Exercise Testing and Prescription in Pregnancy

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Abstract

Physical exercise should be part of an active lifestyle during pregnancy and the puerperium, as shown by growing evidence on its benefits for the health of pregnant women and newborns. Appropriate exercise testing and exercise prescription are needed to tailor effective and safe exercise programs. Exercise testing and prescription in pregnancy is the plan of exercise and fitness-related activities designed to meet the health and fitness goals and motivations of the pregnant woman. It should address the health-related fitness components and the pregnancy-specific conditions, based on previous health and exercise assessments, and take into account the body adaptations and the pregnancy-related symptoms of each stage of pregnancy, in order to provide safe and effective exercise. This

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chapter reviews the guidelines for exercise testing and prescription of pregnant women to be developed by exercise professionals, following the health screening and medical clearance for exercise by healthcare providers.

Keywords

Pregnancy · Physical activity · Exercise · Health screening · Pre-exercise evaluation · Exercise testing · Exercise prescription · Safety

8.1 Introduction

The purpose of this chapter is to provide exercise and healthcare professionals an understanding about the planning of the several steps of health screening, pre-exercise evaluation, exercise testing, and exercise prescription during pregnancy.

Exercise prescription commonly refers to the specific plan of fitness-related activities that are designed for a specified purpose, which is often developed by a fitness or physiotherapy specialist for the client or patient [1]. An exercise training program ideally is designed to meet individual health and physical fitness goals [2] independently of the fact that the client in the group of the apparently healthy adult population, in a special stage of life (such as pregnancy) or has a determined clinical condition. An optimal exercise prescription should address the health-related physical fitness components, and also the neuromotor fitness[1] [2] in order to provide effective and safe training.

Physical fitness is defined as a set of attributes or characteristics individuals have or achieve that relates to their ability to perform physical activity, and these characteristics are usually separated into the health-related and skill-related components of physical fitness [3]. According to the ACSM [2], the *health-related* physical fitness components include the cardiorespiratory endurance, the body composition, the muscular strength and endurance, and the flexibility, while the *skill-related* components of physical fitness include agility, coordination, balance, power, reaction time, and speed. According to the USDHHS [4], the components of physical fitness include: cardiorespiratory fitness,[2] musculoskeletal fitness,[3] flexibility,[4] balance,[5] and speed.[6]

Appropriate exercise testing and prescription are needed to tailor effective and safe exercise programs. This Chapter reviews the guidelines and scientific papers for exercise testing and prescription of pregnant women to be developed by exercise

[1] *Neuromotor exercise* training involves motor skills such as balance, coordination, gait, and agility, and proprioceptive training and is sometimes called *functional fitness* training [2].

[2] *Cardiorespiratory fitness* is the ability to perform large-muscle, whole-body exercise at moderate-to-vigorous intensities for extended periods of time [4].

[3] *Musculoskeletal fitness* is the integrated function of muscle strength, muscle endurance, and muscle power to enable performance of work [4].

[4] *Flexibility* is the range of motion available at a joint or group of joints [4].

[5] *Balance* is the ability to maintain equilibrium while moving or while stationary [4].

[6] *Speed* is the ability to move the body quickly [4].

professionals, following the health screening and medical clearance for exercise by healthcare providers.

8.1.1 Previous Considerations Before Start Exercising

Being a special stage of life, pregnancy includes several phases that have specific needs and, although there are recommendations and guidelines for the exercise prescription during pregnancy, these should always be adapted to each case, and common sense should prevail. It should also be noted that pregnancy is a natural process, although complex, and occurs differently from woman to woman, and even among the potential pregnancies of the same woman. That is, every pregnancy is a unique and special case! Thus, when a pregnant woman intends to become involved in an exercise program or to give continuity to it, it becomes essential to distinguish between two situations in the first place:

- Pregnancy occurs normally, without problems or clinical complications
- Pregnancy is at risk or there is a certain clinical condition.

One frequent question is: When should a pregnant woman start exercising? The answer is that in the absence of clinical contraindications, every pregnant woman should start or continuing exercising. This statement is issued in all official documents supporting physical activity during pregnancy, as reviewed in the previous Chapter by Szumilewicz et al. [5]. Healthcare providers (i.e., gynecologists, general practitioners or midwives) are in charge of assessing women' health and their pregnancies, and answer the question, bearing in mind the benefits of an active lifestyle for all populations [4, 6]. According to Artal [7], pregnant women tend to be highly motivated to improve unhealthy behaviors and have frequent visits with their healthcare providers, which facilitates counseling, support, and supervision. Unfortunately, despite the increasing evidence on the important benefits of exercising during pregnancy [8], many women remain inactive, or significantly reduce their exercise participation during pregnancy [9, 10]. The probability of a woman exercising during pregnancy is increased if her gynecologist/obstetrician encourages her to exercise [11]. Thus, after making sure that there are no contraindications for exercising, healthcare providers should provide counseling on an active lifestyle and refer pregnant women to an exercise professional (e.g., exercise physiologist, exercise specialist, coach) with background and experience on pregnancy and postnatal exercise. In line with The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) [12] "Exercise prescription for the pregnant woman requires appropriate consideration of the frequency, intensity, duration and mode of exercise," thus, the National Health Service of the U.K. (NHS) [13] advises to pregnant women to "… make sure your teacher is properly qualified and knows that you're pregnant, as well as how many weeks pregnant you are."

The pregnancy exercise specialist role is to build exercise participation for beginners and already active women at all stages of pregnancy. In addition, this exercise professional will be expected to assess overall physical fitness, to develop proper

exercise programs, to review participants' progress and to be able to report on adherence and outcomes to relevant stakeholders [14]. Thus, following medical clearance for exercising during pregnancy, it is very important to understand the motivations, facilitators, and barriers for exercising, as discussed by Atkinson et al. [15], and the type of exercise on which she is interested in, as well as the level of experience she has.

In summary, there are three types of pregnant women in terms of practicing exercise:

- Those who didn't practice any kind of exercise or physical activity prior to pregnancy: In them, we would advise to start with a light physical activity or exercise program.
- Those who did perform exercise regularly: In them, we would advise to maintain this regularity and control intensity and safety.
- Those who are athletes: In them, we would advise to continue with their training routine, possibly with some adaptations regarding exercise selection and safety.

On the other hand, a woman with any risk pregnancy or obstetric or clinical complications, with contraindications to exercise, is out of the scope of practice of the exercise professional, unless with medical supervision, prescription, and guidance. Nevertheless, a specific exercise program may be beneficial as an adjunct therapy or primary prevention of determined conditions [2]. The ACSM recommends that a pregnant woman that is severely obese or have gestational diabetes mellitus or hypertension should consult her physician before beginning an exercise program, and the exercise program must be adjusted to her medical condition, symptoms, and fitness level [2]. Moreover, as explained in Chap. 7 [5], the list of contraindications to prenatal physical activity have been substantially modified in the Canadian [16], RANZCOG [12], and the Australian Government—Department of Health (AGDH) [17] guidelines based on scientific evidence, and they are far from completely limiting physical activity in the event of these contraindications. For those women with pregnancy complications, the promotion of exercise may still be appropriate under some circumstances with appropriate medical evaluation and suitable modification of the exercise prescription [12]. According to the Canadian guidelines "women with absolute contraindications may continue their usual activities of daily living but should not participate in more strenuous activities. Women with relative contraindications should discuss the advantages and disadvantages of moderate-to-vigorous intensity physical activity with their obstetric care provider prior to participation" [16].

8.1.2 Contraindications for Exercising While Pregnant

Summarizing, pregnant women who performed exercise or physical activity regularly before pregnancy may continue with it, and previously sedentary women may start exercising during pregnancy [4–6, 12, 13, 16–22]. However, although this practice is safe and recommendable for them, in certain situations, it should be

inadvisable, or, in accordance with recent guidelines by the American College of Obstetricians and Gynecologists (ACOG) [18], in case of obstetric or medical comorbidities, exercise regimens should be individualized. In fact, in 2020, the list of absolute or relative contraindications to exercise in pregnancy were removed from the ACOG guidelines. Instead, they recommend consultation with a specialist (i.e., obstetrics and gynecology, maternal-fetal medicine, cardiology, pulmonology) when questions regarding exercise safety exist [18].

Anyway, there are medical circumstances in which the sudden appearance of complications due to their pregnancy or a bad maternal health status contraindicates the practice in an absolute or in a relative way. The absolute or relative contraindications for exercising during pregnancy, as well as the signs and symptoms to stop exercise, issued in the recent guidelines [5] are summarized in Box 8.1. The appearance of any of these relative contraindications, may lead to stop performing the physical activity in order to avoid future complications and risks.

Once established these limitations under the supervision of the healthcare provider, it is of utmost importance to interact with the exercise physiologist or coach that will adapt the exercise program.

Box 8.1 Relative and Absolute Contraindications for Exercising During Pregnancy, According to Recently Published Guidelines (2017–2021)

Organization	Guidelines
Sport Medicine Australia [19]	**Signs and symptoms to cease exercise**: abdominal pain, any "gush" of fluid from the vagina, calf pain or swelling, chest pain, decreased fetal movement, dizziness or presyncope, dyspnea before exertion, excessive fatigue, headache, pelvic pain, excessive shortness of breath, painful uterine contractions, and vaginal bleeding.
Australian Government—Department of health [17]	**Pregnancy complications:** If you have any of the following you are advised not to exercise until you get individual advice from your health professional: incompetent cervix, ruptured membranes, preterm labor, persistent bleeding in the second or third trimester, placenta previa, pre-eclampsia, evidence of intrauterine growth restriction, multiple gestation (triplets or higher), poorly controlled type 1 diabetes, hypertension or thyroid disease, other serious cardiovascular, respiratory or systemic disorders.
The Royal Australian and New Zealand College of Obstetricians and Gynaecologists [12]	**Warning signs to stop exercise and seek medical attention**: chest pain, unexplained shortness of breath, dizziness, feeling faint or headache, muscle weakness, calf pain, swelling or redness, sudden swelling of the ankles, hands or face, vaginal bleeding or amniotic fluid loss, decreased fetal movement, uterine contractions or pain in the lower back, pelvic area or abdomen (potentially indicating pre-term labor).

(continued)

Organization	Guidelines
2019 Canadian guideline for physical activity throughout pregnancy [16]	**Absolute contraindications to exercise**: ruptured membranes, premature labor, unexplained persistent vaginal bleeding, placenta previa after 28 weeks' gestation, pre-eclampsia, incompetent cervix, intrauterine growth restriction, high-order multiple pregnancy (e.g., triplets), uncontrolled type I diabetes, uncontrolled hypertension, uncontrolled thyroid disease, other serious cardiovascular, respiratory or systemic disorder.
	Relative contraindications to exercise: recurrent pregnancy loss, gestational hypertension, a history of spontaneous preterm birth, mild/moderate cardiovascular or respiratory disease, symptomatic anemia, malnutrition, eating disorder, twin pregnancy after the 28th week, other significant medical conditions.
	Reasons to stop physical activity and consult a healthcare provider: persistent excessive shortness of breath that does not resolve on rest, severe chest pain, regular and painful uterine contractions, vaginal bleeding, persistent loss of fluid from the vagina indicating rupture of the membranes, persistent dizziness or faintness that does not resolve on rest.
American College of Obstetricians and Gynecologists [18]	**Reasons to stop physical activity and consult a healthcare provider**: persistent excessive shortness of breath that does not resolve on rest, severe chest pain, regular and painful uterine contractions, vaginal bleeding, persistent loss of fluid from the vagina indicating rupture of the membranes, persistent dizziness or faintness that does not resolve on rest.
American College of Sport Medicine [2]	**Stop physical activity and consult a medical professional if any of the following occur**: persistent excessive shortness of breath that doesn't resolve with rest, severe chest pain, regular and painful uterine contractions, vaginal bleeding, persistent loss of fluid from the vagina, persistent dizziness or faintness that doesn't resolve with rest.
Exercise is Medicine by ACSM [22]	**Reasons to stop physical activity and seek medical advice**: bleeding or fluid coming from your vagina, chest pain, dizziness or faintness that does not go away with rest, shortness of breath that does not go away with rest, regular painful uterine contractions, calf pain or swelling.

