus rests on the abdominal muscles as in a hammock, weakened abdominal tissue due to uterine pressure may be further separated). Therefore, the position in the supported kneeling should be used in moderation in asymptomatic women. In women with confirmed separation of the rectus abdominis muscles, it seems reasonable to completely exclude this position. Increasing weight of the uterus can hinder proper maintenance of the spine and abdominal contraction; therefore, it is necessary to systematically evaluate the technique of exercises performed in this position.

Supine Position (Fig. 9.14)

Execution: The back of the body lies on the floor, the legs can be straight or bent, the arms along the body, sideways or up.

Recommendations: Excellent relaxation position, relieving the spine, good position for pelvic floor muscle exercises, breathing exercises, and visualization.

Contraindications and remarks: Majority of guidelines on exercise in pregnancy recommended avoiding or limiting the supine position after the first

Fig. 9.14 Supine positions

Fig. 9.15 Supine position with the support of the back

trimester, or after 16 weeks of gestation, or after the fourth month of gestation (see Chaps. 7 and 9). In this position, the heavy uterus presses on the inferior vena cava and decreases the uterine blood flow [95], which may result in discomfort, dizziness, or anxiety in a pregnant woman. The observation, however, shows that not all women experience a worsening of well-being in this position [158]. Therefore, the complete elimination of exercises in supine positions is not justified and should be supported by an individual assessment of the woman's well-being. An alternative solution is to put a pillow or towel underneath one hip [159], change the position for lying on the side, or support the back to get a less horizontal body position (Fig. 9.15).

Lying on the Side (Fig. 9.16)

Execution: The weight of the body rests on one side, evenly from the legs to the shoulders, the head rests on the lower arm stretched along the torso, the trunk muscles can be relaxed. For balance, you can support the front on the palm of the upper hand and / or bend the legs in the hip joints and / or knee joints (according to the purpose of the exercise being performed).

Recommendations: Perfect relaxation position, relieving the spine, good position for pelvic floor muscle exercises, breathing exercises, visualization. It is a good alternative to changing positions for women who feel discomfort in lying on their backs. For longer lying, a left-sided position is more desirable [160], facilitating the free flow of venous blood to the heart. A comfortable way to change the side of lying down seems to be going through lying on the back.

Fig. 9.16 Lying on the side

Contraindications and remarks: A frequent mistake is supporting the head on the hand of the lower arm bent in the elbow or lifting the torso through support on the forearm of the lower arm. This position unnecessarily affects one side of the neck spine.

Prone Position (Lying on the Front)

Due to the growing uterus, lying on the front is a very uncomfortable position for pregnant women, especially in the second and third trimesters. Until more information becomes available, ACSM suggests avoiding prone position [161]. So far, however, there is no scientific evidence that the prone position is dangerous to the course of pregnancy.

Recommendations: Before the belly protrudes, a good position for the hamstrings, gluteus muscles, and posterior muscles of the trunk, shoulders, and neck.

Contraindications and remarks: As the pregnancy progresses, a woman may feel both physical and psychological discomfort associated with the pressure on the abdomen.

Appendix 2: Examples of Aerobics Movements for Pregnant Women

1. Step touch—from the basic standing position step side to side transferring the body weight with the leading leg and putting a foot to the foot (Fig. 9.17). The movement to the side should be extensive to involve the adductors and abductors of the thigh as much as possible. When the body weight is completely transferred, the pelvic floor should be contracted. Modification of the step touch is performed in various spatial variants, e.g., double step touch, L-step, square step (step touch in a square), step touch traveling diagonally (zigzag).
2. Step out (or side to side)—standing with feet apart by a slight bent of both knees (count of 1), the weight of the body is transferred toward the movement being performed, the other leg rests with the toes on the ground (count of 2). When the body weight is completely transferred, the pelvic floor should be contracted. The step is performed alternately in both directions. The torso is in a straight line, the foot of the stepping leg is fully attached to the ground, while

Fig. 9.17 Step touch

the second foot emphasizes the movement with the toes only. Both feet are in one line (Fig. 9.18).

3. Heel back. The step is performed as a step-out step, but in the last phase the second leg is detached from the ground, bent at the knee joint to about 90 degrees, the heel pointing toward the buttock (count of 2). When the body weight is completely transferred, the pelvic floor should be contracted. It is necessary to eliminate the forward movement of the hips in the final stage of the step that increases the lumbar lordosis (Fig. 9.19).
4. Knee up or knee lift. The knee can be raised forward (front knee up – Fig. 9.20a) or sideways (side knee up – Fig. 9.20b). The step is performed as a step-out step, but in the final stage, the second leg is detached from the ground, bent at the knee joint to about 90 degrees, with the knee pointing forward or sideways at the thigh (count of 2). When the weight is completely transferred to the side and the knee is lifted up, the pelvic floor should be stretched. It is necessary to eliminate the forward movement of the hips in the final stage of the step that increases the lumbar lordosis. When detaching the lower limb from the ground and lifting the knee, focus on maintaining the balance of the body. In women with advanced pregnancy, it may be necessary to shorten the lift of the leg so as not to cause the abdomen to be hit from the bottom by the thigh.

   The knee up step can be made in repetitions, e.g., twice or four times (four knee-up repeats). Done four times it is a step changing the leading leg in choreography.

Fig. 9.18 Step out

Fig. 9.19 Heel back

Fig. 9.20 Knee up (**a**—to the front; **b**—to the side)

5. V-step (Fig. 9.21). The step is performed in the shape of the letter V, hence its name. From the basic standing position, step 1 ft diagonally forward, outside (count of 1), then step the second leg diagonally forward, outside to the position of feet apart (count of 2), return of the first leg to the starting position (count of 3), return of the second leg to the starting position (count of 4).

   The forward movement is carried out naturally from the heel, and the feet are directed toward the outside. When returning to the back, the feet are in a parallel position, the entire sole attached to the ground. When the feet are joining in the final stage of the step, the pelvic floor should be contracted. The center of gravity should be as far as possible at the same level, without raising it or lowering it too much. The step is performed alternately in both directions. When the movement starts from the backward direction, the step is called A step.
6. Mambo forward and backward (Fig. 9.22)—from the basic standing position, moving the leading leg forward with the body weight (count of 1), returning the weight of the body onto the second stationary leg (count of 2), moving the leading leg back together with the weight of the body (count of 3), the return of the weight of the body to the stationary leg (count of 4). The stationary leg is always in contact with the ground and remains at the same place, and the feet are arranged in parallel with each other. The pelvic floor muscle contraction should be performed when the body weight is moved back and forth (on the counts of 1 and 3). To make the step from the second leg, it is necessary to change the leading leg.
7. Grape vine (Fig. 9.23). From the basic standing position, step the leading leg sideways with the body-weight transfer (count of 1), the crossing of the second leg at the back (count of 2), another step with the leading leg sideways with the weight transfer (count of 3) and bringing the second leg to (count of 4). The feet are directed slightly to the outside, all the time in one line. To increase the work of the abductor and adductor muscles, the feet are set far to the sides. The pelvic floor muscle contraction should be performed at the moment of crossing the legs (on the count of 2) and with joining the legs in the final step (on the count of 4). The step is performed alternately in both directions.
8. Marching forward/backward (Fig. 9.24)—is a modification of the march. The march forward is performed on 1, 2, 3, attaching legs, the so-called tap on 4 (can be made with knee up or a kick). Return to the starting position by moving backwards to 1, 2, 3, attaching legs to 4. Both legs should be loaded evenly. The pelvic floor muscle contraction should be performed at the moment of performing the tap (at count of 4).

   In order to increase the intensity of exercises, it is possible to perform high impact movements. Adding jumps and hops most often takes place in the final phase of the exercise, e.g., in step touch at the moment of joining the legs (on

Fig. 9.21 V-step

Fig. 9.22 Mambo forward and backward

the count of 2, Fig. 9.25). For the prevention of urinary incontinence, the woman should be advised to maintain the pelvic floor muscle contraction when jumping and the intra-abdominal pressure is at its greatest. It is easier to maintain the pelvic floor muscle activation and the continence in movements where the thighs are together. It is likely that urine leakage may occur in movements where thighs are apart at an increase in intra-abdominal pressure, e.g., in jumping jacks. Although there is a lack of scientific research on the relationship of the frequency and intensity of stress urinary incontinence in high-impact aerobics in pregnant women, it is common sense not to recommend high-impact aerobics for those who already experience this discomfort.

9. Examples of combinations:
   (a) Step touch right (2 beats) + step touch left (2 beats) x 8 times [32 beats].
   (b) Double step touch right (4 beats) + double step touch left (4 beats) x 4 times [32 beats].
   (c) Repeat sequence 1) [32 beats].
   (d) Repeat sequence 2) [32 beats].
   (e) Step touch right (2 beats) + step touch left (2 beats) x 8 times [32 beats].
   (f) Grapevine right (4 beats) + grapevine left (4 beats) x 4 times [32 beats].
   (g) Repeat sequence 5) [32 beats].

Fig. 9.23 Grape vine

Fig. 9.24 Marching forward/backward

Fig. 9.25 Adding high impact elements to the aerobics movements

(h) Repeat sequence 6) [32 beats].
(i) Grapevine right (4 beats) + 3 step touch left and right (12 beats) [16 beats].
(j) Grapevine left (4 beats) + 3 step touch right and left (12 beats) [16 beats].
(k) Repeat sequence 9) and 10) [32 beats].

(l) Repeat sequence 9) and 10) [32 beats].
(m) Repeat sequence 9) and 10) [32 beats].
(n) Grapevine right (4 beats) + step touch left and right (4 beats) + 2 V step left (8 beats) [16 beats].
(o) Grapevine left (4 beats) + step touch right and left (4 beats) + 2 V step right (8 beats) [16 beats].
(p) Repeat sequence 14) and 15) [32 beats].
(q) Repeat sequence 14) and 15) [32 beats].
(r) Repeat sequence 14) and 15) [32 beats].
(s) Progression: replace 2 V step with 2 mambo (or 1 mambo +1 mambo with pivot).
(t) Progression: replace 2 V step with 3 steps forward +1 knee lift +3 steps backwards +1 leg curl.
(u) Intensity: adding jumps and hops, adding arm moves, increasing cadence.

10. Examples of sequences of aerobics:
https://youtu.be/42cPuwrcR1g
https://youtu.be/fxvu5nWiQjg
https://youtu.be/dcn4yFbmbd4
11. Examples of sequences of aerodance:
https://youtu.be/TCWvVionxEM
https://youtu.be/NOdhY2Ve19c
https://youtu.be/BCUDyLwgwUg
https://youtu.be/s1fNIWg2oB4
12. Examples of workouts:
https://youtu.be/w27AHbkfC2Y [aerobics; Portuguese].

Appendix 3: Examples of Basic Step Aerobics Exercises for Pregnant Women

Technique considerations: Head up, shoulders down and back, chest up, abdominals lightly contracted and buttocks gently tucked under the hips. Knees and back should never hyperextend at any time. When stepping up the body should lean from the ankles. The entire sole of the foot should contact the bench, stepping softly and quietly to avoid unnecessary high impacts. When hopping or jumping, softly contact the bench or the floor. The heel should not land over the edge of the bench to avoid Achilles tendon injury. When "touching" the bench, the toes should be used. During knee lift, leg curl, and leg abduction, avoid hyperextending the other knee and the back. When stepping down, the step should be close to the bench (no more than one shoe length away) and the heel should contact the floor. Keep a comfortable distance between the body and the bench (neither too close nor too far).

1. March: Walk/steps in the same place.
2. Basic step: Moves up and down facing the step (Fig. 9.26).

3. Step Touch: Step from side to side, on the step (Fig. 9.27).
4. Step Knee: Step from side to side, lifting your knee, each side on the step (Fig. 9.28).
5. Leg Curl: Step from side to side, kicking your heel back, each side on the step (Fig. 9.29).
6. V Step: Move forward by stepping out wide in front of you with one leg at a time. Then step backward with one leg at a time closing the distance between your feet. Imagine you are making a V shape on the floor with your steps (Fig. 9.30).
7. Tap: Tap 1 ft up on the step and then the other foot (Fig. 9.31).

Fig. 9.26 Basic step

Fig. 9.27 Step Touch with step bench

Fig. 9.28 Step Knee

Fig. 9.29 Leg Curl

8. Mambo: The mambo involves stepping forward the step and then backward in the floor (or in the bench), repeatedly with the same foot while shifting the weight between the supporting, static foot and the moving foot (Fig. 9.32).
9. Examples of Combinations
   (a) Front tap right and left (4 beats) × 8 times [32 beats].
   (b) Cross tap right and left (4 beats) × 8 times [32 beats].
   (c) Repeat sequence 1) [32 beats].
   (d) Repeat sequence 2) [32 beats].

Fig. 9.30 V Step

Fig. 9.31 Tap

Fig. 9.32 Mambo

(e) Right step up and touch (4 beats) + left step up and touch (4 beats) × 4 times [32 beats].
(f) Repeat sequence 5) [32 beats].
(g) Right step up and knee lift (4 beats) + left step up and knee lift (4 beats) × 4 times [32 beats].
(h) Repeat sequence 7) [32 beats].
(i) Right step up and leg curl (4 beats) + left step up and leg curl (4 beats) × 4 times [32 beats].
(j) Repeat sequence 9) [32 beats].
(k) Right step up and knee hop (4 beats) + left step up and knee hop (4 beats) × 4 times [32 beats].
(l) Repeat sequence 11) [32 beats].
(m) Knee repeater right (8 beats) + knee repeater left (8 beats) × 2 times [32 beats].
(n) Repeat sequence 13) [32 beats].
(o) Repeat sequence 13) [32 beats].
(p) Repeat sequence 13) [32 beats].
(q) Knee repeater right (8 beats) + 2 basic steps left (8 beats) + knee repeater left (8 beats) + 2 basic steps right (8 beats) [32 beats].
(r) Repeat sequence 17) [32 beats].
(s) Knee repeater right (8 beats) + 6 basic steps left (24 beats) [32 beats].
(t) Knee repeater left (8 beats) + 6 basic steps right (24 beats) [32 beats].
(u) Knee repeater right (8 beats) + 2 basic steps left (8 beats) + 2 basic steps left over the top (8 beats) + 2 basic steps left (8 beats) [32 beats].
(v) Knee repeater left (8 beats) + 2 basic steps right (8 beats) + 2 basic steps right over the top (8 beats) + 2 basic steps right (8 beats) [32 beats].
(w) Repeat sequence 21) [32 beats].
(x) Repeat sequence 22) [32 beats].
(y) Knee repeater right (8 beats) + 2 step up knee lift left/right (8 beats) + 2 basic steps left over the top (8 beats) + 2 mambo left (8 beats) [32 beats].
(z) Knee repeater left (8 beats) + 2 step up knee lift right/left (8 beats) + 2 basic steps right over the top (8 beats) + 2 mambo right (8 beats) [32 beats].
(aa) Repeat sequence 25) [32 beats].
(bb) Repeat sequence 26) [32 beats].
(cc) Progression: replace 4 step up knee lift side-to-side with 4 step up knee lift "around the world".
(dd) Progression: replace 2 mambo with 1 mambo +1 mambo with pivot.
(ee) Progression: replace knee repeater with L step forward-side + L step side-backward.
(ff) Progression/intensity: replace step up knee lift with step knee hop.
(gg) Intensity: adding jumps and hops, adding arm moves, increasing cadence, using different approaches to the bench.

10. Examples of sequences of step exercise:
https://youtu.be/pPvX_tpI-dI
https://youtu.be/aR3XYAnz2y8

11. Examples of sequences of "invisible step":
    - https://youtu.be/d3hB9B9n32Q
    - https://youtu.be/-uCqgy4IBi8

Appendix 4: Examples of Resistance Exercises for Pregnant Women

1. Squats—from a standing position with feet apart to the width of the hips, bend the legs in the ankles, knees and hips lowering the center of gravity, then return to the starting position. Throughout the exercise, the soles fully touch the ground; the weight of the body rests more on the heels and the outsides of the feet. The torso remains in the neutral position, the abdominal muscles are activated, and the head is in the extension of the torso. The arms are moving forward for the balance. Returning to the starting position should be done with exhalation and simultaneous contraction of the pelvic floor muscles.

   Working muscles: muscles of the lower extremities, trunk muscles

   Difficulty options: The intensity of the exercise can be adjusted by the range of movement; the simplest version is a quarter-squat, intermediate half-squat and advanced - full squat. For a balance exercise, you can add the raising of the bent leg to the front. Squats can be performed with a load, such as dumbbells in the hands or barbells on the shoulders. Arm work can be attached to squats, for example, elbow flexion to activate biceps brachii (Fig. 9.33).
2. So-called Sumo squats—squats performed in the straddle, feet directed outwards.

   Working muscles: as above and additionally, thigh adductor muscles are more engaged.
3. Backward, forward, or sideways lunges—from a standing position a large step backward, forwards or sideways, lowering the center of gravity, then return to

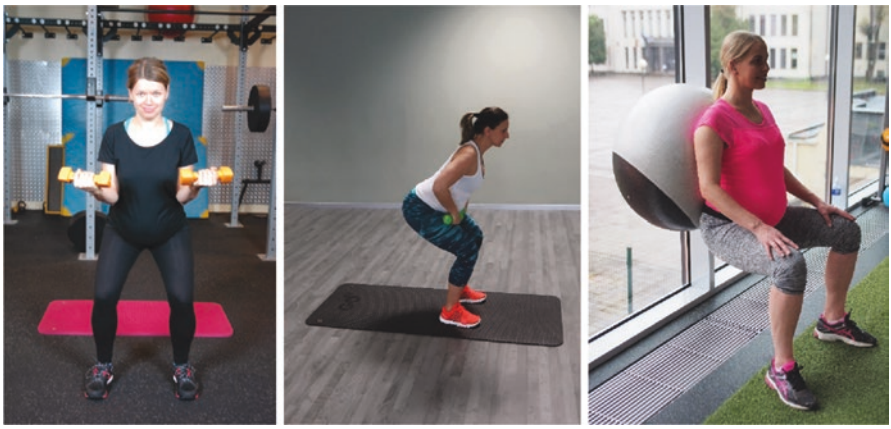


Fig. 9.33 Quarter-squat exercises

the starting position. The torso remains in the neutral position, the abdominal muscles are activated, and the head is in the extension of the torso. The arms are moving forward for the balance. Returning to the starting position should be done with exhalation and simultaneous contraction of the pelvic floor.

Working muscles: in backward and forward lunges, mainly flexors and extensors of the lower extremities, in sideways lunges additionally work the hip abductor and adductor muscles.

Difficulty options: The intensity of the exercise can be adjusted by the range of flexion in the joints of the legs, the smaller the flexion the easier the exercise option. For a balance exercise after backward or forward lunges, you can add the raise of the bent leg forward, with sideways lunges - raising a straight leg to the side. Lunges can be done with a load, such as dumbbells in the hands or barbell on the shoulders. Arms exercise can be added to lunges, for example, the raising of arms to the front or side (activation of the shoulder muscles, Fig. 9.34).

Exercises in high positions (various options of squats and lunges) are good functional exercises, preparing the body of a pregnant woman to move with the growing belly. Due to the fact that they engage several large muscle groups, they are more intensive compared to exercises performed in low positions (sitting, kneeling or lying). Nevertheless, in the case of worsening back pains, it is recommended to replace them with exercises performed while sitting, kneeling or lying down.

4. French press—from a sitting position with legs resting against the ground for stabilization, perform the elbow extension (Fig. 9.35).

   Main working muscles: triceps brachii.

   Difficulty options: the exercise can be done single-handed or with two-handed weight, e.g., a dumbbell or exercise band.

5. Modified unilateral behind the neck press (Fig. 9.36)—from sitting position on a stability ball, with legs resting against the ground for stabilization, shoulders lowered, arms bent in the elbow joints, straighten arm in the elbow joint upwards.

   Main working muscles: triceps brachii, shoulder, and upper back muscles.

   Difficulty options: exercise can be done with both hands with a load, such as a dumbbell.