Organization	Guidelines
International Olympic Committee [20]	**Conditions that post a high risk to the fetus and in which aerobic exercise is absolutely contraindicated**: hemodynamically significant heart disease, intrauterine growth restriction in current pregnancy, poorly controlled hypertension, restrictive lung disease, cervical insufficiency/cerclage, multiple gestation at risk of premature labor, persistent second or third trimester bleeding, placenta previa after 26 weeks gestation, premature labor during the current pregnancy, ruptured membranes, pre-eclampsia/pregnancy-induced hypertension, severe anemia.
	Conditions that post a moderate risk to the fetus and in which aerobic exercise is relatively contraindicated: history of fetal growth restriction, miscarriage, premature birth or labor; cervical enlargement, unevaluated maternal cardiac arrhythmia, chronic bronchitis or other respiratory disorders, poorly controlled type I diabetes, extreme underweight, orthopedic limitations, poorly controlled seizure disorder.
World Health Organization [6]	Pregnant women should be informed by their health-care provider of the danger signs alerting them as to when to stop; or to limit physical activity and consult a qualified health-care provider immediately should they occur.

After medical clearance, pregnant women can begin or continue an exercise program, preferably, supervised by a qualified exercise professional. However, both participants and exercise professionals should be familiarized themselves with the absolute and relative contraindications to exercise during pregnancy, as well as with the signs and symptoms to terminate exercise.

8.2 Guidelines on Exercise During Pregnancy and Useful Sources of Information

When promoting physical activity and exercise during pregnancy, and developing exercise prescription plans, either health professionals or exercise professionals are supposed to follow specific guidelines for physical activity and exercise during pregnancy. These guidelines may be published by national or international organizations. The main international organizations supporting and publishing guidelines for physical activity and exercise during pregnancy are listed in Box 8.2.

Box 8.2 International Organizations Supporting and Publishing Guidelines for Physical Activity and Exercise During Pregnancy

ACOG—American Congress of Obstetricians and Gynecologists—https://www.acog.org/

ACSM—American College of Sports Medicine—http://www.acsm.org/ (http://www.acsm.org/public-information/roundtables)

AGDH—Australian Government. Department of Health—https://www.health.gov.au/

APA—American Pregnancy Association—http://americanpregnancy.org/ (http://americanpregnancy.org/pregnancy-health/exercise-guidelines/)

CSEP—Canadian Society Exercise Physiology—http://www.csep.ca/home (http://www.csep.ca/view.asp?ccid=519)

Department of Health—UK Government—https://www.gov.uk/ (https://www.gov.uk/government/publications)

ESSA—Exercise and Sports Science Australia—https://www.essa.org.au

EuropeActive—http://www.europeactive.eu (http://www.ehfa-standards.eu/es-standards)

IOC—International Olympic Committee—https://www.olympic.org/ (https://www.olympic.org/news/ioc-drives-discussions-on-pregnancy-and-elite-athletes)

Promotion Santé Suisse—https://promotionsante.ch/ (German, French, Italian)

RCOG—Royal College of Obstetricians and Gynaecologists—https://www.rcog.org.uk/

SASMA—South African Sports Medicine Association—https://www.sasma.org.za/

SMA—Sports Medicine Australia—http://sma.org.au/ (http://sma.org.au/publications-media/sma-position-statements/)

SOGC—Society of Obstetricians and Gynaecologists of Canada—https://sogc.org/

US-DHHS—U.S. Department of Health and Human Services—https://www.hrsa.gov/

WHO—World Health Organization—http://www.who.int/about/en/ (http://www.who.int/nutrition/publications/guidelines/antenatalcare-pregnancy-positive-experience/en/)

The American College of Obstetricians and Gynecologists was the organization that published in 1985, the first guidelines for pregnant and postpartum women [23], subsequently improved in 1994 [24]. In 2002, the ACOG published recommendations for physical exercise during pregnancy, promoting its benefits to the health and safety of exercise, both for active and inactive women prior to pregnancy, assuming the existence of medical authorization and the absence of contraindications [25]. These ACOG recommendations from 2002, stated that pregnant women should

accumulate 30 min or more of moderate-intensity exercise on most, if not all, days of the week if no medical or obstetric complications are present, i.e., a minimum of three exercise sessions of at least 15 min each, gradually increasing to 30 min per day, preferably on all days of the week [25]. The recommendations were highlighted again in 2009, including the practice of 30 min or more of moderate exercise, mostly, if not every day of the week, in the absence of medical or obstetrical complications. According to the review paper on the available guidelines for exercising during pregnancy provided by Evenson et al. in 2013 [26], nine out of ten guidelines on exercise in pregnancy from different countries contained information on the intensity and duration of exercise, and eight of these documents contained recommendations on the exercise frequency. Evenson et al. [26], state that the program should consist of moderate-intensity exercise (including moderate-intensity aerobic exercise, light-intensity resistance training, Pilates and balance exercises, pelvic-floor training and stretching), performed three times per week, under the supervision of an exercise specialist. In a previous review by Szumilewicz et al. [27] we analyzed existing guidelines at that time. In 2015, we verify that the documents analyzed contain very general recommendations on exercise during pregnancy and little information that exercise professionals could use when programming the contents of targeted exercise classes for pregnant women.

In December 2015, the ACOG republished its recommendations on "Physical Activity and Exercise during Pregnancy and in the Postpartum Period" [28]. To be noted that this was the first document stating officially that moderate exercise during pregnancy does not cause miscarriage, fetal growth restriction, premature delivery, or musculoskeletal injury. Between 2016 and 2018, Bø et al. and the Medical and Scientific Commission of the International Olympic Committee (IOC) drove a discussion about the management of pregnancy for an elite athlete and produced comprehensive guidelines and recommendations on exercise during pregnancy and postpartum [20, 29–31], as well as for future research [32].

More recently, namely since 2018, these above-mentioned organizations published for the first time (i.e., WHO [6], ADGH [17], ACSM/EIM [21, 22], NHS [13]), endorsed (i.e., ACSM [2] endorsed ACOG, SOGC/CSEP, and USDHHS) or updated (i.e., ACOG [18], USDHHS [4], RANZCOG [12], SMA [19], SOGC/CSEP [16]) specific recommendations on physical activity during pregnancy. To be noted that the World Health Organization published for first time in 2020, specific international recommendations on physical activity for pregnant and postpartum women, as well as on the need to reduce sedentary behaviors. A general overview, further discussion, and update of the recent guidelines are provided in another Chapter of the present publication, by Szumilewicz et al. [5].

8.3 Health Screening of Pregnant Women Before Starting Exercise

The first step before planning to start or continuing an exercise program during pregnancy is the health screening of the woman by a healthcare provider, i.e., overall health and medical and obstetric risks should be reviewed [2, 4, 7, 12, 16, 18, 20].

The American College of Obstetricians and Gynecologists' Antepartum Records and Postpartum form [33] can assist healthcare providers in health screening.

To establish a prenatal fitness class for pregnant women, we have to know if she is going to be capable of following it in terms of prenatal fitness and health, intensity, type of pregnancy and exercise. In a normal healthy pregnancy, no study has found any negative effect of moderate-intensity aerobic training on the development of the fetus or the outcome of pregnancy. In fact, it appears that the benefits of exercise during pregnancy clearly outweigh the potential risks. Current research suggests that healthy pregnant women can begin or maintain moderate intensity aerobic exercise programs with little fear of adverse effects on their unborn fetus [34]. Moreover, recent systematic reviews show strong evidence on the effectiveness of (moderate intensity) physical activity on maternal cardiorespiratory fitness [35–37], reduced risk of excessive gestational weight gain [8, 37], reduced risk of gestational hypertensive disorders overall and gestational hypertension [8, 37, 38], prevention and treatment of gestational diabetes mellitus [8, 37–40], prevention of urinary incontinence [36], reduced cesarean delivery [38], and prevention of antenatal [41] and post-birth [8, 42] depression, as well as positive impact on offspring health in adulthood [37, 43]. The maternal-fetal physiological reserve is going to be the limiting factor for prescribing a safe prenatal exercise program, thus, before performing the fitness activities, there is the need to evaluate pregnant women with a convenient checklist. In this regard, after medical clearance regarding a regular healthcare protocol, healthcare providers should encourage pregnant women to start or continue with a fitness program suitable for their needs and gestational status.

Other important role of the healthcare providers is to promote the benefits of physical activity and exercise during pregnancy. Pregnant women should be educated on these benefits, and be aware of the normal symptoms, physiological and biomechanical adaptations related to pregnancy [6, 12, 19, 44]. They should be educated on the existence and contents of the documents referred as "guidelines," some of them, designed and produced in plain language in order to be more attractive for them (e.g., SMA [19], AGDH [17], EIM [22]), and also including videos (e.g., NHS [13]).

A convenient and worldwide used checklist is the Physical Activity Readiness Medical Examination (PARmed-X) for Pregnancy, which aims to facilitate the communication between the healthcare provider, the fitness professional, and the pregnant woman [45]. The PARmed-X for Pregnancy questionnaire was recently replaced by the Get Active Questionnaire for Pregnancy. This questionnaire is available from CSEP website (https://csep.ca/2021/01/20/pre-screening-for-physical-activity/) in the English and French languages, and it can also be found in the literature, its translations to other languages are required to fill in the four-page form:

1. Pregnant women should provide all the information about their general health status, their status of current pregnancy, and provide the information about the daily activity habits during the past month.
2. The healthcare provider must remark the absolute and relative contraindications based on the current medical information provided by the pregnant women.

3. Once the health evaluation form has been signed by the healthcare provider, and in the absence of contraindications, pregnant women should give it to their prenatal fitness professional.

If necessary, the Get Active Questionnaire for Pregnancy may be used together with other preliminary screening tools, such as the latest version of the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) available at the official website [46] (http://eparmedx.com/) and in the main ACSM's publications [2, 47]. This questionnaire helps on the decision of whether it is necessary to seek further advice before becoming more physically active or engaging in a fitness appraisal, and can be fulfilled by a doctor, another healthcare practitioner, or a qualified exercise professional. Another widely used tool is the ACSM Health Status & Health History Questionnaire [48] to assess safety or possible contraindications to exercise. According to ACSM, these tools can be used in the two basic approaches to preparticipation physical activity screening: the self-guided screening and the professionally supervised screening [2, 47]. In addition, ACSM provides the Exercise Preparticipation Health Screening Questionnaire for Exercise Professionals, which is a simple tool asking for symptoms, current activity, and medical conditions of the participants [49].

To be noted that health screening is of particular importance when these pregnant women are obese, have gestational diabetes mellitus, or hypertension. These women should consult the healthcare provider before beginning an exercise program, which, in turn, must be adjusted to her medical condition, symptoms, and physical fitness level [2].

8.4 Pre-exercise Evaluation with Pregnant Exercisers and Athletes

Following the medical clearance provided by the healthcare provider, the exercise professional develops the pre-exercise evaluation of the pregnant women. It is important to understand some personal factors regarding her health and fitness level that will affect the exercise program plan, namely the intensity, the complexity, and the adaptation of exercises. The fact that pregnant women are either sedentary or experienced in some exercise modes, will affect the exercise prescription significantly. Thus, the second step is to know her pattern, level, and experience with physical activity and exercise:

- For those who were sedentary prior to pregnancy, we need to plan a simpler exercise program, regarding the intensity (light) and complexity (low) of the exercises.
- For those who were active and perform exercise regularly, we need to plan an exercise program in order to maintain the intensity and complexity of the exercises she is motivated to do, or evaluate other options, regarding the safety of the program.
- For those who are athletes, we also need to plan an exercise program in order to maintain the intensity and complexity of the exercises she is motivated to do, to maintain her sports level as much as possible or evaluate other options, regarding the safety of the program for her to continue with the training routine, possibly with some adaptations regarding exercise selection.

An objective form of better understanding the physical activity pattern and/or volume is using basic equipment, such as pedometers or accelerometers. The advantages of using accelerometers compared to other techniques of gait analysis include: low-cost methods; testing is not restricted to a laboratory environment; accelerometers are small, and not restricting walking [50]. The use of wearable body sensors for measuring physical activity is quite useful and a growing field in health monitoring and sport assessment. From free mobile applications to expensive and extensive sports monitoring, plenty of wearables can be found nowadays. The conclusions from recent systematic reviews pointed that several healthcare interventions using feedback on objectively monitored physical activity had a moderately positive effect on levels of physical activity [51], and that the use of wearable trackers in healthy adults may be associated with modest short-term increases in physical activity [52].

Questionnaires such as the 7-day Physical Activity Recall interview (7-day PAR) [53, 54] (available from Professor James F. Sallis website: http://sallis.ucsd.edu/measures.html), and the Pregnancy Physical Activity Questionnaire (PPAQ) developed by Chasan-Taber et al. in 2004 [55], can also be used to recall physical activity pattern and volume. The PPAQ is a self-administered questionnaire regarding the current trimester of pregnancy. It assesses sedentary, light, moderate, and vigorous activity regarding household/caregiving, occupational, and sports/exercise activities. Pregnant women are asked to select the category that best approximates the amount of time spent in 32 activities and in inactivity during the current trimester. At the end of the questionnaire, an open-ended section allows the respondent to add activities not already listed.