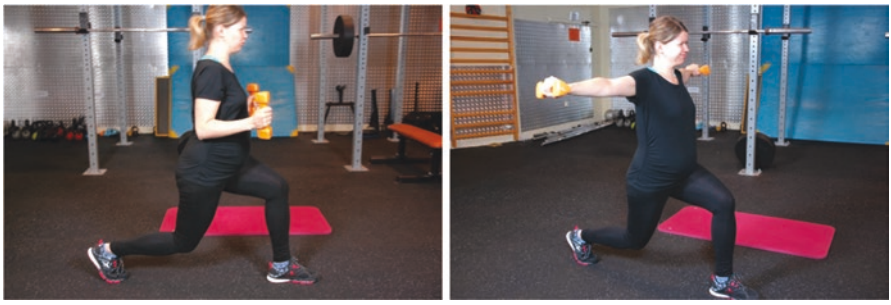
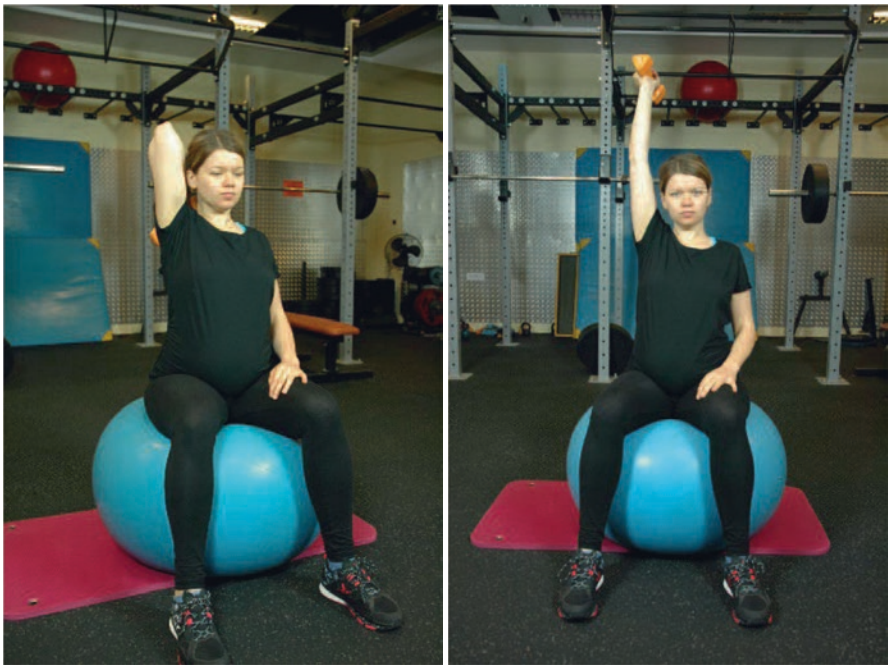


Fig. 9.34 Lunges with different arm moves



Starting position Exercise

Fig. 9.35 French press

Starting position Exercise

Fig. 9.36 Modified unilateral behind the neck press

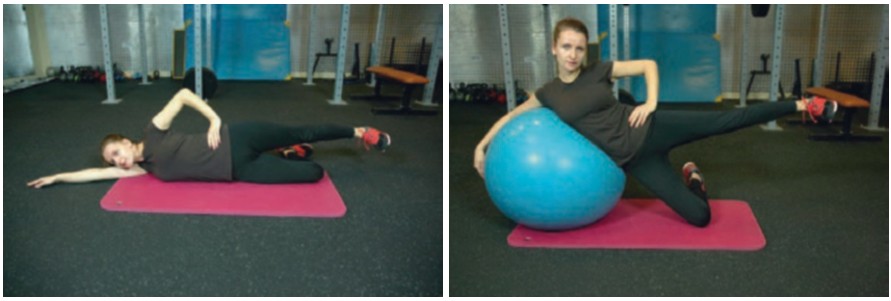
6. Pelvic bridging (Fig. 9.37)—from lying on the back, knees flexed, feet on the ground, lift hips together with hip joint extension, while feet, shoulders and head maintain contact with the ground. It is recommended to contract pelvic floor muscle together with lifting the hips.

   Main working muscles: hip extensor muscles.

   Difficulty options: The intensity and difficulty of the exercise can be increased by putting feet on a platform or a stability ball or by performing the exercise on one leg.

Easy option Advanced option

Fig. 9.37 Pelvic bridging



Easy option Advanced option

Fig. 9.38 Outer thigh lift

7. Outer thigh lift (Fig. 9.38)—from lying on the side, hip and knee of the lower leg flexed to stabilize the body, lift (abduct) the upper leg.
   Main working muscles: thigh abductors.
   Difficulty options: The intensity of the exercise can be adjusted by increasing the time of the abductor muscles contraction by keeping the upper leg up or by putting the body on the stability ball (which activates the core muscles).
8. Inner thigh lift (Fig. 9.39)—lying on the side, hip and knee of the upper leg flexed to about 90 degrees, placed in front of the body, lift (adduct) the lower leg. It is recommended to contract the pelvic floor muscle together with the leg lift.
   Main working muscles: thigh adductors.
   Difficulty options: The intensity of the exercise can be adjusted by increasing the time of the adductor muscle contraction by keeping the lower leg up.
9. Squeezing the ball with your knees and hands (Fig. 9.40)—from the seated position, knees flexed, feet on the ground, stability ball in the front between the thighs, hands on the upper part of the ball. At exhalation there is simultaneous pressure of thighs and hands on the ball, with inhalation—relaxation. It is recommended to contract abdominal and pelvic floor muscles together with the activation of the thigh and chest muscles.

Fig. 9.39 Inner thigh lift

Fig. 9.40 Squeezing the ball with your knees and hands

Main working muscles: thigh adductors, chest muscles, optionally abdominal and pelvic floor muscles.

Difficulty options: The intensity of the exercise can be adjusted by increasing the time to maintain muscle contraction (squeezing the ball).

10. Sideways push-ups (Fig. 9.41)—in the position of lying on the side, hips and knees flexed to stabilize the body. The hand of the lower arm covers the abdomen, the hand of the upper arm on the ground at the chest level. Straighten the upper arm.

    Main working muscles: triceps brachii, unilateral trunk muscles.

    Difficulty options: advanced exercise, toward the end of pregnancy, it may be necessary to shorten the extension movement in the elbow joint (incomplete extension).

11. Modified side plank (Fig. 9.42)—in lying on the side position, in the position of lying on the side, hips, and knees flexed to stabilize the body, the forearm of the lower arm is a support for the trunk. Lift the hips laterally. It is recommended to contract pelvic floor muscles together with the hips lift.

    Main working muscles: unilateral trunk muscles, hips abductors.

Fig. 9.41 Sideways push-ups

Fig. 9.42 Modified side plank

Difficulty options: advanced exercise, toward the end of pregnancy, additional support of the torso on the upper hand may be necessary.

12. Examples of sequences of resistance exercises (upper body):
    https://youtu.be/dRA-oA9_x7o (only arms).
    https://youtu.be/TxF_SO97qnE (bar).
    https://youtu.be/glqDhwxmz-0 (with bottle).
    https://youtu.be/ym6jkV_mx8Q (with bottle).
13. Examples of sequences of resistance exercises (lower body):
    https://youtu.be/5rlvSh46fLA (only legs).
    https://youtu.be/s1WYFR7fcb0 (squat, free weights).
    https://youtu.be/n7gaDSMKbYM (squat).
14. Examples of sequences of resistance exercises (core and back):
    https://youtu.be/O6O7IC5B7pA
15. Examples of workouts of resistance exercises:
    https://youtu.be/_yZVEoY1elM (free weights) [Portuguese].
    https://youtu.be/v8q55RtFPp4 (bar) [Portuguese].
    https://youtu.be/UybynJ0m_aQ (Pilates) [Portuguese].
    https://youtu.be/wtPBLgvKN5w (Pilates) [Portuguese].

Appendix 5: Examples of Abdominal Exercises for Pregnant Women Previously Inactive

1. Breathing abdominally, air pushing the belly forward, increasing the waist circumference (inhale through the nose, exhale through the mouth). Exercise can be performed in any position.
2. Sit on the ball, arms crossed on the chest, tilt the trunk back while rotating the pelvis forward and performing a full exhalation, return.
3. Sit on the ball, arms along the torso, bend the trunk to the right, return, and change sides. You can add a load in your hands (e.g., dumbbells, kettlebells).
4. Sit on the ball, arms to the side. Twist the trunk to the right, return to the starting position, change sides.
5. Sit on the ball, circular movements on the pelvis.
6. Sit on the ball, alternating the lift of the bent leg. A more difficult option of this exercise is the alternate lift of the bent leg from the semi-squat position, with the back resting against the wall (the ball may be under the back).
7. Sitting down with legs bent on the floor, hands are holding the back of the thigh. Tilting of the trunk back, back to the starting position. Exercise recommended for beginners. A more difficult version of this exercise is to keep your hands crossed on the chest. The more the trunk tilts back, the greater the activation of the abdominal muscles.
8. Sitting down with bent legs, torso twists. A more difficult version of the exercise is the twist of the torso with simultaneous tilting back. The more the torso tilts back, the greater the activation of the abdominal muscles.
9. A kneeling sit, a "cat's back" or emphasizing the thoracic and lumbar part of the spine, activating the abdominal muscles. In women with no diastasis recti abdominis, the exercise can be performed in the position of a supported kneeling (see exercise positions, p. 51).
10. Lying back, legs bent. Arms along the torso. Pelvic lift, return to starting position.
11. Lying on the side. Side-lying trunk lifts.

    Active women can continue their pre pregnancy abdominal exercises as long as the large abdomen does not interfere with the proper exercise technique (Fig. 9.43).
12. Example of sequence of core exercise:

    https://youtu.be/uwvYPWrIPcE

Suggestions for Exercises in the Presence of Diastasis Recti Abdominis

The following exercises are recommended for both pregnant and postpartum women with the separation of abdominal muscles.