Other questions regarding maternal health and pregnancy itself that will affect exercise prescription includes the following:

- What is woman's age?
- Is it the first pregnancy?
- On which stage of pregnancy is she?
- How were previous pregnancies?
- How is her self-perception of health?
- Is she aware of relative and absolute contraindications for exercising?
- Which are the main sign and symptoms related to pregnancy she is experiencing?
- What are her occupation and other leisure activities?
- When to start exercise during pregnancy?

In brief, age may be related to fatigue, as well as her perception of health, and the existence of any disability or discomfort when performing the exercises. The type of occupation, regarding stress and physical activity, and other leisure activities will influence the global level of physical activity. A first pregnancy will promote physiological and psychological changes that she is experiencing for the first time. If it is the second or third pregnancy, the tendency will be to compare it with the previous ones (which may not have any comparison!). It means that, in practice, we must not assume that different pregnancies in the same client will progress in the same way. The stage of pregnancy is of particular importance regarding exercise selection and

adaptation, as well the main body adaptations and the signs and symptoms that can be more common and prevalent at each stage.

Regarding signs and symptoms related to pregnancy, exercise professionals and healthcare providers may objectively monitor them using a validated inventory available from Foxcroft et al. [56]. The authors developed a comprehensive inventory of pregnancy-related symptoms, with a mechanism for assessing their effect on function, providing a validated tool for assessing the impact of interventions in pregnancy [56]. Exercise professionals must be aware of the possible relative and absolute contraindications for exercising, as well as the signs for stopping exercise, as above-mentioned, in order to refer the client for a healthcare provider, as necessary.

Previous sedentary women can begin light activity anytime and progressively increase it. Previous active women can continue the exercise routine. Sometimes, the normal pregnancy-related symptoms, such as low back pain, tiredness or nauseousness, may interfere with the adoption of an active lifestyle, but pregnant women should start exercising anytime they feel comfortable.

Other important questions, regarding the exercise prescription plan, as well as establishing realistic objectives and promoting adherence to exercise are the following:

- What are the main motivations for exercising during pregnancy?
- Which are the women's preferences regarding exercise?
- What can be the main barriers and facilitators?

- Which strategies should but put in practice regarding adherence to exercise?

Assessing motivations and preferences of pregnant women, as well as identifying barriers and facilitators towards exercise is a very important stage in the prescription process to avoid failure and behavioral relapse. More development on these topics can be found in Chap. 2 by Atkinson et al. [15]. Finally, it is important to explain to a pregnant woman that physical activity and exercise, if tailored to her health and fitness level, will not bring any harmful effects neither for her nor for the baby. On the contrary, the participation in an exercise program may increase her perception of health [57], and there are several trustable sources of information from where she can learn about the general and specific benefits of exercise during pregnancy. For example, an interesting source of information is the infographic with new advice on "physical activity for pregnant women" published by the UK's chief medical officers (CMOs), aiming at providing health and exercise professionals, with the latest evidence on physical activity during pregnancy [58, 59].

In summary, addressing a pregnant woman at the beginning of an exercise program and developing a pre-exercise evaluation process is a key element to plan a tailored exercise prescription for an effective and safe exercise program. Exercise professionals must bear in mind that some of the above-described questions may be openly placed (or can be included in validated questionnaires) not only at the beginning of the exercise program, but whenever there is an alteration or adaptation regarding her health or fitness status. Furthermore, it is important to understand the normal process of pregnancy [60], as well as the psychological [15], physiological [61, 62], musculoskeletal [63, 64], and biomechanical [65] adaptations occurring during this period of life.

8.5 Exercise Testing with Pregnant Women

Although not harmful, and unless the pregnant woman desires and requires it, extensive exercise testing during pregnancy should only be performed for medical reasons or for research purposes [2]. An extensive assessment protocol will take a long time and maybe bore or without significance for a (monthly) changing body and mind. Unless the testing is useful for motivation and education purposes, as well as requested by the pregnant participant or athlete in order to evaluate aerobic fitness, or other fitness components. On the other hand, the assessment of cardiovascular fitness is important in pregnant women because it is linked to increased risk of cardiac disease but is rarely undertaken or studied [66]. However, cardiopulmonary exercise testing during pregnancy is valuable in identifying underlying cardiopulmonary conditions, stratifying the risk of adverse pregnancy outcomes, as well as establishing exercise tolerance/limitations [67]. Special care should be taken to ensure that the pregnant woman feels comfortable and there are no risk of falls or injuries.

In practice, there are several maximal and submaximal tests to evaluate the health-related physical fitness components (cardiorespiratory endurance, body composition, muscular strength and endurance, and flexibility), as well as the skill-related components of physical fitness (agility, coordination, balance, power, reaction time, and speed) [2]. Most tests were built for the apparently healthy adult population, and there are specific tests or adapted tests for the special populations. These tests can be used to objectively understand the effectiveness of an exercise intervention and to know the fitness status of the client. Nevertheless, simple tests could be used for motivation purposes, and to quantify the effects of physical activity and exercise programs for pregnant women.

Regarding ethical and legal considerations, before any exercise testing, adequate informed consent should be obtained from participants. An example of form can be found in ACSM [2] or from the website: https://certification.acsm.org/files/file/B_ExPrescripReferral_pdf.pdf.

However, this form may vary according to the objectives and methods of the exercise testing. The consent form, along with a verbal explanation, should include the following information: (1) purpose (either exercise prescription or research), and explanation on the test (equipment, procedures, etc.); (2) potential participant's risks and discomforts; (3) responsibilities of the participant (e.g., information about health status); (4) benefits to be expected (e.g., diagnosis of illness, fitness evaluation, or exercise progression); (5) inquiries (e.g., any concerns or questions about the test); (6) state the privacy of personal and health information (to be kept confidential); and (7) freedom of consent [2].

A comprehensive fitness testing includes in the first place, the measurements of heart rate[7] (HR) and blood pressure[8] (BP). Usually, in a fitness setting, HR can be determined using pulse palpation (for 30 or 60 s), or a heart rate monitor. Both methods can be used during the exercise session or to assess resting HR. Assessing resting heart rate requires allowing to the participant some time to relax at least 5 min in order to stabilize HR. The same principle applies to resting BP

[7] Measurements in beats per minute (beats/min) or (bpm).

[8] Measurements in mmHg.

Fig. 8.1 Treadmill walking and upright leg cycling are the most useful testing modalities during pregnancy

measurement. Further description of heart rate and blood pressure measurements and procedures can be found in ACSM [2].

Due to the limited amount of data on the use of maximal tests in pregnant women, ACSM [2, 47] does not recommend performing maximal exercise testing on pregnant women for the exercise program design, unless medically necessary, and with medical supervision. Submaximal exercise testing is appropriate and effective for this special population [2] in order to assess the maximum rate of oxygen utilization of muscles during exercise (VO_{2max}). We can find guidance on clinical exercise testing during pregnancy in other publications provided by O'Toole and Artal [68], and Wolfe [69], regarding cycle ergometer or graded treadmill exercise. Jędrzejko et al. [70] assessed a group of pregnant women with a submaximal cardiopulmonary exercise test up to 80% HRmax with a supine cycle ergometer, concluding that it is a safe and precise method for assessing work efficiency in term pregnancy women.

According to Wolfe [69], treadmill walking and upright leg cycling are the most useful testing modalities during pregnancy (Fig. 8.1), since the injury risk is low, the physiologic monitoring is easy (not much vertical movement), and the exercises require basic movements. On the contrary, both treadmill running and bench stepping tests are less convenient in these respects, as well as arm cranking ergometry because a relatively small muscle mass is employed [69].

A peak maximal oxygen consumption[9] predicted equation determined for pregnant women can be found in Mottola et al. [71]. This equation was developed using a treadmill modified Balke protocol:

[9] Measure of highest rate of oxygen consumption during an exercise test regardless of whether or not a VO_2 plateau is reached.

$$\begin{aligned} VO_{2peak} &= (0.055 \times \text{peak HR in bpm}) + (0.381 \times \text{incline in percent}) \\ &+ (5.541 \times \text{speed in mph}) + (-0.090 \times \text{BMI in kg/m}^2) - 6.846 \end{aligned} \tag{8.1}$$

Other recommended treadmill protocols include, e.g., the modified Bruce and the Naughton protocols, because most sedentary pregnant women have low capacity for non-weight-supported exercise [69].

Typically, a submaximal test (i.e., <75% of heart rate reserve) is used in place of a maximal test, and most research studies have selected cycle ergometry, due to changes in posture and center of gravity of the pregnant women [48]. Cycling tests may involve one or more steady-state submaximal power outputs or progressive increases in power output, while the pedaling frequency should be 60–80 rpm to avoid lower limb fatigue [69].

Another option may be a field test consisting of walking for a predetermined time or distance, such as the Rockport One-Mile Fitness Walking Test and the 6-min walk test. They are easy to administer and require little equipment. In the well-recognized Rockport One-Mile Fitness Walking Test the pregnant woman walks 1.6 km (1 mi) as fast as possible on a level surface, and HR is obtained in the final minute of completion of the walk. Then, the VO_{2max} of the woman is estimated using the following regression equation [2]:

$$\begin{aligned} VO_{2max}\,(\text{mL/kg/min}) &= 132.853 - (0.1692 \times \text{body mass in kg}) \\ &- (0.3877 \times \text{age in years}) \\ &- (3.2649 \times \text{time in min}) \\ &- (0.1565 \times \text{HR in bpm}) \end{aligned} \tag{8.2}$$

The 6-min walk test (6 MWT) has been used with older and clinical populations, and its results have been related to morbidity and mortality. Recently, Tinius et al. [72] have validated the 6-Minute Walk Test during midpregnancy. In this test the pregnant woman is assessed as the most distance she can walk in a 6 min time interval. Then, one of the equations used to estimate the VO_{2max} is the following [2]:

$$\begin{aligned} VO_{2max}\,(\text{mL/kg/min}) &= (0.02 \times \text{distance in m}) - (0.191 \times \text{age in years}) \\ &- (0.07 \times \text{body mass in kg}) \\ &+ (0.09 \times \text{height in cm}) + (0.26 \times \text{RPP} \times 10^{-3}) + 2.45; \\ &\text{where RPP} = \text{rate} - \text{pressure product}: \\ &\text{HR} \times \text{SBP in mmHg; SEE} = 2.68\ \text{mL/kg/min}. \end{aligned} \tag{8.3}$$

Dennis et al. [66] concluded that the 6 MWT is safe, feasible, and applicable in term pregnant women. Moreover, the authors generated reference intervals for resting HR and distance walked.

Unfortunately, the main publications on the guidelines for exercise during pregnancy (i.e., CSEP [16], ACOG [18], and IOC [20]) do not address submaximal and maximal exercise testing, but further description of these procedures can be found elsewhere [2, 47, 48, 68, 69].

After understanding the most appropriate tests for pregnant women, procedures should be selected according to the facilities and equipment available, the existence of appropriate environment, and the qualifications of the exercise professional performing the tests [48]. The exercise professional must ensure the proper conditions of the facility and thermal environment where the testing takes place, and must be aware of the proper conditions of the testing equipment, the full testing protocol (e.g., regarding the duration and the work rate of each stage, the monitoring of HR at least two times during each stage, the use of additional effort rating scales, etc.), as well as the subject appearance and symptoms, and the test termination criteria. All exercise test protocols should incorporate a 3–5 min low-intensity warm-up to acquaint the pregnant woman with the equipment, as well as a gradual cool-down to avoid venous pooling of maternal blood, arterial hypotension, and reduced uterine blood flow [2, 69]. Moreover, Wolfe [69] recommended that the total length of a progressive treadmill or cycling exercise test should not exceed 10–12 min in order to minimize the potential reduction of uterine blood flow. However, there is no scientific evidence to date to support this risk.

According to Szumilewicz et al. [73] there is some evidence that in the laboratory settings pregnant women may undergo progressive maximal exercise test and that they tolerate it well. However, due to the acute physiologic responses normally observed during pregnancy (which are increased during pregnancy compared to non-pregnancy) [74], submaximal protocols might be more useful in exercise professionals' practice in determining the effects of training rather than accurately estimating maximal aerobic power [2]. Other interesting and useful utilization of this data is to establish intensity and metabolic calculations to determine calorie expenditure.

There are no specific tests for proper assessment of musculoskeletal function—muscular strength and resistance, and flexibility—although these components of health-related physical fitness are addressed in the recommended guidelines for exercise during pregnancy. The same situation occurs regarding the skill-related fitness components, namely, agility, coordination, and balance. Nevertheless, the main purpose of a prenatal exercise program is to promote maternal-fetal health, rather than to maximize physical performance [69]. Nevertheless, fitness testing protocols might be useful in determining the effects of training, and to increase motivation.

To our knowledge, it is no established literature, for the safety and validity of maximal muscle strength assessment for pregnant women. In addition, commonly used tests for the strength evaluation of the upper and lower body, or abdominal muscles, such as the bench press, leg press, curl-ups and the push-ups tests, are not practically justified in this stage of life due to anatomical and musculoskeletal changes. Isometric and isotonic strength involves a pressure response, which is undesirable during pregnancy [69]. Further explanation of the musculoskeletal health adaptations during pregnancy can be found in Fitzgerald and Segal [64].

A good option may be static handgrip strength test. The static handgrip strength test is measured with a dynamometer and has been predicted mortality and functional status in older populations [2, 47]. After adjusting the grip, the participant holds the dynamometer in line with the forearm at the level of the thigh, away from

the body, without touching the body or any other object. Then, the participant squeezes the handgrip as hard as possible, twice with each hand. The score is the highest of two readings with each hand (e.g., 58–62 would be a good score for women of 20–39 years). Other option is the modified push-up test which measures upper body strength and endurance (Fig. 8.2). A modified push-up begins with the hands touching the floor or an object (e.g., a step bench), the knees resting on the

Fig. 8.2 The modified push-up test (left) and the reverse push up test (right)

ground, and the back straight. The flexion and extension of the arms is performed to the point of 90-degree flexion, during 1 or 2 min. The score corresponds to the maximal push-ups performed in this time interval. Further explanation of the procedures and fitness categories can be found in ACSM [2, 47].

Regarding flexibility, test procedures and fitness categories are also provided in ACSM [2]. Test procedures for goniometry assessment of joints commonly of concern to health and fitness professionals, and static stretches for the major muscle groups are provided in ACSM [47]. The range of motion of selected single-joint movements is provided in ACSM [2]. However, the value of specific flexibility tests during pregnancy is questionable because flexibility is temporarily altered, and because the anatomic changes will interfere mechanically with some common tests (e.g., sit-and-reach) [68]. Thus, no single test can characterize flexibility and there are no specific tests to be used during pregnancy. Due to anatomical changes, a good option may be the (modified) sit-and-reach test which is a reflection of hamstring, hip and lower back flexibility, which in turn, is important to prevent low back pain [48] (Fig. 8.3). However, specific procedures and norms regarding pregnant women are lacking [47]. The Back Scratch Test measures how close the hands can be brought together behind the back. It was designed to test the functional fitness of seniors [75], but could be a good option for pregnant woman.

Physical performance testing protocols that have been used for the assessment of functional status and fitness components of senior populations [75, 76], might be useful and safe for pregnant women, although there are no reference data to

Fig. 8.3 The modified sit-and-reach test (left) and the back scratch test (right)

accurately interpret the results. Postural analysis and body alignment are also very important to be assessed in pregnant women. Physical performance testing is appealing since most performance tests require little space, equipment, and cost; can be administered by lay or health/fitness personnel with minimal training; and are considered extremely safe in healthy and clinical populations [2]. However, to our knowledge, there are no testing batteries validated for the pregnant population, regarding the static and dynamic assessment of posture, functionality, and overall autonomy in pregnant women. Chapter 6 in ACSM [47] provides a comprehensive functional movement assessment for apparently healthy participants.

One option is the Timed Up and Go (TUG) test which is a simple test used to assess a person's mobility and requires both static and dynamic balance [75]. The TUG is a commonly used screening tool to identify patients at risk of falling, sometimes used along with other outcome measures to assess functional mobility or balance. In this test, the time that a person takes to rise from a chair, walk 3 m, turn around, walk back to the chair, and sit down is recorded. Usually applied to older populations, it has been used with pregnant women.

Static changes to the body in pregnancy include anterior displacement of the center of mass, anterior tilt of the pelvis, increased lumbar lordosis, knee hyperextension, and increased length and width of the feet. Angular kinematics and spatiotemporal parameters of gait will suffer changes as well, due to increase body mass and musculoskeletal adaptations [62]. Gait alterations during pregnancy may contribute to pain, falls, and muscle fatigue. Thus, gait assessment may be useful to diagnose and prevent such situations. Further development on this topic is provided in Chap. 5 [65] and Chap. 6 [63].

Monitoring the maternal body fatness, weight gain, and nutritional status is very important. On the one hand, a normal fetal growth depends on adequate maternal energy stores and specific guidelines for optimal maternal weight gain are available. On the other hand, excessive gains in body fatness are undesirable. The exercise professional can provide general advice regarding healthy nutrition during pregnancy. However, dietary analysis and tailored nutrition plans should be conducted by a qualified nutritionist. Regarding the assessment of the pregnant women's body composition, body circumferences, body fat distribution markers and other body indexes can be used. Please refer to Chap. 4 [62] for further explanation.

Other publications provide comprehensive instructions for fitness assessment regarding the different components of physical fitness [2, 47, 48]. Of course, there are other assessment techniques, but those techniques have limited applicability in fitness settings because of the cost and the need of highly trained staff (e.g., body composition with DEXA or three-dimensional gait analysis). Moreover, there is a lack of knowledge regarding safety, validity, reliability, or accuracy considerations with pregnant populations. However, we do not find in the literature any evidence or guidelines regarding the evaluation of the other components of physical fitness with pregnant women.

The key point is that exercise testing does not need to be too much invasive with the pregnant client. Instead, it should aim to increase motivation, to objectively understand the effects of training, and to support the exercise prescription for the pregnant woman, since it should consider her baseline level of fitness as well as her previous exercise experience, as pointed as good practice by the RANZCOG [12].

8.6 Exercise Prescription for Pregnant Women

Exercise prescription and monitoring during pregnancy require knowledge and expertise from the fields of obstetrics and exercise physiology, and on the interactive effects of pregnancy and exercise on maternal-fetal biologic and psychologic functions [69]. For most adults, an exercise program including aerobics, body composition, resistance, flexibility, and neuromotor training is indispensable to improve and maintain physical fitness and health [77]. For pregnant women, we need to add pelvic floor training [78], and preparation for birth exercises [79, 80]. Pregnant women fall into the category of apparently healthy adults, although they are considered a special population. Thus, the general guidelines of ACSM regarding the "FITT-VP principle" apply to pregnant women, with some modifications [2, 47]. This principle states that there are recommended levels of the following elements that address mainly one or more physical fitness components:

- F—Frequency (how many exercise sessions per week?)
- I—Intensity (how hard or difficult is the exercise?)
- T—Time (how long is each exercise session?)
- T—Type of exercise (which mode of exercise?)
- V—Volume (which amount?)[10]
- P—Progression/Periodization (how to advance?).[11]

Thus, the recommended exercise prescription for pregnant women should be modified according to the woman's symptoms, discomforts, and abilities during pregnancy [2]. Table 8.1 resumes the exercise prescription components applied to pregnant women.

[10] Usually, the volume is considered to be the product of intensity, frequency and duration of the exercise sessions.

[11] With pregnant clients, the "progression" is assumed as the adaptation of exercise to each trimester of pregnancy, rather than focused on intensity and complexity, taking into account the physiological adaptations to pregnancy.

Table 8.1 Summary of exercise prescription components for pregnant women

Type	Intensity	Duration	Frequency	Progression/Adaptation
Aerobic				
Exercises that activate large muscle groups in a rhythmic and continuous fashion	Moderate intensity exercise (3–5.9 METs; RPE = 12–13; 40–60% $VO_{2reserve}$)	30 min/day of accumulated moderate intensity exercise to total at least 150 min/week	Previous sedentary: up to 3 days/week	The optimal time to progress is after the first trimester (13 week) because the discomforts and risks of pregnancy are lowest at that time
A variety of weight- and non-weight-bearing activities are well-tolerated during pregnancy	Vigorous intensity exercise (>6 METs; RPE = 14–17) for women who were highly active prior to pregnancy or for those who progress to higher fitness levels during pregnancy	or	Previous active: 3–5 days/week to most days of the week	Avoid activities with risk of fall and trauma
Aerobic exercises can be categorized by the intensity and skill demands	So far, there is not much evidence on the influence of exercise of high intensity (RPE > 17) on the course of pregnancy.	75 min/week of vigorous intensity Previous inactive women should progress from 15 to 30 min/day		Activities that require jumping movements and quick changes in direction which can stress joints should be done with caution to—minimize the risk of joint injury

Resistance				
A variety of machines, free weights, and body weight exercises are well-tolerated during pregnancy	Intensity that permits multiple submaximal repetitions (i.e., 8–10 or 12–15 repetitions) to be performed to the point of moderate fatigue	1 set for beginners	2–3 nonconsecutive days/week	Consider exercising in the supine position after 16 weeks of pregnancy to ensure that venous obstruction does not occur, or if the pregnant woman feels uncomfortable
	(40–60% of estimated one repetition maximum)	2–3 sets for intermediate and advanced		Modifying the position of the exercise to instead be performed on one's side, sitting or standing is a safe alternative
		Target major muscles groups		Avoid performing the Valsalva maneuver during exercise
		A basic program includes 8–10 different exercises		Heavy-resistance weight lifting and intense repetitive isometric exercises should be performed with caution until more data is available
Flexibility				
A series of active or passive static and dynamic flexibility exercises for each muscle-tendon unit	Stretch to the point of feeling tightness or slight discomfort	Hold static stretch for 10–30 s (up to 60 s) 2–4 repetitions of each exercise	At least 2–3 up to 7 days/week	Avoid excessive joint stress

(continued)

Table 8.1 (continued)

Type	Intensity	Duration	Frequency	Progression/Adaptation
Neuromotor				
Exercises involving motor skill (e.g., balance, agility, coordination, gait), proprioceptive training, and multifaceted activities (e.g., Pilates, Yoga, tai chi)	Intensity in balance training refers to the degree of difficulty of the postures, movements, or routines practiced	20–30 to 60 min/day	At least 2–3 up to 7 days/week	Can be included in daily activities
	An effective intensity (and volume) of neuromotor exercise has not been determined			The only supervision requirement is the safety considerations and the level of fall risk
				Avoid positions that are uncomfortable or likely to result in loss of balance and falling
Pelvic floor training				
Complex training for pelvic-floor muscles should be focused both on their contraction and relaxation	An effective intensity (and volume) of pelvic floor exercise has not been determined	10–30 min/day	1–7 days/week	Can be done anywhere, anytime, everyday
Various devices can be used to increase the effectiveness and attractiveness of exercise (e.g. vaginal cones)				Should be incorporated in any prenatal exercise program
				Ensure proper technique
				Different exercises should be performed to improve pelvic floor muscle speed, strength, endurance and muscular coordination, and engaging both fast and slow twitch muscle fibers

RPE rating of perceived exertion (6–20 scale), *METs* metabolic equivalents, $VO_{2reserve}$ oxygen uptake reserve ($VO_{2max} - VO_{2rest}$)

8.6.1 Type and Mode of Exercise

There are plenty of physical activities to be performed alone or in group, indoor or outdoor, with or without equipment. In the first place it is important to understand the physical activity pattern of the pregnant women, as addressed in Chap. 1 [81], and choose an activity or activities for which the women are motivated for. Thus, the pregnant woman should select the physical activity or exercise program she is more motivated and able to do, having in mind that those activities or sessions may be adapted according to her health and fitness, and trimester of pregnancy (Fig. 8.4). According to the USDHHS [4] it is important to break up long periods of sitting and standing still, and understand that even a very low volume of physical activity is better than none, in line with WHO [6].

The development of safe and effective exercise programs is a main role and competence of exercise professionals. Each of the several activities available should respect the technical and progression issues of the activity, as well as the associated safety issues. As examples, indoor or outdoor cycling, aerobic and step exercise, or swimming, can be performed using a span of intensity and complexity, and require different pedagogical approaches. Each of the activities given as example can be performed by pregnant women who already practiced them and who already acquired the basic aspects inherent in their safety. For a pregnant woman who has never practiced these activities, the entire learning process must be kept in mind so as not to jeopardize her safety in the event of falls or collisions.