1. While lying on the back, slowly perform an abdominal crunch lifting the head and shoulders, with a deep exhalation, pelvic floor contraction, and abdominal

Fig. 9.43 Core exercises

bracing, using hands or a large towel or sheet secured around the abdominal section, so as to bring the two sides of the rectus abdominis muscle as close as possible. If you do not feel well in the supine position, sit in a chair or on the ball, tilt your torso back slightly to activate your abdominal muscles and bend your torso as if you are performing a crunch exercise with the same technique as described above.

2. Standing, back based on the wall (alternatively using a stability ball). Perform elongation of the spine with the simultaneous activation of the abdominal muscles. Try to make sure that your entire back is leaning against the wall. Make a slight flexion in the knee joints while trying to keep the spine straight.
3. Sit cross-legged or sit on the ball, hands on the abdomen. Inhale through the nose, abdomen forward. Exhaling with the mouth, direct the navel towards the spine. Imagine that you hug the baby with the outer part of the abdomen. (Exercise combined with visualization, activating the transversus abdominis muscles).
4. Straddle sit with legs bent. The ball in the front is held with the inner side of the thighs and palms, simultaneous pressure with the legs and hands on the ball with the exhalation and conscious abdominal contraction.
5. Sit on the ball, back straight, arms along the torso. Raise the right knee, or gently bend the lower limb in the hip joint. Lower, change sides. It is important that the back remains in the same position during the exercise.

Appendix 6: Examples of Posture Exercises for Pregnant Women

1. In a standing position balancing from the front to the back of the foot and back looking for the moment when the weight of the body rests exactly in the middle of the foot. Exercise can be done with eyes closed (Fig. 9.44).
2. Exercise as above balancing on both sides of the body.
3. In standing position, the head, shoulders, buttocks, and feet are touching the wall, the task is to touch the wall with the largest part of the back.
4. In standing, sitting or kneeling position, keeping your hands on the belly, conscious activation of the abdominal muscles by making a loud grunt or an energetic exhalation through the mouth. The back and head remain in an unchanging vertical position.
5. Maintaining the correct posture in march and / or aerobic movements.
6. In sitting position consciously "opening" the chest, making the maximum inhale, pushing out the chest and pulling the shoulders back.
7. In the standing, sitting, or kneeling position, performing the elongation of the spine, independently checking the position of the head, shoulders, shoulder blades, and activation of the abdominal muscles.
8. In supine position, arms to the side, shoulder blades touching the floor, the task is to touch the floor with the largest part of the back. Note: for some women, this position may be uncomfortable. The alternative is to practice this exercise in standing back to the wall.
9. Examples of sequences of posture exercises:
   https://youtu.be/qT0_-fRzpro (Yoga).
   https://youtu.be/a7eIvHa-s0Q (barre).
   https://youtu.be/ilcUBX1Gmn0 (barre).
   https://youtu.be/ztgZT6n9DwA (barre).
   https://youtu.be/bWqaSG4s0FA (barre).
   https://youtu.be/Gl1Udp38aPs (arms).
   https://youtu.be/WEyYXs3FOVc (back).

Fig. 9.44 Posture exercise

Appendix 7: Examples of Balance Exercises for Pregnant Women

1. In a standing position, maintain correct posture, checking the elongation of the spine, the position of the head, shoulders, shoulder blades, and activation of the abdominal muscles (Fig. 9.45).
2. Difficulty can be increased by adding arm moves, increasing the time of the exercise, or by performing the exercises with eyes closed.
3. Difficulty can be decreased by performing the exercises with support (wall, chair, etc.).
4. Example of sequence of balance exercises:
   https://youtu.be/CMkoEhCSqA4

Fig. 9.45 Examples of balance exercises

https://youtu.be/isX_y7AiUpE
https://youtu.be/9JRawKd6N-I

5. Example of Workout of Balance Exercise
   https://youtu.be/jgyE3wj_6CY [Portuguese]

Appendix 8: Examples of Flexibility Exercises for Pregnant Women

1. Hip Flexor Stretch—from the kneeling position, the stability ball held on the side for balance, forward step, shifting the weight of the body on the forward leg with the maximum movement of the hips down and forward. Exercise is performed alternately, first on one, then on the other side (Fig. 9.46).
2. Inner thigh (thigh adductors) stretch with both legs bent—from the sitting position with the soles of the feet together, moving the knees maximally downwards. Optionally, one can gently press the inner parts of the thighs with a smooth motion (Fig. 9.47).
3. Inner thigh (thigh adductors) stretch with one leg bent - from the position of sitting with straight legs, bending of one leg and its maximum move outwards. A hand on the same side of the body can hold the leg and support the movement (Fig. 9.48).
4. Trunk muscle stretch in kneeling position—from the kneeling position, the trunk flexion with the maximum extension of the arms forward. Optionally, the exercise can be performed with a roller or a ball (Fig. 9.49).
5. Back muscle stretch in sitting position—from the sitting position with legs slightly bent, in a slight stride, the maximum rounding of the back with the chin pulled toward the sternum (stretching of the upper back muscles and posterior neck muscles). When the trunk flexion is deepened, the stretching of the lower part of the back muscles also intensifies. When performing this exercise

Fig. 9.46 Hip flexor stretch

Fig. 9.47 Hip flexor stretch with both legs bent

Fig. 9.48 Inner thigh stretch with one leg bent

Fig. 9.49 Trunk muscle stretch

Fig. 9.50 Back muscle stretch in sitting position

in a sitting position with straight legs, the hamstrings will also be stretched (Fig. 9.50).

6. Chest muscle stretch—from the supine position, the roller under the chest, the arms to the side, the bulge of the chest up. Optionally, the exercise can be performed on a stability ball. Due to the lack of data on the potential impact of stretching exercises on the intensification of abdominal muscle separation, it is recommended to limit the stretching movement at abdominal level in this exercise (Fig. 9.51).
7. Trunk muscle and thigh abductors stretch in lying back position—from the supine position one-sided flexion in the hip and knee joints, and then performing internal rotation trying to put the inner part of the knee on the floor. Throughout the exercise, both shoulders should be in contact with the floor. This is a very good position for strengthening the diaphragm by abdominal breathing (Fig. 9.52).
8. Examples of sequences of stretching exercises:
   https://youtu.be/0xqoOWQtcb8 (sitting position)
   https://youtu.be/TF_bNAz5yTg (sitting position)
   https://youtu.be/AoUUzyZcjQI (standing position)
   https://youtu.be/wMs0zsfn308 (standing position)
   https://youtu.be/n3w1aejyn7k (standing position)
   https://youtu.be/wihJoAFLAZE (chair)
   https://youtu.be/DiID0v9uQ4o (neck stretch)
   https://youtu.be/4XQyxy38E1M (hands stretch)
9. Examples of workouts of stretching exercises:
   https://youtu.be/uAgJVlZ1t10 [Portuguese]

Fig. 9.51 Chest muscle stretch

Fig. 9.52 Trunk muscle and thigh abductors stretch

Appendix 9: Examples of Exercises for Proper Pelvic Floor Muscle Contraction

1. It is best to perform the exercises lying on your back with bent knees and feet resting on the floor (alternatively lying sideways or sitting with your back leaning against the wall or stability ball) (Fig. 9.53).
2. Contract pelvic-floor muscles for 3–5 s, as if you were trying to stop a flow of urine or squeeze a tampon. Then relax these muscles. Try recognizing the difference between contracting and relaxing these areas.
3. Put your hands on your abdomen and contract abdominal muscles for 3–5 s as if you wanted to grunt or cough. Then relax those muscles. Try feeling the difference between contracting and relaxing abdominal muscles.
4. Put your hands on your buttocks and contract gluteal muscles for 3–5 s, lifting slightly your hips off the floor. Then relax those muscles. Try feeling the difference between contracting and relaxing gluteal muscles.

Fig. 9.53 Pelvic floor muscles exercises

5. Put your hands on the inner parts of thighs and contract thigh adductor muscles for 3–5 s pushing one knee into the other. Then relax those muscles. Try feeling the difference between contracting and relaxing the thigh adductor muscles.
6. Breathe deeply in and out relaxing all the above muscles.
7. Try keeping the abdominal, gluteal and thigh muscles relaxed and once again contract the pelvic-floor muscles for 3–5 s, as if you tried stopping urine flow or squeezing a tampon.

Appendix 10: Examples of Birth Position Exercises

1. Standing birth position—the pregnant woman is standing with feet apart; hands are based on thighs. In this position, the woman can perform any movements of the pelvis, circular, forward, and backward. Another version of this position is a standing position leaning against the wall or hanging on ladders.

   Recommendations and remarks: The position is proposed between a series of exercises strengthening the muscles of the legs in high positions, i.e., squats, half-squats, and lunges. Recommended for beginners as an alternative to squatting position (Fig. 9.54).
2. Squatting position (Fig. 9.55)—typical for the primitive human during the physiological, instinctive push. It provides the most effective biomechanics during the pushing. A full squat should be made, feet pointing outwards, while bending the torso. The abdomen, buttocks, and pelvic floor muscles should be maximally relaxed. Thighs can touch the stomach and chest, compressing the ribs and making the diaphragm's work easier, thus shortening the pushing phase. The inclination of the body forward along with the weight transfer on hands based on the floor ensures correct positioning of the pelvis and the coccyx bone, increasing

Fig. 9.54 Standing birth position

Fig. 9.55 Squatting position

Fig. 9.56 Sitting birth position

the space of the birth canal. In addition, laying the body close to the ground responds to the instinctive need of the woman. The position allows the woman to give birth to a child on her own.

Recommendations and remarks: The position is proposed between a series of exercises strengthening the muscles of the legs in high positions, i.e., squats, half-squats, and lunges. Performing the above position requires strong leg muscles, as well as stretching of the anterior and inner thigh and shank muscles. As most Western adults find it difficult to squat with heels down, compromises are often made such as putting a support under the elevated heels or another person supporting the squatter. For beginners, it is recommended to start from a standing delivery position (Fig. 9.54), gradually increasing the flexion in the joints of lower extremities.

3. Sitting birth position (Fig. 9.56)—the pregnant woman is sitting with her legs apart, knees are bent, her hands can hold her thighs or lower legs, her torso is slightly bent forward. Recommendations and remarks: The position is proposed between a series of exercises strengthening the abdominal muscles from the sitting position.