In the second place, the several recommended types of exercise for pregnant should address all health-related physical fitness components (i.e., aerobic, resistance training, and flexibility), as well as neuromotor exercises, pelvic floor training, and preparation for birth exercises. In other words, the type or mode of exercise should be selected first using the specificity principle of training [47]. A variety of exercise modes places different impact stresses on the body, i.e., walking, running, swimming, cycling, or stepping uses different muscles groups, and weight-bearing activities produce greater mechanical loading than non-weight-bearing activities. This loading from physical activity will impact bone metabolism and bone health across the lifespan [82]. Sañudo et al. [83] highlight the importance of quantifying loading intensity and frequency, as these parameters are determinants for bone adaptation. ACSM [77] also recommends loading exercises (i.e., weight-bearing and resistance exercise) to maintain bone health.

This means that on one hand, the exercise program may be focused on one or more types of exercise, and on the other hand, each session of the exercise program can be planned having in mind to include at least 30 min if aerobic exercise, and also strength and flexibility training (including posture and functional exercise), neuromotor exercise (especially, balance and coordination), and pelvic floor muscle training. For example, a step exercise session may combine aerobic, lower limb resistance, and neuromotor training, while a Pilates exercise session may combine upper, core and lower limb resistance, posture, flexibility, and neuromotor training.

Fig. 8.4 Walking, jogging, running, cycling, swimming, water exercise, aerobics, Pilates, flexibility, and resistance training are among the recommended types of exercise during pregnancy

As discussed in the previous Chap. 7 [5], most of the existing guidelines [4, 6, 12, 13, 16–19, 21, 22] refer that the more appropriate and safe physical activities during pregnancy include walking, swimming, stationary cycling, cycling[12] [19], low-impact aerobics, dancing, modified yoga, and modified Pilates. Other physical activities, such as running, jogging, strength training and racquet sports, are considered safe for pregnant women who participated in these activities regularly before pregnancy, upon consultation with an obstetric care provider [12, 21]. Several study of review and trials available in the literature, on the potential benefits of different forms of exercise during pregnancy on health outcomes, can also help to acknowledge the effectiveness of different activities, such as pelvic-floor muscle training [78, 84], indoor cycling [85–87], resistance exercise [35, 88, 89], home exercise [90], Pilates [91–94], yoga [95–97], aquatic exercise [98–100], swimming [101–103], aerobic exercise [35, 38, 74, 104, 105], dancing [106, 107], and group exercise [108].

Regarding the pregnant athlete, vigorous intensity exercise appears to be safe in healthy pregnancies [18], and elite athletes who wish to become pregnant, should discuss specific issues with their medical team [16, 20]. According to the Australian Sports Commission [109], recreational and competitive athletes may train safely at higher intensities and volumes throughout pregnancy with the understanding that they are undergoing close obstetric supervision. They can continue their exercise programs or sports, unless prior to pregnancy, the women athletes were engaged in extreme sports [110]. However, although potential impact on neonatal outcomes is unknown, athletes may push beyond a threshold intensity at which fetal well-being may be compromised [110], and there may be a limit to how intense an elite performer should exercise during pregnancy [111]. Nevertheless, the key message from IOC [20] is that elite athletes with an uncomplicated pregnancy should be reassured that they can continue exercising, although some adjustments in intensity and activity may be required.

The USDHHS [4], Canadian [16], AGDH [17], ACOG [18], SMA [19], and EiM [22] guidelines also point non-recommended physical activities, including contact sports, activities with high risk of falling, activities at high altitude, scuba diving, skydiving, downhill skiing, water skiing, activities in excessive heat (e.g., hot Pilates, and hot yoga). It should be emphasized, however, that these forms are listed as deprecated based on expert opinion and not based on scientific evidence supporting the harmfulness of these forms of physical activity. Regarding exercise selection and adaptation, exercise specialists must be aware of the morphological, physiological, and musculoskeletal and biomechanical changes that occur during pregnancy (addressed in previous Chap. 3 [61], Chap. 4 [62], and Chap. 5 [65], respectively), such as increased ligament laxity, weight gain, change in the center of gravity, and carpal tunnel syndrome, that will affect the response to exercise. Moreover, the

[12] Outdoor cycling may be safe but requires regular participation prior to pregnancy. As any other activity, it requires balance and ability, depending on the purpose of use (e.g., sports, fitness, well-being, commuting), as well as appropriate equipment (i.e., there are several types of bikes). On the contrary, the Canadian guidelines are quite conservative regarding cycling [16].

typical signs and symptoms associated to each trimester of pregnancy, the motivations and objectives, the safety considerations, the fitness level, and the level of experience of the pregnant women, will also impact on exercise selection and adaptation. Chapter 9 [112] further develops the methods for planning an exercise program, including exercise selection and adaptation.

8.6.2 Exercise Duration, Frequency, and Intensity

Exercise time or duration is prescribed as a measure of the amount of time physical activity is performed, i.e., time per session, per day, and per week [2]. Frequency is prescribed in sessions per day and in days per week. Exercise duration typically ranges from 20 to 60 min. Most adults, including pregnant women are recommended to accumulate at least 150 min/week. Most guidelines for exercise during pregnancy [4, 6, 12, 13, 16–19, 21, 22] suggest 30 min of exercise daily, 5–7 days per week. Pregnant women who have not been regular exercisers should follow a gradual progression of increasing the duration of exercise and can begin with as little as 10 min. Previously sedentary women should begin with 10–20 min of continuous low-intensity exercise three times per week, increasing the intensity, frequency, and duration gradually.

According to the overload principle of training, exercising below a minimum intensity or threshold, will not challenge the body sufficiently to result in changes in physiologic parameters, including the increased maximal volume of oxygen consumed per unit of time [74]. The individual threshold depends on several factors, and it is important to bear in mind that, in general, the physiologic responses to acute exercise may be different in pregnancy compared to non-pregnancy, due to inter alia increased rest cardiac output, rest HR, and plasma volume, and decreased blood pressure [2, 18].

Several methods can be used to estimate intensity during exercise; however, the intensity is usually prescribed using heart rate reserve (%HRR) (Eq. 8.4) or oxygen uptake reserve (VO_2) (Eqs. 8.5 and 8.6) [2].

$$\text{HRR method}(\text{training}) = \left[(\text{HRmax} - \text{HRrest}) \times \text{intensity in percent}\right] + \text{HRrest}(\text{bpm}) \tag{8.4}$$

$$\text{Gross } VO_2 \text{ reserve method}(\text{training}) = \left[\begin{matrix}(VO_{2\max} - VO_{2\text{rest}}) \times \text{intensity} \\ \text{in percent}\end{matrix}\right] + VO_{2\text{rest}}(\text{mL/kg/min}) \tag{8.5}$$

$$\text{Net } VO_2(\text{training}) = (VO_{2\max} - VO_{2\text{rest}}) \times \text{intensity in percent}(\text{mL/kg/min}) \tag{8.6}$$

Because maximal exercise testing is rarely performed with pregnant women, Mottola et al. [71] developed and validated heart rate (HR) ranges that correspond to moderate intensity exercise for low-risk pregnant women based on age and body

mass index (BMI) while taking fitness levels into account. The Canadian [16] and RANZCOG [12] guidelines, ACSM [2], and SMA [19], provide the HR ranges.

Regarding maximal heart rate the estimation equations by Gellish et al. [113] are more accurate than other formulas, and were estimated for men and women participants in an adult fitness program with a broad range of age and fitness levels, as follows:

$$\text{HRmax} = 207 - \left(0.7 \times \text{age}\right)\left(\text{bpm}\right) \tag{8.7}$$

$$\text{HRmax} = 192 - \left(0.007 \times \text{age}^2\right)\left(\text{bpm}\right) \tag{8.8}$$

Although the nonlinear predictor model (Eq. 8.8) was slightly more accurate than the linear equation (Eq. 8.7), the authors suggest that the linear model is easier to use.

However, due to HR variability during pregnancy, two other simpler and more practical methods may be used to monitor intensity [2, 12, 16, 19]:

- Monitoring perceived exertion: for moderate exercise, ratings of perceived exertion should be 13–14 (somewhat hard) on a Borg Rating of Perceived Exertion scale (Fig. 8.5), where 6 represents no exertion and 20 represents maximal exertion [114]. The participant is instructed to report the overall sensation of effort
- OMNI scales of perceived exertion for walking/running and cycling are also available [48]
- The "talk test": the individual should be able to carry on a normal conversation with moderate exercise intensity. By comparison, vigorous exercise is associated with substantial increases in breathing, inability to carry on a normal conversation easily, and perspiration [115]. The participant is asked to work at a level that causes a sensation of increased breathing but that still allows comfortable speaking in complete sentences [48].

Independently of the intensity monitoring methods, an exercise program should start slowly and gradually improve intensity. Throughout the exercise program, a pregnant woman should feel comfortable and avoid overexertion. The limits of intensity are

20	Maximal exertion
19	Extremely hard
17-18	Very hard
15-16	Hard (heavy)
13-14	Somewhat hard
10-12	Light
8-9	Very light
7	Extremely light
1-6	No exertion at all

Fig. 8.5 Borg's Rating of Perceived Exertion (RPE) 6–20 scale [114]

individual, depending on the previous physical activity patterns. Each body will naturally provide signals that it is time to reduce the level of exercise she is performing. Pregnant women should not exercise to the point of exhaustion or breathlessness.

8.6.3 Exercise Volume

Exercise volume is the product of frequency, intensity, and duration of exercise. Usually, the exercise volume is used to estimate the gross energy expenditure in metabolic equivalents (in MET-min/week or in kcal/week) with respect to body composition and weight management outcomes [2]. A target volume of 500–1000 MET-min/week is recommended for most adults because is associated with lower rates of cardiovascular disease and premature mortality. The calculation of exercise volume may use different methods, as follows [2]:

- Metabolic equivalents (METs): an index of energy expenditure. A MET is the ratio of the rate of energy expended during an activity to the rate of energy expended at rest. By convention, 1 MET = an oxygen uptake of 3.5 mL/kg/min
- MET-min: an index of energy expenditure that quantifies the total amount of physical activity performed in a standardized manner across individuals and types of activities, usually per week or per day (i.e., METs × min)
- Kilocalorie (kcal): by convention, the energy needed to increase the temperature of 1 kg of water by 1 °C. Usually standardize as kcal per week or per day. Conversion of METs to kcal:

$$\text{kcal / min} = \left[\left(\text{METs} \times 3.5\text{mL / kg / min} \times \text{body weight in kg}\right) / 1000\right] \times 5 \quad (8.9)$$

- Treadmill walking, running, and cycling metabolic equations: conventional equations to predict energy cost are probably valid during pregnancy [69]:

$$\begin{aligned} \text{VO}_2\ \text{walking}\left(\text{cadence of } 50-100\text{m / min}\right) = {} & \left(0.1 \times \text{speed in m / min}\right) \\ & + \left(1.8 \times \text{speed} \times \%\text{grade}\right) \\ & + 3.5\left(\text{mL / kg / min}\right) \end{aligned} \quad (8.10)$$

$$\begin{aligned} \text{VO}_2\ \text{running}\left(\text{cadence over } 130\text{m / min}\right) = {} & \left(0.2 \times \text{speed in m / min}\right) \\ & + \left(0.9 \times \text{speed} \times \%\text{grade}\right) \\ & + 3.5\left(\text{mL / kg / min}\right) \end{aligned} \quad (8.11)$$

$$\text{VO}_2\ \text{cycling}\begin{pmatrix}\text{work rate of } 50-200\text{W or } 300 \\ -1200\text{kgm / min}\end{pmatrix} = \begin{bmatrix}\left(1.8 \times \text{work rate}\right) / \\ \text{body mass in kg}\end{bmatrix} + 7 \quad (8.12)$$

- Another form of estimating the exercise volume is the steps per day given by pedometers which are effective tools for promoting physical activity [116]. The goal of 10,000 steps/day is often cited regarding health benefits, but it appears that achieving a pedometer step count of at least 5400–7900 steps/day can meet recommended exercise targets [77, 117]. This step count volume is approximately equal to 1000 kcal/week or 150 min/week of moderate-intensity physical activity [2].

8.6.4 Other Forms of Physical Activity

Doing any physical activity is better than doing none [6, 19]. If the pregnant woman does not do any physical activity, she should be advised to start by doing some, and gradually build up to the recommended amount. Other forms of increasing the volume of physical activity or exercise are by integrating it into occupational activities, active commuting, and daily activities, such as (Fig. 8.6):

- Engaging in walking groups
- Using a pedometer
- Increasing the walking time to a minimum of 10,000 steps per day
- Playing with other children
- Walking or biking for active commuting
- Taking stairs instead of the elevator
- Parking far away from office or garage
- Doing housework
- Not standing in the same position for long periods of time
- Limiting the seating time

Fig. 8.6 Other forms of increasing the volume of physical activity or exercise are by integrating it into occupational activities, active commuting, and daily activities

- Doing stretching pauses while working in the seated position
- Using a standing desk
- Decreasing the time spent in sedentary activities (e.g., television watching, computer use, sitting in a car or at a desk).
- Taking short bouts of exercise at home (e.g., by following YouTube videos [118, 119])
- Using available apps that encourage physical activity
- Dancing with the music at home
- Walking the dog

8.6.5 Exercise Progression and Adaptation

Exercise goals and progression may vary at different time points during pregnancy, and exercise routines should remain flexible [2]. The progression of exercise during pregnancy may consist of increasing exercise volume or adapting the exercise routine in accordance with the physiological and biomechanical adaptations occurring over the time course of pregnancy [60].

The body undergoes major changes during the first trimester of pregnancy. During the first trimester, the initiation or continuity of physical activity should be established gradually by pregnant women, once the absence of risk is established, and will be adjusted in accordance with participants' clinical situation, fitness level, and the level of adaptation to their new state. In the first trimester, the pregnant woman experiences the typical symptoms of pregnancy, such as mood changes, nausea, vomiting, breast tenderness, dyspepsia, frequent urination, and constipation, which can limit her daily activity and therefore limit her capacity to carry out activities that could aggravate this symptomatology. Although these are common pregnancy symptoms, every woman has a different experience. Depending on the level of symptoms and discomfort, those may prevent the practice of physical activity or exercise (e.g., breast tender may limit exercising in the ventral position; frequent urination and vomiting may require a quick access bathroom during an exercise session). In sedentary pregnant women, it is recommendable to start gradually. Those pregnant women who exercised regularly or are athletes, they can maintain this physical activity uninterruptedly, adapting the intensity and frequency to their personal needs and abilities. Due to the risk of trauma, for some athletes of contact sports it may be necessary to plan a different exercise routine with other types of exercise that provide the maintenance of fitness level during this stage. Along with the other fitness components, pelvic floor training should be advised from the first trimester.

During the second trimester, the previously described discomforts of the first trimester are gone in most cases, and the physical limitations of the third trimester have not yet appeared. For many pregnant women the second trimester is the easiest 3 months of pregnancy. During this period, women feel emotionally better, since they are better adapted to pregnancy. The anatomic changes allow them to comfortably perform most of the types of exercise included in a program. However, it is important to bear in mind that throughout this trimester, the uterine volume increases, and in the

supine position, the inferior vena cava syndrome can develop, which consists in the reduction of the venous return through said vessel, due to the pressure exerted by the pregnant uterus when the pregnant woman is lying on her back. That is why some women may feel discomfort or dizziness in the supine position and sometimes it is necessary to avoid it while exercising. In practice, it is rarely to observe this situation, and many women report sleeping lying on back. Nevertheless, some guidelines recommend avoiding this position after the first trimester of pregnancy [6, 13] or, states that pregnant women should be advised to avoid long periods lying flat on back weeks [13, 18]. The Canadian guidelines [16] are clearer when stating that "pregnant women who experience light-headedness, nausea or feel unwell when they exercise flat on their back should modify their exercise position to avoid the supine position." During the third trimester, the increase in the volume of the gravid uterus as well as the weight gain of the pregnant woman produces a compromise of space at the abdominal level as well as at the pulmonary level. That is why the pregnant woman tends to decrease the intensity and duration of their physical activity. To avoid this negative effect it is recommended the start of activities in the aquatic environment, which give the pregnant woman a situation of weightlessness. The aquatic environment also allows mobilizing joints with passive resistance. It is very important to also take into account the possibility of the appearance of inferior vena cava syndrome, which in water is attenuated by weightlessness. AGDH guidelines [17] recommend that after 28 weeks, the exercises should not be performed lying flat on back, and to, instead, tilt the upper body to a 45-degree angle or doing the exercises lying on side. Another aspect to take in consideration is the change in balance and coordination, which can lead to falls. Moreover, hormonal, and biomechanical adaptations may be related to the prevalence of joint and low back pain. Many pregnant women experience low back pain and strengthening of abdominal and back muscles could minimize this risk [18]. This is the period when pregnant women tend to reduce the intensity of exercise, although maintaining pelvic floor exercises [63, 73, 78, 84] and starting a preparation for birth program [79, 80, 120, 121]. However, reducing exercise intensity at this stage of pregnancy should be based on the individual well-being of the woman and is not a standard recommendation. If a woman in the third trimester wants to continue the current intensity of exercise, there are no contraindications for this provided that the pregnancy is progressing well.

8.6.6 Session Organization

- All exercise sessions should always start with a 5–10 min warm-up period, including slow walk, light stretching, or movements that will be performed during the main part of the session.
- All sessions should end with a cool-down period, which can include breathing exercises, light stretching, pelvic floor training, movements that were performed during the main part of the session (reinforcing the motor task learning), or movements that will be performed in the next sessions. Further development of this topic can be found in Chap. 9 [112].

8.7 Exercise Prescription in Special Conditions

Exercise can be planned in a recreational or competitive perspective, but also as an adjunct treatment for several disorders, such as gestational diabetes, excessive weight gain and obesity, hypertension and preeclampsia, low back pain, and antenatal depression. In these cases, it is of particular importance the communication between healthcare providers and exercise professionals. Pregnant women in special clinical conditions face substantial barriers to participating in exercise and require support to enable them to benefit from the increased physical activity. Under medical supervision, exercise professionals will need to select appropriate exercise interventions and behavioral strategies which will benefit the pregnant women regarding the disorder or disease. Independently of the level of evidence, the following issues should be addressed in antenatal care programs and supported by exercise programs. IOC guidelines [20] advise that special attention should be paid to screening for these conditions and referral to a gynecologist or sport/women's health physiotherapist for proper individual management.

8.7.1 Gestational Diabetes

A healthy pregnancy can be associated with resistance to the action of insulin on glucose uptake and utilization. This leads to more use of fats than carbohydrates for energy by mother and saves carbohydrates for the growing fetus [122]. In 1–14% of pregnant women this condition develops into gestational diabetes mellitus (GDM) [123]. GDM is associated with a wide range of adverse health consequences for women and their infants in the short and long term, including an increased risk of macrosomia, birth complications, and maternal diabetes after pregnancy. It may also increase the risk of obesity and type 2 diabetes in offspring later in life [124]. Thus, any strategy to prevent GDM should be considered.

Gestational diabetes is the most common metabolic disorder in pregnancy and its prevalence is nowadays increasing because there is a higher number of pregnant women with a body mass index (BMI) or weight gain level in the range of overweight or obesity, and also because childbearing age is increasing [125].

There is growing evidence in favor of the fact that exercise and physical activity are basic tools to be able to control this prevalent disorder, as they are easy to be carried out, effective and with minimum costs [126]. It is therefore been introduced a new tendency in this disorder's therapy that helps to preserve the glycemia levels in a normal range, by modifying pregnancy women's lifestyles in a salutary way thanks to maternal education, acquisition of healthy living habits such as balanced dietary patterns and performing exercise and physical activity, and finally, a fetal's close monitoring [127, 128]. If despite these circumstances, the glycemic control is not in the proper values, glucose-lowering drugs should be prescribed.

Observational studies strongly support the performance of exercise and physical activity not only as a tool that may control glycemia levels in pregnancy, but also as a preventive factor by reducing the risk of gestational diabetes. In the meta-analysis

published by Russo et al. [129], in which there are described 10 interventional trials suitable for the risk group, has shown a significant reduction of developing a gestational diabetes of 28% (95% IC) in comparison to the control group ($R^2 = 0.72$, $p = 0.0005$), consenting to exercise and physical activity a protective factor.

The exercise that pregnant women with gestational diabetes can perform does not differ from that prescribed to a pregnant woman without this disorder. However, it is necessary to take into account that those pregnant women who need glucose-lowering drugs for the metabolic control of glycemia should be closely monitored, since exercise may misadjust the prescribed pharmacological regimen.

In the management of pregnant women with gestational diabetes, there is evidence that exercise, in particular aerobic and resistance is the most beneficial [130–132]. Another meta-analysis, which evaluated seven randomized trials, found that exercise and physical activity are helpful as a complement to good gestational follow-up, increasing postprandial blood glucose control, and decreasing the rapid passage of blood into the bloodstream in pregnant women with gestational diabetes compared with the control group [133]. Brown et al. [134] concluded that both fasting and postprandial blood glucose concentrations in pregnant women involved in exercise programs were reduced compared with the control groups. Shepherd et al. [135] based in a review of 23 RCT concluded that moderate-quality evidence suggests reduced risks of GDM and caesarean section with combined diet and exercise interventions during pregnancy as well as reductions in gestational weight gain, compared with standard care. However, both authors concluded that current evidence is confounded by the large variety of exercise (and diet) interventions [134, 135]. Davenport et al. [136] reviewed 106 RCT and concluded that exercise-only interventions were effective at lowering the odds of developing GDM, as well as gestational hypertension and pre-eclampsia. Moreover, their meta-analysis point that to achieve at least a 25% reduction in the odds of developing GDM (and also gestational hypertension and pre-eclampsia), pregnant women need to accumulate at least 600 MET-min/week of moderate-intensity exercise (i.e., approximately 140 min) [136]. Recently, the integrative review of Ribeiro et al. [137] supported that exercise in pregnancy is safe for both mother and fetus, contributing to prevent pregnancy-related disorders, such as GDM.

8.7.2 Excess Weight and Obesity

Gestational weight gain (GWG) has often been identified in the literature as a critical modifier of maternal and fetal health. In a systematic review and meta-analysis of randomized controlled trials performed by Choi et al. [138], the authors suggest that supervised physical activity plus diet programs were most effective in managing weight among overweight and obese pregnant and postpartum women. The American College of Obstetricians and Gynecologists reaffirmed in 2017 [139], that “in pregnancy, physical inactivity and excessive weight gain have been recognized as independent risk factors for maternal obesity and related pregnancy complications, including gestational diabetes mellitus” (p. 136). The same experts’

advice that obese pregnant women should be encouraged to engage in healthy lifestyle modification in pregnancy that includes physical activities and judicious diets [139]. This special population should start with low-intensity, shorts periods of exercise and gradually increase as able [16, 18]. The effect of exercise among pregnant, obese women in systematic review studies has been demonstrated modest reductions in weight gain and no adverse outcomes among those who were assigned to exercise [140, 141]. More recently, a review of 36 RCT [142] concluded that diet and physical activity-based interventions during pregnancy reduce gestational weight gain and lower the odds of caesarean section. Ruchat et al. [143] reviewed 86 RCT and concluded that prenatal exercise reduced the odds of excessive GWG (and postpartum weight gain) but increased the risk of inadequate GWG (based in 5 RCT). Recently, the integrative review of Ribeiro et al. [137] supported that exercise in pregnancy is safe for both mother and fetus, contributing to prevent pregnancy-related disorders, such as excessive weight gain and postpartum weight retention.

8.7.3 Hypertension and Preeclampsia

Hypertensive disorders in pregnancy may produce adverse perinatal outcomes for both, mother and the fetus or newborn. Preeclampsia is an exclusive pathology in pregnancy and postpartum period due to an abnormal development of uterine spiral arteries that, furthermore, produces an alteration in the placental exchange, leading to oxidative stress and producing antiangiogenic factors in the maternal body that can reach target organs such as the liver or kidney. There are also other pathologies related to hypertensive disorders in pregnancy, such as chronic hypertension, which can produce important complications when associated with preeclampsia. Thus, prevention of these complications is critically important. Despite the scientific advances related to the determination of risk factors associated with preeclampsia, and the introduction of preventive measures to try to prevent its appearance, it remains the second most prevalent cause of global maternal mortality, reaching 14% [144]. And these preventive measures do not provide sufficient evidence to be able to reduce it, so that the only treatment known nowadays is the termination of gestation [145, 146].

At present, most research to try to prevent this disease focuses on improving the development of uterine spiral arteries, determining factors related to genetic predisposition, and improving the low immunological response of most pregnant women that develop this pathology [147]. This is why exercise has played a leading role in this pathology because it promotes the improvement of maternal circulation, increasing placental vascularity thanks to the release with the exercise of an anti-inflammatory component and stimulates the immune system of women at risk of preeclampsia [148]. Chawla and Anim-Nyame [149] advise that exercise in pregnancy seems to be beneficial in pregnancies complicated by hypertension. In the systematic review by Magro-Malosso et al. [38] aerobic exercise for about 30–60 min, two to seven times per week during pregnancy, as compared with being

more sedentary, is associated with a significantly reduced risk of gestational hypertensive disorders overall, gestational hypertension. However, the intensity of the exercise to be recommended for specific types of these conditions remains unclear. More recently, the meta-analysis of Davenport et al. [136] point that to achieve at least a 25% reduction in the odds of developing gestational hypertension and pre-eclampsia (and also GDM), pregnant women need to accumulate at least 600 MET-min/week of moderate-intensity exercise (i.e., approximately 140 min). The integrative review of Ribeiro et al. [137] also supported that exercise in pregnancy is safe for both mother and fetus, contributing to prevent pregnancy-related disorders, such as gestational hypertensive disorders.