An option of this position can be performed sitting on the ball with legs apart, hands resting on the women's thighs, her torso leaning slightly forward, her feet on the floor. One can add circular movement of the hips. The position is proposed between a series of exercises strengthening the various muscle groups made from the sitting position on the ball. The elasticity of the ball supports the rhythm of the up-down movement of the hips and facilitates relaxing of the pelvic muscles. Both sitting positions are a good alternative for women who for some reason cannot execute the standing or squatting positions.

4. Horizontal kneeling, or so-called child position (Fig. 9.57)—the pregnant woman is in the sit-on kneeling position (sitting on the heels) the torso maximally bent, arms forward, the forehead can be based on the hands.

   Recommendations and remarks: The position is proposed between a series of exercises strengthening various muscle groups from the position of kneeling or kneeling sit-down. It is a very good position for relaxation and exercise stretching the muscles of the back, buttocks, chest, and arms.
5. "All fours" position (Fig. 9.58)—kneeling supported on the straightened arms, thighs in a slight straddle, the coccyx high up. Birthing in this position requires the help of a third party.

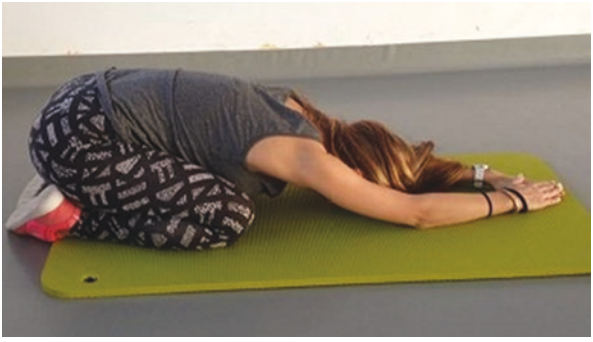


Fig. 9.57 Horizontal kneeling

Fig. 9.58 "All fours" position

Recommendations and remarks: The position relieves the spine. Proposed between series of exercises strengthening different muscle groups from the position of kneeling or kneeling sit-down. It is not recommended for women with a diagnosed diastasis recti abdominis.

6. Knee-elbow position (Fig. 9.59)—it is a variation of a kneeling position, with the upper body resting on bent forearms. Thanks to this, it is possible to lift the pelvis higher up. Birthing in this position requires the help of a third party.

   Recommendations and remarks: The position relieves the spine. Proposed between series of exercises strengthening various muscle groups from the position of kneeling or kneeling sit-down. It is not recommended for women with a diagnosed diastasis recti abdominis. One should be cautious about using it for women with a tendency to a headache (blood flows to the head with gravity).

7. Side-lying with open legs (Fig. 9.60)—lying sideways, upper leg bent, moved apart, knee pointing up, the hand of the upper arm grabs the leg below the knee and pulls it towards the chest. Birthing in this position requires the help of a third party.

   Recommendations and remarks: The position relieves the spine. Proposed between a series of strengthening exercises performed from the position lying sideways. During labor, it is recommended to lie on the left side to ensure the proper flow of venous blood to the heart. However, during the exercise classes,

Fig. 9.59 Knee-elbow position

Fig. 9.60 Side-lying with open legs

Fig. 9.61 Side-lying curled up

to ensure the bilateral balance of muscular work, one should change the sides of the exercises of this position.

8. Side lying curled up, or so-called fetal position (Fig. 9.61)—lying sideways, body curled up, legs bent and drawn toward the chest. Birthing in this position requires the help of a third party.

   Recommendations and remarks: As for the side lying with open legs position (see Fig. 9.60).

Appendix 11: Examples of Breathing Exercises for Pregnant Women

1. Abdominal (belly or "diaphragmatic") breathing—the abdominal cavity expands during inhalation and decreases during exhalation. During the exercise, take a deep breath, directing the air to the abdomen, and then perform a calm maximum exhalation. In this exercise, the diaphragm maximally drops into the abdomen, creating more space for optimal oxygen intake. This way of breathing improves blood flow to the abdominal region and helps to relax abdominal muscles. It also calms the nervous system and that is why it is recommended for relaxation and also during labor (Fig. 9.62).
2. Chest breathing—in this exercise, women should focus on working rib cage during breathing. At the time of inhalation, the chest should clearly increase in volume, rising up, forward, and sideways. Abdominal muscles should be activated throughout the entire duration of the exercise. A good position to perform this exercise is standing, requiring constant activation of the abdominal muscles to maintain the correct posture. They can be performed on a walk or during other exercises involving large muscle groups, e.g., during squats. Chest breathing is useful especially in the last weeks of pregnancy, when a large uterus makes it difficult to lower the diaphragm.
3. "Three-dimensional breathing"—both above exercises can be supported by an additional sensory stimulus. While breathing, the woman puts her hands in the front and on the side of the abdomen or chest and then on the back. With each breath, the hands should float slightly, with the exhalation slightly falling.

Fig. 9.62 Breathing exercises

4. Breath visualization—the effectiveness of the breath can be increased by visualization. For example, you can imagine your abdominal cavity or lungs as a large vase, which fills with water when you inhale and is emptied during exhalation. In another exercise, a woman can imagine that during the breath her child performs inhalation and exhalation together with her. Such exercises are to increase the awareness of breathing.
5. Diaphragm exercises in trunk lateral flexion and rotations. Deep abdominal breathing is an exercise for strengthening the diaphragm. It is difficult to breathe this way when the trunk is laterally inclined or twisted, which changes the biomechanical conditions for diaphragm operation.
6. Breathing exercises preparing for delivery. Painful uterine contractions during delivery disturb the respiratory rhythm and may lead an inexperienced woman to hold her breath. The task of the pregnancy exercise session is to prepare the woman's body for a quick and shallow breath, which can help her to overcome the pain of childbirth. The breathing resembles the panting or blowing out of a candle or feather flame, hence the name pant breathing or feather blowing.

Acceleration and shallowness of breath impede gas exchange and may cause hyperventilation in a beginner. Therefore, this exercise should start from 15–20 s, gradually extending to 60–90 s. Respiratory delivery exercises are good to perform in delivery positions, including visualization of labor and delivery pain. Each breathing sequence can be ended with a long, deep inhale through the nose followed by a long, deep exhale through the mouth, recommended for pushing. The exercise of the pushing itself is not recommended during pregnancy.

7. Example of breathing exercise sequences:
   https://youtu.be/z6UxFIsfQpE
   https://youtu.be/EKPsQAcKiT8
   https://youtu.be/DxqVr139-O0

References

1. Pivarnik JM, Mudd L. Oh baby! Exercise during pregnancy and the postpartum period. ACSMs Health Fit J. 2009;13(3):8–13.
2. ACOG. ACOG Committee Opinion No. 650. Physical activity and exercise during pregnancy and the postpartum period. In: Obstetrics and gynecology. Philadelphia: Lippincott Williams & Wilkins; 2015. p. e135–e42. Reaffirmed 2017.
3. ACOG. ACOG Committee Opinion No. 804. Physical activity and exercise during pregnancy and the postpartum period. Obstet Gynecol. 2020;135(4):e178–e88.
4. Szumilewicz A, Worska A, Rajkowska N, Santos-Rocha R. Summary of guidelines for exercise in pregnancy—are they comprehensive enough for designing the contents of a prenatal exercise program? Curr Women Health Rev. 2015;11(1):3–12.
5. Wojtyła A, Kapka-Skrzypczak L, Paprzycki P, Skrzypczak M, Biliński P. Epidemiological studies in Poland on effect of physical activity of pregnant women on the health of offspring and future generations—adaptation of the hypothesis development origin of health and diseases. Ann Agric Environ Med. 2012;19(2):315–26.
6. Hanghøj S. When it hurts I think: now the baby dies. Risk perceptions of physical activity during pregnancy. Women Birth. 2013;26(3):190–4.
7. ASC. Pregnancy in sport: guidelines for the Australian sporting industry. Bruce, ACT: Australian Sports Commission; 2002.
8. ASC. A new doubles partner: staying active during pregnancy—such as by hitting the court—can be beneficial to a woman's health. Tennis. 2017;53(5):14.
9. Szumilewicz A, Worska A, Santos-Rocha R, Oviedo-Caro M. Evidence-based and practice-oriented guidelines for exercising during pregnancy. In: Santos-Rocha R, editor. Exercise and physical activity during pregnancy and postpartum. Evidence-based guidelines. 2nd ed. Cham: Springer International; 2022, Ch.7.
10. Santos-Rocha R, Corrales-Gutierrez I, Szumilewicz A, Pajaujiene S. Exercise testing and prescription in pregnancy. In: Santos-Rocha R, editor. Exercise and physical activity during pregnancy and postpartum. Evidence-based guidelines. 2nd ed. Cham: Springer International; 2022, Ch.8.
11. WHO. WHO guidelines on physical activity and sedentary behaviour. Geneva: World Health Organization; 2020.
12. DHHS. Physical activity guidelines for Americans. 2nd ed. Washington, DC: U.S. Department of Health and Human Services; 2018.
13. ACOG. Early pregnancy loss. 2015. https://www.acog.org/-/media/Practice-Bulletins/Committee-on-Practice-Bulletins%2D%2D%2D%2DGynecology/Public/pb150.pdf. Accessed 6 Jan 2018.