8.7.4 Low Back Pain

The majority of pregnant women experience low back pain and pelvic girdle during their pregnancy. These circumstances worsen as pregnancy progresses and interferes with their daily routine. In the last few years various studies showed the effectiveness of exercise in reducing back pain [150–152]. Based on the meta-analysis of 11 randomized controlled trials with 2.347 pregnant women, Shiri et al. [153] concluded that exercise reduced the risk of low back pain in pregnancy by 9% and prevented new episodes of sick leave due to lumbopelvic pain. Evidence from single studies suggests that acupuncture [154] or craniosacral therapy improves pregnancy-related pelvic pain, and osteomanipulative therapy or a multi-modal intervention (manual therapy, exercise and education) may also be of benefit [155].

Further evidence is very likely to have an important impact on our confidence in the estimates of effect and change the estimates. Studies would benefit from the introduction of an agreed classification system that can be used to categorize women according to their presenting symptoms, so that treatment can be tailored accordingly. The meta-analysis of Davenport et al. [156] conclude that, compared with not exercising, prenatal exercise decreased the severity of low back, pelvic girdle, and lumbopelvic pain during and following pregnancy but did not decrease the odds of any of these conditions at any time point. Shiri et al. [153] concluded that exercise appears to reduce the risk of low back pain in pregnant women, but there is no clear evidence for an effect on pelvic girdle pain. The integrative review of Ribeiro et al. [137] also supported that exercise in pregnancy may contribute to prevent lumbopelvic pain. However, exercise interventions varied on type, frequency, intensity, and duration, hindering a possible association of specific types of exercise interventions with these outcomes.

8.7.5 Depression and Mental Disorders

Ohman et al. [157] reported that among the most common concerns raised by pregnant women were: fear of labor pain, fear of perinatal complications, fetal health problems, or the possibility of miscarriage. The prevalence of depression during the

first trimester of pregnancy was reported as 7.4–11%; in the second trimester reaches 12.8%; and in the third trimester from 8.5% to 12%. The prevalence of depression at 40 weeks of pregnancy was 18.4% [158, 159].

Physical exercise practice is included in the guidelines as a therapeutic recommendation for the treatment of depression and there is sufficient scientific evidence to support it as a complement to pharmacological treatment even in major depression cases [160]. Padmapriya et al. [161] observed that in Asian women sufficient physical activity was associated with a reduced likelihood of probable antenatal depression and trait anxiety symptoms. A meta-analysis by McCurdy et al. [162] has shown that light-to-moderate intensity aerobic exercise improves mild-to-moderate depressive symptoms and increases the likelihood that mild-to-moderate depression will resolve in the postpartum period. The meta-analysis by Davenport et al. [163] concluded that prenatal exercise reduced the odds and severity of prenatal depression. More recently, Ribeiro et al. [137] also supported that exercise in pregnancy may contribute to prevent perinatal depression and anxiety.

To be noted that during the COVID-19 pandemic, a substantial worsening of the mental condition of future mothers has been observed [164], which results, among others, from changes in previous physical activity [165]. Thus, it is necessary to popularize pro-health exercises in pregnant women from various social groups, especially those with a low degree of involvement in physical activity before the pandemic [166].

8.8 Specific Considerations and Safety Issues Regarding Exercise During Pregnancy

There are several special considerations that should be taken into account to maximize the effective development and ensure the safety of an exercise program for pregnant women, including the following.

8.8.1 Weight Gain and Caloric Intake

- During pregnancy, the metabolic demand increases by 300 kcal/day. Caloric intake should increase to meet the caloric costs of pregnancy and exercise. Intake above or below recommended levels with concomitant changes in weight gain during pregnancy may be associated with adverse maternal and fetal outcomes [2]. Chapters 13 [167] and Chap. 14 [168] provide further information on this topic.
- In order to avoid excessive weight gain during pregnancy, the weight gain guidelines based on prepregnancy BMI, available from the Institute of Medicine (US) and the National Research Council (US) [169], should be consulted [2].
- High-intensity or prolonged exercise in excess of 45 min can lead to hypoglycemia; therefore, adequate caloric intake before exercise, or limiting the exercise session, is essential to minimize this risk [18].

- Since competitive athletes tend to maintain a more strenuous training schedule throughout pregnancy as compared to other pregnant women, they require frequent and closer supervision [18]. Such athletes should pay particular attention to avoiding hyperthermia, maintaining proper hydration, and sustaining adequate caloric intake to prevent weight loss, which may adversely affect fetal growth [18].

8.8.2 Hydration and Urinary Incontinence

- Pelvic floor muscle dysfunctions can lead to urinary incontinence, a condition which often affects women both during pregnancy and after childbirth. Urinary incontinence (UI) is prevalent in antenatal and postnatal women, and pelvic floor muscle training (PFMT) is the first-line treatment for UI [170].
- A recent systematic review by Woodley et al. [171] concluded that structured pelvic floor muscle training in early pregnancy for continent women may prevent the onset of UI in late pregnancy and postpartum. However, Yang et al. [170] concluded that evidence of weak quality supports the effectiveness of undertaking group-based PFMT in pregnancy to prevent UI during pregnancy and the postnatal period.
- PFMT (e.g., Kegel exercises) may be performed on a daily basis to reduce the odds of urinary incontinence [6, 16, 21, 22].
- Targeted exercises to strengthen the pelvic floor muscles are recommended by RANZCOG guidelines [12]. AGDH guidelines [17] advises that pelvic floor exercises help strengthen and tone the pelvic floor muscles and other tissues. Moreover, a strong pelvic floor can reduce the chance of having problems (such as UI) after giving birth and later in life, so it is important to learn how to do these correctly. If symptoms are present, assessment and training by a gynecologist/women's health physiotherapist is indicated [20].
- There are recommendations to increase hydration during pregnancy [6, 13, 16–18], and while and after exercising [172]. Pregnant women should drink water before, during and after exercise. However, pregnant women experience UI during exercise because of mechanical and anatomical changes. Thus, there are considerations to take into account to minimize urinary incontinence related to exercise, such as: voiding before activity; avoiding breath holding and use of Valsalva maneuver during exercise; practicing pelvic muscle-strengthening exercises; minimizing high-impact activities when incontinence symptoms appeared, and using an external pad during exercise [48].
- Moreover, pregnant women feel better when there is a bathroom available in the (indoor or outdoor) area where the exercise session is taken place.
- According to RANZCOG guidelines [12], activities that involve jumping or bouncing may add extra load to the pelvic floor muscles and are probably best avoided. However, there is some evidence that women participating in high-low impact exercise program (containing jumps and runs) supplemented it with pelvic floor muscle training, maintained urinary continence and improved neuromuscular activity of pelvic floor muscles [73].

8.8.3 Falls and Injury

- Pregnant women should avoid contact sports and sports or activities that may cause loss of balance or trauma to the mother and fetus (e.g., soccer, basketball, ice hockey, rollerblading, horseback riding, skiing, snowboarding, scuba diving, and vigorous intensity racquet sports) [2, 4, 6, 16, 20]. However, in the absence of medical contraindications, the decision to stop or continue particular sports activities should be based on the assessment of woman's individual abilities, skills, previous experience and her sense of security and comfort related with performing sports activities.
- The increase in body weight as pregnancy progresses is associated with increased loading at the joints [12, 63, 65, 173]. Thus, weight-supported activities such as water-based exercise or stationary cycling may be more comfortable compared with weight-bearing exercises such as walking in the later stages of pregnancy [12].
- During pregnancy an increase in the laxity of the musculoskeletal system is a natural adaptive process. So far, there is a very little scientific data on this subject. Schauberger et al. [173] found a significant increase in joint laxity in five of seven peripheral joints over the course of the pregnancy and postpartum. In the study by Dumas [174], the exercise program employing minimal to moderate weight-bearing did not result in any measurable increases in knee laxity and, therefore, appears to be appropriate with regard to knee stability.
- According to RANZOG guidelines [12], the increase in ligament laxity associated with pregnancy may have implications for the risk of injury. However, there is no scientific evidence that the prevalence of joint injury related to physical activity increases in pregnant women. For this reason, until more data is available, activities that require jumping movements and quick changes in direction (e.g., court sports, aerobic dancing, etc.) which can stress joints should be done with caution, and adapted to skill level, to minimize the risk of joint injury [7, 12].
- According to SMA guidelines [19], stretching exercises are also useful but should be done gently due to the increased joint laxity during pregnancy. Flexibility exercises should be individualized to reduce susceptibility to joint injury. Because of increased relaxation of ligaments in pregnancy, joints are supported less effectively, especially in women with poor muscle mass. Activities that may result in excessive joint stress should be discontinued, modified, or include cautionary advice, with consideration of individual abilities [7].
- The altered center of gravity resulting from the change in weight distribution as pregnancy progresses may influence balance [12, 63]. Thus, precaution should be taken to modify the exercise routine to minimize or avoid fast changes in direction, if necessary [12].
- Balance exercises can improve the ability to resist forces within or outside of the body that cause falls while a person is stationary or moving [4]. Strengthening muscles of the back, abdomen, and legs also improves balance [4].

8.8.4 Nausea and Dizziness

- In any activity, using the Valsalva maneuver, prolonged isometric contraction, and motionless standing should be avoided [2].
- For some women it may be necessary to avoid physical activity in the supine position or to modify this position after Week 16 of pregnancy [16, 18]. Due to the weight of the growing fetus, exertion or prolonged periods in the supine position may reduce venous return and cardiac output [2].
- Fast modifications of the movement plan (e.g., from lying or sitting to standing; fast stand to sit and sit to stand) may cause dizziness and imbalance, associated with a reduction in blood pressure.
- Exercise should always be completed with a slow and sustained a cool-down and never stopped suddenly [12].

8.8.5 Heat, Humidity, and Environment

- According to Ebi et al. [175], hot ambient conditions and associated heat stress can increase mortality and morbidity, as well as increase adverse pregnancy outcomes and negatively affect mental health.
- A scoping review by Dervis et al. [176] concluded that evidence suggest that during exercise, evaporative (sweating) and dry (skin blood flow and temperature) heat loss responses increase from early to late pregnancy in addition to greater cardiac output, blood volume and reduced vascular resistance.
- Pregnant women should avoid exercising in a hot humid environment, be well hydrated at all times, and dress appropriately to avoid heat stress [6, 16–18, 21]. Further information on this topic is available by ACSM [2, 172].
- Prolonged exercise should be performed in a thermoneutral environment or in controlled environmental conditions (air conditioning) with close attention paid to proper hydration and caloric intake [16, 18].
- Pregnant women are quite sensitive to smell. Exercise should be performed in a clean environment, avoiding air pollution and bad smell settings.
- When running or cycling, rocky terrains or unstable grounds should be avoided, since the joints are more lax in pregnancy, and ankle sprains and other injuries may occur.

8.8.6 Sportswear and Shoes

- Endocrine changes occurring during pregnancy result in increased laxity of the ligaments of the foot, and several gait adaptations may occur [65, 177].
- AGDH guidelines [17] advise that pregnant women should always wear appropriate shoes, non-restrictive clothing, and a supportive pregnancy-safe bra, and, if it is hot, to wear loose clothing made from “breathable” fabric.

- Pregnant women should wear comfortable and proper exercise footwear that gives strong ankle and arch support, and provides impact absorbing features and better balance, especially during weight-bearing activities and outdoor activities.
- Appropriate shoes that provide shock absorption and stability are particularly important for pregnant women. Shoe specialists can provide recommendations or appropriate shoes to meet individual biomechanical profiles.
- Special footwear designed for pregnant women [178] may increase comfort and safety.
- The breasts became more sensitive and will grow. A good sports bra helps to control breast movement during physical activities such as walking and running. Sometimes a sports bra is not enough to provide support during exercise. A proper pregnancy bra should provide comfort and support during exercise.
- Sportswear should be light, comfortable and allow perspiration. Moreover, it should be seamless, due to the increased sensitivity of the skin.