14. Artal R. Exercise during pregnancy and the postpartum period. Wolters Kluwer; 2017. https://www.uptodate.com/contents/exercise-during-pregnancy-and-the-postpartum-period.
15. Clapp JF. The effects of maternal exercise on early pregnancy outcome. Am J Obstet Gynecol. 1989;161:1453–6.
16. ACOG. Physical activity and exercise during pregnancy and the postpartum period. The American College of Obstetricians and Gynecologists (ACOG). Committee Opinion No. 650; 2015.
17. Pivarnik JM. Cardiovascular responses to aerobic exercise during pregnancy and postpartum. Semin Perinatol. 1996;20(4):242–9.
18. Wolfe LA, Weissgerber TL. Clinical physiology of exercise in pregnancy: a literature review. J Obstet Gynaecol. 2003;25(6):473–83.
19. Wolfe LA, Kemp JG, Heenan AP, Preston RJ, Ohtake PJ. Acid-base regulation and control of ventilation in human pregnancy. Can J Physiol Pharmacol. 1998;76(9):815–27.
20. McAuley SE, Jensen D, McGrath MJ, Wolfe LA. Effects of human pregnancy and aerobic conditioning on alveolar gas exchange during exercise. Can J Physiol Pharmacol. 2005;83(7):625–33.
21. Pivarnik JM, Connolly CP, Marshall MR, Schlaff RA. Can pregnancy be an ergogenic aid to athletic performance?: a review. Women Sport Phys Activ J. 2017;25(2):111–7.
22. WHO. Nutritional interventions. In: WHO recommendations on antenatal care for a positive pregnancy experience [Internet]. Geneva: World Health Organization; 2016. p. 14–39. https://www.health.govt.nz/system/files/documents/publications/food-and-nutrition-guidelines-preg-and-bfeed.pdf. Accessed 6 Jan 2018.
23. Clapp JF, Cram C. Exercise through your pregnancy. 2nd ed. Omaha, NE: Addicus Books; 2012. p. 268.
24. Bryant CX, Franklin BA, S. N-M. ACE's guide to exercise testing and program design: a fitness professional's handbook. 2nd ed. Monterey: Healthy Learning; 2007.
25. Perales M, Santos-Lozano A, Ruiz JR, Lucia A, Barakat R. Benefits of aerobic or resistance training during pregnancy on maternal health and perinatal outcomes: a systematic review. Early Hum Dev. 2016;94:43–8.
26. White E, Pivarnik J, Pfeiffer K. Resistance training during Pregnancy and perinatal outcomes. J Phys Act Health. 2014;11(6):1141–8.
27. Karowicz-Bilińska A, Sikora A, Estemberg D, Brzozowska M, Berner-Trabska M, Kuś E, et al. Physiotherapy in obstetrics. Ginekol Pol. 2010;81(6):441–5.
28. Zwelling E. Overcoming the challenges: maternal movement and positioning to facilitate labor progress. Am J Matern Child Nurs. 2010;35(2):72–8.
29. Artieta-Pinedo I, Paz-Pascual C, Grandes G, Espinosa M. Framework for the establishment of a feasible, tailored and effective perinatal education programme. BMC Pregnancy Childbirth. 2017;17:1–10.
30. Miquelutti MA, Cecatti JG, Makuch MY. Antenatal education and the birthing experience of Brazilian women: a qualitative study. BMC Pregnancy Childbirth. 2013;13(1):1–8.
31. Levett KM, Smith CA, Bensoussan A, Dahlen HG. The complementary therapies for labour and birth study making sense of labour and birth - experiences of women, partners and midwives of a complementary medicine antenatal education course. Midwifery. 2016;40:124–31.
32. Gaston A, Prapavessis H. Tired, moody and pregnant? Exercise may be the answer. Psychol Health. 2013;28(12):1353–69.
33. Foxcroft KF, Rowlands IJ, Byrne NM, McIntyre HD, Callaway LK. Exercise in obese pregnant women: the role of social factors, lifestyle and pregnancy symptoms. BMC Pregnancy Childbirth. 2011;11(1):1–7.
34. ACSM. In: Thompson WR, editor. ACSM's resources for the personal trainer. 5th ed. Philadelphia: Wolters Kluwer Health; 2017. p. 632.
35. Eckmann T, Stoddart D. The power of posture: a program to encourage optimal posture. J Active Aging. 2015;14(4):54–68.

36. Kennedy-Armbruster C, Yoke MM. Methods of group exercise instruction. 3rd ed. Champaign, IL: Human Kinetics; 2014. p. 440.
37. Jensen D, Wolfe LA, Slatkovska L, Webb KA, Davies GAL, O'Donnell DE. Effects of human pregnancy on the ventilatory chemoreflex response to carbon dioxide. Am J Physiol Regul Integr Comp Physiol. 2005;288(5):R1369–R75.
38. SMA. Pregnancy and exercise. Women in sport. SMA_AWiS_Pregnancy_-_Exercise.Pdf: sport medicine Australia. Accessed 13 Jul 2021.
39. RANZCOG. Exercise in pregnancy. The Royal Australian and New Zealand College of Obsterticians and Gynaecologists; 2020.
40. Mottola MF, Davenport MH, Ruchat S-M, Davies GA, Poitras VJ, Gray CE, et al. 2019 Canadian guideline for physical activity throughout pregnancy. Br J Sports Med. 2018;52(21):1339–46.
41. ACSM. ACSM information on Pregnancy physical activity. Indianapolis, IN: American College of Sports Medicine; 2020.
42. DHHS US. 2008 Physical activity guidelines for Americans. U.S. Department of Human and Health Services; 2008. https://health.gov/paguidelines/pdf/paguide.pdf.
43. Santos-Rocha R, Pimenta N. Teaching group fitness to music. In: Santos Rocha R, Rieger T, Jimenez A, editors. EuropeActive's essentials for Fitness Instructors. Champaign, IL: Human Kinetics; 2015.
44. Haakstad LAH, Bø K. Exercise in pregnant women and birth weight: a randomized controlled trial. BMC Pregnancy Childbirth. 2011;11:66.
45. Halvorsen S, Haakstad LAH, Edvardsen E, Bø K. Effect of aerobic dance on cardiorespiratory fitness in pregnant women: a randomised controlled trial. Physiotherapy. 2013;99(1):42–8.
46. Barakat R, Cordero Y, Coteron J, Luaces M, Montejo R. Exercise during pregnancy improves maternal glucose screen at 24-28 weeks: a randomised controlled trial. Br J Sports Med. 2012;46(9):656–61.
47. Stafne SN, Salvesen K, Romundstad PR, Torjusen IH, Mørkved S. Does regular exercise including pelvic floor muscle training prevent urinary and anal incontinence during pregnancy? A randomised controlled trial. BJOG. 2012;119(10):1270–80.
48. Barakat R, Pelaez M, Montejo R, Refoyo I, Coteron J. Exercise throughout pregnancy does not cause preterm delivery: a randomized, controlled trial. J Phys Act Health. 2014;11(5):1012–7.
49. Barakat R, Pelaez M, Lopez C, Montejo R, Coteron J. Exercise during pregnancy reduces the rate of cesarean and instrumental deliveries: results of a randomized controlled trial. J Matern Fetal Neonatal Med. 2012;25(11):2372–6.
50. Szumilewicz A, Dornowski M, Piernicka M, Worska A, Kuchta A, Kortas J, et al. High-low impact exercise program including pelvic floor muscle exercises improves pelvic floor muscle function in healthy pregnant women—a randomized control trial. Front Physiol. 2019;9:1867.
51. Szumilewicz A, Kuchta A, Kranich M, Dornowski M, Jastrzębski Z. 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. 2020;99(6):e18874.
52. Laukkanen RM, Kalaja MK, Kalaja SP, Holmala EB, Paavolainen LM, Tummavuori M, et al. Heart rate during aerobics classes in women with different previous experience of aerobics. Eur J Appl Physiol. 2001;84(1–2):64–8.
53. Bourcier AP. Incontinence during sports and fitness activities. In: Baessler K, Schüssler K, Burgio KL, Moore K, Norton PA, Stanton SL, editors. Pelvic floor re-education principles and practice. 2nd ed. Berlin: Springer; 2008. p. 267–70.
54. Reebok University Press. Introduction to step reebok. Stoughton: Reebok International; 1994.
55. Reebok University Press. Power Step Reebok. Stoughton: Reebok International; 1994.
56. Santos-Rocha R, Veloso A, Machado ML. Analysis of ground reaction forces in step exercise depending on step pattern and stepping rate. J Strength Cond Res. 2009;23(1):209–24.
57. Santos-Rocha RA, Oliveira CS, Veloso AP. Osteogenic index of step exercise depending on choreographic movements, session duration, and stepping rate. Br J Sports Med. 2006;40(10):860–6.
58. Engels HJ, Currie JS, Lueck CC, Wirth JC. Bench/step training with and without extremity loading. Effects on muscular fitness, body composition profile, and psychological affect. J Sports Med Phys Fitness. 2002;42(1):71–8.

59. Forczek W, Curyło M, Forczek B. Physical activity assessment during gestation and its outcomes: a review. Obstet Gynecol Surv. 2017;72(7):425–44.
60. Price BB, Amini SB, Kappeler K. Exercise in pregnancy: effect on fitness and obstetric outcomes-a randomized trial. Med Sci Sports Exerc. 2012;44(12):2263–9.
61. Skreden M, Øverby NC, Sagedal LR, Vistad I, Torstveit MK, Lohne-Seiler H, et al. Change in active transportation and weight gain in pregnancy. Int J Behav Nutr Phys Activ. 2016;13:10.
62. Butler JM. Fit & pregnant. The pregnant women guide to exercise. 2nd ed. Montpelier: Vitesse Press; 2006. p. 192.
63. Nascimento SL, Surita FG, Godoy AC, Kasawara KT, Morais SS. Physical activity patterns and factors related to exercise during pregnancy: a cross sectional study. PLoS One. 2015;10(6):1–14.
64. Davenport MH, Mottola MF, McManus R, Gratton R. A walking intervention improves capillary glucose control in women with gestational diabetes mellitus: a pilot study. Appl Physiol Nutr Metab. 2008;33(3):511–7.
65. de Oliveria Melo AS, Silva JLP, Tavares JS, Barros VO, Leite DFB, Amorim MMR. Effect of a physical exercise program during pregnancy on uteroplacental and fetal blood flow and fetal growth: a randomized controlled trial. Obstet Gynecol. 2012;120(2 Pt 1):302–10.
66. Ruchat SM, Davenport MH, Giroux I, Hillier M, Batada A, Sopper MM, et al. Walking program of low or vigorous intensity during pregnancy confers an aerobic benefit. Int J Sports Med. 2012;33(8):661–6.
67. Garnæs KK, Nyrnes SA, Salvesen KÅ, Salvesen Ø, Mørkved S, Moholdt T. Effect of supervised exercise training during pregnancy on neonatal and maternal outcomes among overweight and obese women. Secondary analyses of the ETIP trial: a randomised controlled trial. PLoS One. 2017;12(3):1–15.
68. Garnæs KK, Mørkved S, Salvesen KÅ, Salvesen Ø, Moholdt T. Exercise training during pregnancy reduces circulating insulin levels in overweight/obese women postpartum: secondary analysis of a randomised controlled trial (the ETIP trial). BMC Pregnancy Childbirth. 2018;18:1–11.
69. Baciuk EP, Pereira RI, Cecatti JG, Braga AF, Cavalcante SR. Water aerobics in pregnancy: cardiovascular response, labor and neonatal outcomes. Reprod Health. 2008;5:10.
70. Cavalcante SR, Cecatti JG, Pereira RI, Baciuk EP, Bernardo AL, Silveira C. Water aerobics II: maternal body composition and perinatal outcomes after a program for low risk pregnant women. Reprod Health. 2009;6:1.
71. Vallim AL, Osis MJ, Cecatti JG, Baciuk ÉP, Silveira C, Cavalcante SR. Water exercises and quality of life during pregnancy. Reprod Health. 2011;8(1):14–20.
72. Batrakoulis A. European survey of fitness trends for 2020. ACSMs Health Fit J. 2019; 23(6):28–35.
73. Wood G, Murrell A, van der Touw T, Smart N. HIIT is not superior to MICT in altering blood lipids: a systematic review and meta-analysis. BMJ Open Sport Exerc Med. 2019;5(1):e000647.
74. Campbell WW, Kraus WE, Powell KE, Haskell WL, Janz KF, Jakicic JM, et al. High-intensity interval training for cardiometabolic disease prevention. Med Sci Sports Exerc. 2019;51(6):1220–6.
75. Yeh S-W, Lin L-F, Chen H-C, Huang L-K, Hu C-J, Tam K-W, et al. High-intensity functional exercise in older adults with dementia: a systematic review and meta-analysis. Clin Rehabil. 2021;35(2):169–81.
76. Lavín-Pérez AM, Collado-Mateo D, Mayo X, Humphreys L, Liguori G, James Copeland R, et al. High-intensity exercise to improve cardiorespiratory fitness in cancer patients and survivors: a systematic review and meta-analysis. Scand J Med Sci Sports. 2021;31(2): 265–94.
77. Songstad NT, Kaspersen K-HF, Hafstad AD, Basnet P, Ytrehus K, Acharya G. Effects of high intensity interval training on pregnant rats, and the placenta, heart and liver of their fetuses. PLoS One. 2015;10(10):1–15.
78. Ong MJ, Wallman KE, Fournier PA, Newnham JP, Guelfi KJ. 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.
79. Nagpal TS, Everest C, Goudreau AD, Manicks M, Adamo KB. To HIIT or not to HIIT? The question pregnant women may be searching for online: a descriptive observational study. Perspect Public Health. 2021:1757913920985898.
80. El Refaye G. Insulin sensitivity response to high-intensity training in insulin resistance during pregnancy. NCT04830995 ClinicalTrials.gov; 2021.
81. Moholdt T. Acute effects of high intensity training in pregnancy on fetal well-being and blood flow distribution. NCT04288479 ClinicalTrials.gov; 2021.
82. Szumilewicz A. HIIT vs MICT during pregnancy and health and birth outcomes in mothers and children (HIIT MAMA). ClinicalTrials.gov; 2021.
83. Bø K, Artal R, Barakat R, Brown W, Davies GAL, Dooley M, et al. Exercise and pregnancy in recreational and elite athletes: 2016 evidence summary from the IOC expert group meeting, Lausanne. Part 1-exercise in women planning pregnancy and those who are pregnant. Br J Sports Med. 2016;50(10):571–89.
84. Palatini P, Mos L, Munari L, Valle F, Del Torre M, Rossi A, et al. Blood pressure changes during heavy-resistance exercise. J Hypertens Suppl. 1989;7(6):S72–S3.
85. Harman EA, Frykman PN, Clagett ER, Kraemer WJ. Intra-abdominal and intra-thoracic pressures during lifting and jumping. Pressions intra-abdominales et intra-thoraciques lors de souleves de poids et de sauts. Med Sci Sports Exerc. 1988;20(2):195–201.
86. Bø K, Artal R, Barakat R, Brown WJ, Davies GAL, Dooley M, 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):1080–5.
87. Avery ND, Stocking KD, Tranmer JE, Davies GA, Wolfe LA. Fetal responses to maternal strength conditioning exercises in late gestation. Can J Appl Physiol. 1999;24(4):362–76.
88. O'Connor PJ, Poudevigne MS, Cress ME, Moti RW, Clapp IIIJF. Safety and efficacy of supervised strength training adopted in Pregnancy. J Phys Act Health. 2011;8(3):309–20.
89. Dumas GA, Leger A, Plamondon A, Charpentier KM, Pinti A, McGrath M. Fatigability of back extensor muscles and low back pain during pregnancy. Clin Biomech. 2010;25(1):1–5.
90. Wells C, Kolt GS, Bialocerkowski A. Defining Pilates exercise: a systematic review. Complement Ther Med. 2012;20(4):253–62.
91. 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.
92. Shu-Ming W, Dezinno P, Maranets I, Berman MR, Caldwell-Andrews AA, Kain ZN. Low back pain during pregnancy: prevalence, risk factors, and outcomes. Obstet Gynecol. 2004;104(1):65–70.
93. Kwiecińska K. Aksjomaty nt. Prenatalnej aktywności fizycznej w świadomości przyszłych matek (the axioms about the prenatal physical activity in the awareness of expectant mothers). Gdansk: Gdansk University of Physical Education and Sport; 2013.
94. Worska A, Szumilewicz A. Aktywność fizyczna kobiet w ciąży w świadomości przyszłych instruktorów rekreacji ruchowej (physical activity of expecting mothers in the awareness of future exercise professionals). J Educ Health Sport. 2015;5(8):91–102.
95. Jeffreys RM, Stepanchak W, Lopez B, Hardis J, Clapp JF. 3rd. Uterine blood flow during supine rest and exercise after 28 weeks of gestation. BJOG. 2006;113(11):1239–47.
96. Mottola MF, Nagpal TS, Bgeginski R, Davenport MH, Poitras VJ, Gray CE, et al. Is supine exercise associated with adverse maternal and fetal outcomes? A systematic review. Br J Sports Med. 2019;53(2):82–9.
97. Raines DA, Whitten RA. Braxton Hicks Contactions. Treasure Island, FL: StatPearls; 2017.
98. Mota P, Pascoal AG, Vaz C, João F, Veloso A, Bø K. Diastasis recti during pregnancy and postpartum. In: Brandão S, DaRoza T, Ramos I, Mascarenhas T, editors. Women's health and biomechanics: where medicine and engineering meet. Lecture notes in computational vision and biomechanics, vol. 29. Cham: Springer; 2018. p. 121–32.

99. Bø K, Hilde G, Tennfjord MK, Sperstad JB, Engh ME. Pelvic floor muscle function, pelvic floor dysfunction and diastasis recti abdominis: prospective cohort study. NeurourolUrodyn. 2017;36(3):716–21.
100. Boissonnault JS, Blaschak MJ. Incidence of diastasis recti abdominis during the childbearing year. Phys Ther. 1988;68(7):1082–6.
101. Mota P, Pascoal AG, Carita AI, Bø K. Normal width of the inter-recti distance in pregnant and postpartum primiparous women. Musculoskelet Sci Pract. 2018;35:34–7.
102. Walton LM, Costa A, LaVanture D, McIlrath S, Stebbins B. The effects of a 6 week dynamic core stability plank exercise program compared to a traditional supine core stability strengthening program on diastasis recti abdominis closure, pain, oswestry disability index (ODI) and pelvic floor disability index scores (PFDI). Phys Ther Rehabil. 2016;3.
103. Thabet AA, Alshehri MA. Efficacy of deep core stability exercise program in postpartum women with diastasis recti abdominis: a randomised controlled trial. J Musculoskelet Neuronal Interact. 2019;19(1):62–8.
104. Maring-Klug R. Reducing low back pain during pregnancy. Nurse Pract. 1982;7(10):18.
105. Szczygieł E, Blaut J, Zielonka-Pycka K, Tomaszewski K, Golec J, Czechowska D, et al. The impact of deep muscle training on the quality of posture and breathing. J Mot Behav. 2017:1–9.
106. Bouisset S, Duchêne JL. Is body balance more perturbed by respiration in seating than in standing posture? Neuroreport. 1994;5(8):957–60.
107. Opala-Berdzik A, Bacik B, Kurkowska M. Biomechanical changes in pregnant women. Physiotherapy/Fizjoterapia. 2009;17(3):51–5.
108. Behm DG, Blazevich AJ, Kay AD, McHugh M. Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: a systematic review. Appl Physiol Nutr Metab. 2016;41(1):1–11.
109. Bø K, Berghmans B, Mørkved S, Van Kampen M. Evidence-based physical therapy for the pelvic floor: bridging science and clinical practice. 1st ed. London: Churchill Livingstone/Elsevier; 2007. p. 456.
110. Wagg A, Bunn F. Unassisted pelvic floor exercises for postnatal women: a systematic review. J Adv Nurs. 2007;58(5):407–17.
111. Woodley SJ, Boyle R, Cody JD, Mørkved S, Hay-Smith EJC. Pelvic floor muscle training for prevention and treatment of urinary and faecal incontinence in antenatal and postnatal women. Cochrane Database Syst Rev. 2017;12:CD007471.
112. Davenport MH, Nagpal TS, Mottola MF, Skow RJ, Riske L, Poitras VJ, 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):1397–404.
113. Woodley SJ, Lawrenson P, Boyle R, Cody JD, Mørkved S, Kernohan A, et al. Pelvic floor muscle training for preventing and treating urinary and faecal incontinence in antenatal and postnatal women. Cochrane Database Syst Rev. 2020;5:CD007471.
114. Cerruto MA, D'Elia C, Aloisi A, Fabrello M, Artibani W. Prevalence, incidence and obstetric factors' impact on female urinary incontinence in Europe: a systematic review. Urol Int. 2013;90(1):1–9.
115. Delancey JOL, Kane Low L, Miller JM, Patel DA, Tumbarello JA. Graphic integration of causal factors of pelvic floor disorders: an integrated life span model. Am J Obstet Gynecol. 2008;199(6):610.e1–5.
116. Newman DK. Pelvic floor muscle rehabilitation using biofeedback. Urol Nurs. 2014;34(4):193–202.
117. Bø KB, Mørkved S. Motor learning. Ability to contract the pelvic-floor muscles. In: Bø KB, Mørkved S, Van Kampen M, editors. Evidence-based physical therapy for the pelvic floor: bridging science and clinical practice. 1st ed. London: Churchill Livingstone; 2007. p. 113–9.
118. Miller JM. Graduated strength training: a pelvic muscle exercise program. The Regents of the University of Michigan; 2012. http://www.med.umich.edu/1libr/HealthyHealing/GraduatedStrengthTraining.pdf.