8.9 Exercise Supervision and Multidisciplinary Teams

During pregnancy women need to feel safe and professionally framed while exercising [179]. It is important to understand why it is not enough for pregnant women just to join general, non-specific classes in fitness clubs and why well-trained and qualified exercise professionals are required to conduct pre- and postnatal classes, in order to increase participation rates amongst pre- and postnatal clients and ensure safety and effectiveness. Supervision is recommended to ensure proper technique, provide confidence, and ensure the progression of appropriate levels of intensity and complexity. The exercise professional should provide regular feedback, positive reinforcement, and behavioral strategies to enhance adherence [14].

ACSM [21, 22] recommends that physical activity programs should be individualized for each woman based on situation, experience, and current health status. These guidelines also state that while it's not required, working with an exercise professional can help to reach fitness goals, tailor exercises to abilities and most importantly, minimize the risk of injury [21]. Moreover, an exercise professional can help with strength training, pelvic floor muscle training or yoga [22]. NHS guidelines [13] advise pregnant women going to exercise classes or water exercise classes to make sure the exercise professional is properly qualified and knows that they are pregnant (and how many weeks of gestation). The SMA guidelines [19] advise pregnant women that the doctor may recommend her to see a physiotherapist or exercise physiologist for an individually prescribed exercise program. The Canadian [16] and the RANZCOG [12] guidelines refer that among the target users of their evidence-based guidelines are fitness professionals and exercise physiologists who provide guidance on the impact of prenatal physical activity on maternal, fetal and neonatal health outcomes. The Physical Activity Guidelines for Americans by USDHHS [4] state that physical activity specialists can help people attain and

maintain regular physical activity by providing advice on appropriate types of activities and ways to progress at a safe and steady pace. Moreover, they advise that people with chronic conditions and symptoms can consult a healthcare professional or physical activity specialist about the types and amounts of activity appropriate for them [4]. These references in the official position documents regarding physical activity during pregnancy, shows the increasing importance of the exercise professional in promoting and implementing effective and safe exercise programs.

The purpose of the Pregnancy and Postnatal Exercise Specialist is to build exercise participation for beginners and already active women at all stages of pregnancy and during the postpartum period. This could be done through group or individual exercise programs that meet their needs and objectives. In addition, the Pregnancy and Postnatal Exercise Specialist will be expected to assess overall physical fitness, to develop proper exercise programmes, to review participants' progress and to be able to report on adherence and outcomes to relevant stakeholders [14].

Exercise specialists should consider the multifaceted determinants and outcomes of prenatal physical activity and intervene to promote physical activity before, during, and after pregnancy, helping women to overcome any identified barriers. When working with pre- and postnatal clients specialized knowledge is needed in the following areas, amongst others: the official and updated guidelines for exercising during pregnancy; the absolute and relative contraindications to exercise; the symptoms indicating the need for the interruption of exercise; the methods for planning and delivering adapted exercise programs for this target group [14]. Further development of exercise selection and delivering methods is provided in Chap. 9 [112].

An exercise professional should also provide the safest possible training and testing environment, as well as preventing exercise-related emergencies, and be familiar with the safety and emergency procedures available at the fitness setting where the exercise program is delivered. Further development of this topic can be found in ACSM [2, 47, 48].

8.10 Further Research

The body of knowledge on prenatal exercise is increasing. Growing evidence has been supporting that several types of moderate exercise is safe for the mother [8, 18, 34, 35, 137, 180, 181] and fetus [34, 37, 39, 180, 181]. However, the information about the dose-response of exercise and its effects on the cardiovascular and musculoskeletal systems of the pregnant body are still relatively limited. More knowledge of the physiologic, biochemical, and musculoskeletal changes that result from various patterns of physical activity in pregnant women, i.e., short- and long-term, sustained and intermittent, isotonic and isometric, low to moderate, moderate to high intensity, high intensity, minimum-intensity threshold required for benefit, is needed. Harrison et al. [180] highlighted the need for large, high-quality studies to clarify the optimal type, frequency, duration, and intensity of physical activity required for beneficial health outcomes during preconception, pregnancy and postpartum.

Research on better and more effective physical activity and exercise interventions that improve long-term compliance with a physically active lifestyle is also needed. Future studies should focus not only on the benefits of physical activity and exercise, but also on exercise adherence strategies and the methods used to facilitate dissemination of present and future knowledge to pregnant women, healthcare providers, and exercise professionals.

Healthy women and female athletes can usually maintain their regular training regime once they become pregnant, however, as suggested by Kehler and Heinrich [182], research is needed to determine the upper limits of exercise frequency and intensity for pregnant women who are already trained.

Exercise interventions are complex interventions because they contain several interacting components [183, 184]. Applying the Criteria for Reporting the development and Evaluation of Complex Interventions in healthcare (CREDECI2) [184], as well as the Consensus on Exercise Reporting Template (CERT) [185] would allow a better understanding of the prenatal exercise program itself and the dose-response impact. Our study "development and validation of a complex intervention: ACTIVE PREGNANCY—a physical exercise program aimed at promoting health and fitness during pregnancy" [186] was the first validation study using this methodology. So far, there are no other validation studies regarding exercise interventions tailored to pregnant women. In addition, there is a lack of standardizing physical activity measurement during pregnancy, as well as specific fitness assessment batteries [67], allowing to quantify the effectiveness of exercise interventions for pregnant women in the physical fitness parameters, such as maternal cardiorespiratory fitness [35–37, 181].

Other focus would be the best types of exercise that could be beneficial for reducing the prevalence of symptoms, pain, and musculoskeletal disorders commonly associated to pregnancy, improving fitness and balance performance, decreasing fear of falling and incidence of falls, as well as to reduce sedentary behavior [4, 6].

Regarding clinical conditions, results from recent systematic reviews and meta-analysis suggest that structured moderate physical exercise programs during pregnancy may be used as adjunct treatment and provides protective effect against the development of gestational diabetes mellitus [8, 37, 40, 126–129, 132–137], excessive maternal weight gain [8, 37, 105, 132, 137, 138, 143, 181], low back and pelvic girdle pain [99, 136, 153, 155, 156], urinary incontinence [36, 78, 84, 170, 171], hypertensive disorders [8, 37, 38, 136, 145], and anxiety and depressive symptoms [8, 41, 42, 162, 163]. Physical exercise programs during pregnancy also impact on maternal health and perinatal outcomes [8, 35, 37, 39, 134, 137, 181], bone health [82, 83], and also a positive impact on offspring health in adulthood is observed [37, 43]. Moreover, diet and physical activity-based interventions during pregnancy reduce gestational weight gain and lower the odds of cesarean section [38, 143]. Nevertheless, current evidence is confounded by the large variety of exercise interventions [134]. Thus, further studies evaluating type, intensity, duration, and compliance of physical activity and exercise routines are needed to

establish recommendations for exercise practice and best inform obstetric guidelines, as well as to provide advice for pregnant women with such clinical conditions or disabilities. Moreover, as suggested by Brown et al. [134], further research is required comparing different types of exercise interventions with another exercise intervention that reports on both the short- and long-term outcomes for mother and baby. Other field of study that lacks evidence-based knowledge is the quality, feasibility, engagement and effectiveness of maternal health and exercise mobile apps [187].

Overall, we suggest that future research should be focused on the dose-response of exercise and in comparing different types of exercise programs, either presential or online, rather than with no exercise control groups, which, based on current knowledge, might be considered as unethical and unnecessary procedure. Hopefully, texts like this will increase the recognition of the need for further research on the above-mentioned topics.

8.11 Conclusions

Exercise testing and prescription in pregnancy is the plan of exercise and fitness-related activities designed to meet the health and fitness goals and motivations of the pregnant woman, addressing the health-related fitness components and the pregnancy-specific conditions, based on previous health and exercise assessments, and taking into account the body adaptations and the pregnancy-related symptoms of each stage of pregnancy and postpartum, as well as fitness level, motivations and experience, in order to provide safe and effective exercise.

In this Chapter, we have reviewed the guidelines for exercise testing and prescription in pregnant women. Moreover, we proposed a sequential order for exercise prescription and planning. There is increasing evidence on the benefits of physical activity and exercise during pregnancy. The first step before planning to start or continuing an exercise program during pregnancy is the health screening of the woman by a healthcare provider. The second step is the appropriate pre-exercise evaluation, followed by the testing of determined fitness and postural components. Appropriate exercise prescription is then developed to tailor effective and safe exercise programs. When planning an exercise intervention, exercise professionals should bear in mind that for each type of exercise, i.e., aerobic, resistance, flexibility, or neuromotor, there is a frame of intensity, frequency, and duration, which will provide a metabolic, mechanical, and psychological stimulus. In addition, pelvic floor training and preparation for birth exercises are specific interventions for this special stage of life. Supervision of exercise programs by qualified exercise professionals is of particular importance to provide safe and effective exercise meeting women's goals and motivations. The synthesis of this information can be found in the infographic of the present Chapter (Fig. 8.7).

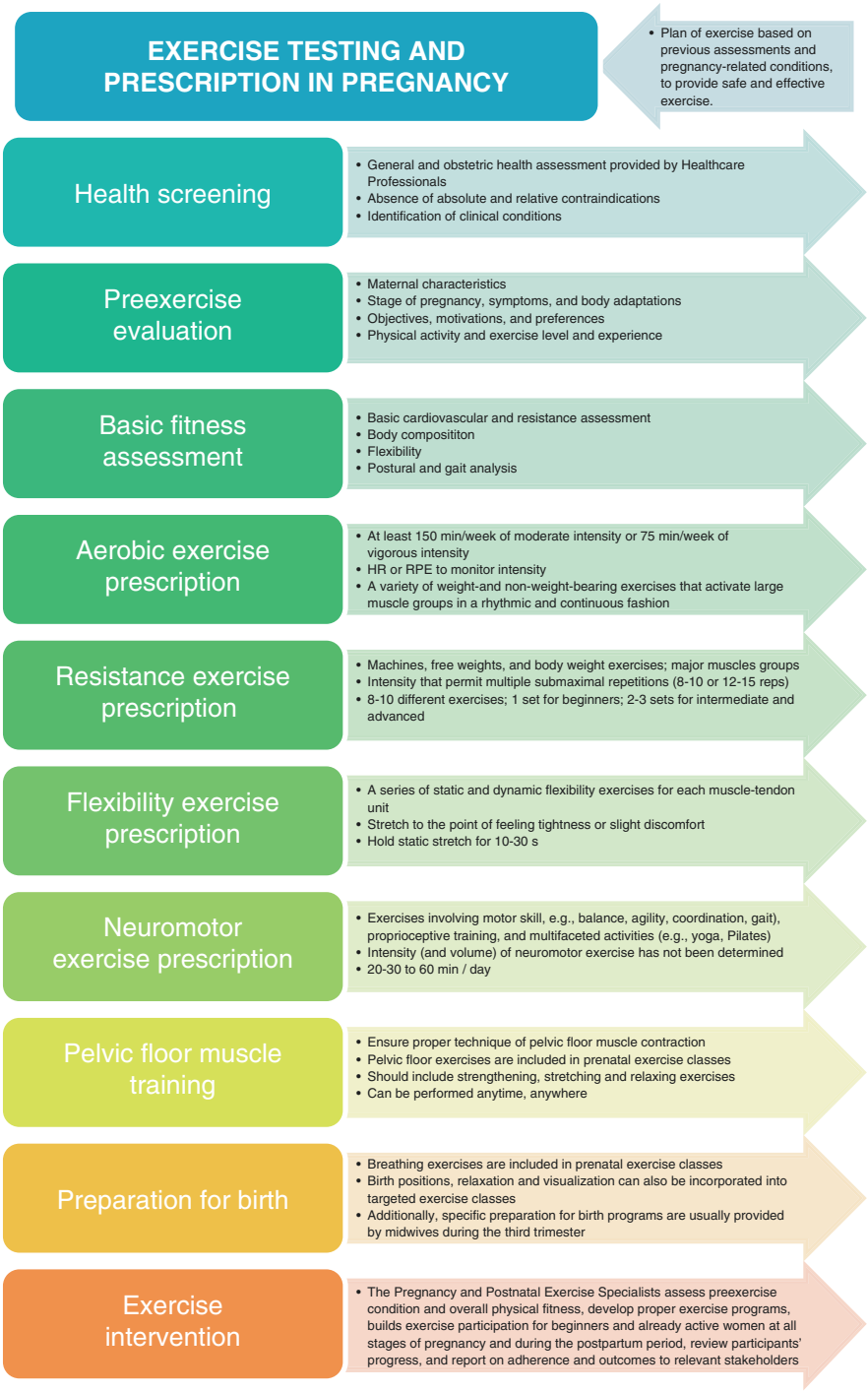

Fig. 8.7 Infographic of the chapter "Exercise Testing and Prescription in Pregnancy"

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