119. Szumilewicz A, Hopkins WG, Dornowski M, Piernicka M. Exercise professionals improve their poor skills in contracting pelvic-floor muscles: a randomized controlled trial. Res Q Exerc Sport. 2019;90(4):641.
120. Kandadai P, O'Dell K, Saini J. Correct performance of pelvic muscle exercises in women reporting prior knowledge. Female Pelvic Med Reconstr Surg. 2015;21(3):135–40.
121. Vermandel A, De Wachter S, Beyltjens T, D'Hondt D, Jacquemyn Y, Wyndaele JJ. Pelvic floor awareness and the positive effect of verbal instructions in 958 women early postdelivery. Int Urogynecol J. 2015;26(2):223–8.
122. Henderson JW, Wang S, Egger MJ, Masters M, Nygaard I. Can women correctly contract their pelvic floor muscles without formal instruction? Female Pelvic Med Reconstr Surg. 2013;19(1):8–12.
123. Chiarelli P, Murphy B, Cockburn J. Women's knowledge, practices, and intentions regarding correct pelvic floor exercises. NeurourolUrodyn. 2003;22(3):246–9.
124. Batista RLA, Franco MM, Naldoni LMV, Duarte G, Oliveira AS, Ferreira CHJ. Biofeedback and the electromyographic activity of pelvic floor muscles in pregnant women. biofeedback na atividade eletromiográfica dos músculos do assoalho pélvico em gestantes. Braz J Phys Ther. 2011;15(5):386–92.
125. Bump RC, Hurt GW, Fantl AJ, Wyman JF. Assessment of Kegel pelvic muscle exercise performance after brief verbal instruction. Am J Obstet Gynecol. 1991;165(2):322–9.
126. Bludnicka M, Piernicka M, Szumilewicz A. The characteristics of biofeedback techniques used in pelvic floor muscle training for healthy pregnant women. A narrative review. Baltic J Health Phys Activ. 2019;11(4):87–95.
127. Opara J, Socha T, Prajsner A, Poświata A, Opara J, Socha T, et al. Fizjoterapia w wysiłkowym nietrzymaniu moczu u kobiet Część I. Aktualne rekomendacje dotyczące ćwiczeń według Kegla / Physiotherapy in stress urinary incontinence in females. Part I. Contemporary recommendations for Kegel exercises (PFME). Physiotherapy. 2011;19(3):41–9.
128. Piernicka M, Duda-Biernacka B, Bludnicka M, Szumilewicz A. The characteristics of the pelvic floor muscle training programs used in experimental studies with surface electromyography in non-Pregnant women: a systematic review. Iran J Public Health. 2020;49(6):1022–32.
129. Bø K, Mørkved S. Motor learning. In: Bø K, Berghmans B, Mørkved S, Van Kampen M, editors. Evidence-based physical therapy for the pelvic floor: bridging science and clinical practice. 1st ed. London: Churchill Livingstone/Elsevier; 2007. p. 113–9.
130. Chesnel C, Charlanes A, Tan E, Turmel N, Breton FL, Ismael SS, et al. Influence of the urine stream interruption exercise on micturition. Int J Urol. 2019;26(11):1059–63.
131. Miller JM. On pelvic floor muscle function and stress urinary incontinence: effects of posture, parity and volitional control. Dissertation [Thesis]. University of Michigan, Horace H. Rackham School of Graduate Studies; 1996, pp. 145–157.
132. Carriere B. Fitness for the pelvic floor. Stuttgart, New York: Thieme; 2002. p. 112.
133. Odent M. New reasons and new ways to study birth physiology. Int J Gynaecol Obstet. 2001;75(Suppl 1):S39–45.
134. WHO. Care in normal birth: a practical guide. Geneva: World Health Organization; 1996. http://apps.who.int/iris/bitstream/10665/63167/1/WHO_FRH_MSM_96.24.pdf.
135. Russell JB, Mitchell D, Musey PI, Collins DC. The relationship of exercise to anovulatory cycles in female athletes: hormonal and physical characteristics. Obstet Gynecol. 1984;63(4):452–6.
136. Magann EF, Evans SF, Weitz B, Newnham J. Antepartum, intrapartum, and neonatal significance of exercise on healthy low-risk pregnant working women. Obstet Gynecol. 2002;99(3):466.
137. Desseauve D, Fradet L, Lacouture P, Pierre F. Position for labor and birth: state of knowledge and biomechanical perspectives. Eur J Obstet Gynecol Reprod Biol. 2017;208:46–54.
138. Blankfield A. The optimum position for childbirth. Med J Aust. 1965;2(16):666–8.

139. Jianfang W, Xuemei L, Chunhong W, Xuemei L. The effectiveness of delivery ball use versus conventional nursing care during delivery of primiparae. Pak J Med Sci. 2020;36(3):550–4.
140. Zang Y, Lu H, Zhao Y, Huang J, Ren L, Li X. 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):3154–69.
141. Panda S. Stress and health: symptoms and techniques of psychotherapeutic management. Indian J Posit Psychol. 2014;5(4):516–20.
142. Illi SK, Held U, Frank I, Spengler CM. Effect of respiratory muscle training on exercise performance in healthy individuals: a systematic review and meta-analysis. Sports Med. 2012;42(8):707–24.
143. Dominelli PB, Archiza B, Ramsook AH, Mitchell RA, Peters CM, Molgat-Seon Y, et al. Effects of respiratory muscle work on respiratory and locomotor blood flow during exercise. Exp Physiol. 2017;102(11):1535–47.
144. Berk B. Motherwell maternity fitness plan. Champaign, IL: Human Kinetics; 2005. p. 232.
145. Boaviagem A, Melo Junior E, Lubambo L, Sousa P, Aragão C, Albuquerque S, et al. The effectiveness of breathing patterns to control maternal anxiety during the first period of labor: a randomized controlled clinical trial. Complement Ther Clin Pract. 2017;26:30–5.
146. Lewis LK, Williams MT, Olds T. Short-term effects on outcomes related to the mechanism of intervention and physiological outcomes but insufficient evidence of clinical benefits for breathing control: a systematic review. Aust J Physiotherapy. 2007;53(4):219–27.
147. Amola M, Pawara S, Kalra S. Effect of inspiratory muscle training and diaphragmatic breathing exercises on dyspnea, pulmonary functions, fatigue and functional capacity in pregnancy during third trimester. J Clin Diagn Res. 2019;13(8):1–4.
148. Yildirim G, Sahin NH. The effect of breathing and skin stimulation techniques on labour pain perception of Turkish women. Pain Res Manag. 2004;9(4):183–7.
149. Ahmadi Z, Torkzahrani S, Roosta F, Shakeri N, Mhmoodi Z. Effect of breathing technique of blowing on the extent of damage to the perineum at the moment of delivery: a randomized clinical trial. Iran J Nurs Midwifery Res. 2017;22(1):62–6.
150. Bergström M, Kieler H, Waldenström U. Effects of natural childbirth preparation versus standard antenatal education on epidural rates, experience of childbirth and parental stress in mothers and fathers: a randomised controlled multicentre trial. BJOG. 2009;116(9):1167–76.
151. Ricchi A, La Corte S, Molinazzi MT, Messina MP, Banchelli F, Neri I. Study of childbirth education classes and evaluation of their effectiveness. Clin Ter. 2020;170(1):e78–86.
152. Munzert J, Lorey B, Zentgraf K. Cognitive motor processes: the role of motor imagery in the study of motor representations. Brain Res Rev. 2009;60(2):306–26.
153. Rakhshani A, Nagarathna R, Mhaskar R, Mhaskar A, Thomas A, Gunasheela S. Effects of yoga on utero-fetal-placental circulation in high-risk pregnancy: a randomized controlled trial. Adv Prev Med. 2015;2015:1–10.
154. Möhler R, Köpke S, Meyer G. Criteria for reporting the development and evaluation of complex interventions in healthcare: revised guideline (CReDECI 2). Trials. 2015;16:204.
155. Barsky E, Smith T, Patricios J, Collins R, Branfield A, Ramagole M. South African sports medicine association position statement on exercise in Pregnancy. S Afr J Sports Med. 2012;24(2):69–71.
156. Carvalho MECC, Lima LC, de Lira Terceiro CA, Pinto DRL, Silva MN, Cozer GA, et al. Low back pain during pregnancy. Rev Bras Anestesiol. 2017;67(3):266–70.
157. Stover MD, Edelstein AI, Matta JM. Chronic anterior pelvic instability: diagnosis and management. J Am Acad Orthop Surg. 2017;25(7):509–17.
158. Bartnikowska I. Ćwiczenia oddechowe i pozycje porodowe w subiektywnym odczuciu kobiet ciężarnych w prenatalnych ćwiczeniach fizycznych (breathing exercises and positions of childbirth in the perception of pregnant women in prenatal exercise programs). Gdansk: Gdansk University of Physical Education and Sport; 2016.
159. ACNM. Exercise in pregnancy. J Midwifery Womens Health. 2014;59(4):473–4.
160. Oz M, Roizen M. Sleep like a baby. Fit Preg. 2012:56.
161. ACSM. Current comment: exercise during pregnancy [press release].