Physical Activity, Exercise, and Health Promotion for the Pregnant Exerciser

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Abstract

Currently, there is consensus that maintaining light to moderate physical activity during an uncomplicated pregnancy has several benefits for the health of the woman and the fetus. Pregnancy provides good opportunities for promoting women's health and an active lifestyle. The purpose of this chapter is to provide exercise and healthcare professionals with a basic understanding of the importance of an active lifestyle, health promotion, and education during the different stages of pregnancy, by emphasizing the benefits, correlates, and patterns of physical activity during

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pregnancy. We highlight the importance of healthcare professionals in promoting the benefits of physical activity and advising women on a healthy and active lifestyle during pregnancy, referring them to a prenatal exercise specialist.

Keywords

Pregnancy · Postpartum · Health promotion · Education for health · Physical activity · Exercise

1.1 Introduction

Currently, there is consensus that maintaining light to moderate physical activity during an uncomplicated pregnancy has several benefits for the health of the woman and the fetus [1–5]. In the last three decades, scientific evidence has clearly supported the importance of physical activity and exercise during pregnancy [6–11]. In the first place, one should clarify the meaning of these terms, because sometimes the terms physical activity and exercise are used interchangeably, and there is no clear consensus on the definitions of fitness or exercise prescription [5].

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure [5, 12]. *Exercise* is a type of physical activity consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness [12] and/or prolong life [13]. In other words, exercise is a subcategory of physical activity. Although energy expenditure is increased during physical activity, it does not always reflect exercise and should not be confused with fitness [14]. Thus, physical activity can be categorized either in different contexts, such as leisure-time, exercise, sports, occupational, household, and transportation activities, or by intensity, i.e., light (less than 3 METs—metabolic equivalents[1]), moderate (between 3 and 5.9 METs), and vigorous (6 METs or more) [14]. The World Health Organization (WHO) guidelines recommend adults to do 150–300 min of intentional physical activity of moderate to vigorous intensity per week for good health and reduction of several diseases [15].

On the contrary, *sedentary behavior* involves activities that less than 1.5 METs [5], and *physical inactivity* is a behavioral state of not achieving on a regular basis, a certain minimum standard of physical activity [14], i.e., fail to meet the WHO recommended level of physical activity required for good health. Physical inactivity is the fourth leading cause of death worldwide [16] and considered the biggest public health problem of the twenty-first century [17].

Physical inactivity during pregnancy may be a significant public health[2] issue due to its prevalence and associates with adverse pregnancy and birth outcomes, as

[1] MET = Multiple of resting metabolic rate, used as a measure of exercise intensity [5].

[2] Public health is a field that encompasses many disciplines in an effort to promote and protect health and prevent disease and disability in defined populations and communities [16]. In other words, the science and art of promoting health, preventing disease, and prolonging life through the organized effects of society [17].

well as the short- and long-term risk for several chronic diseases for mother and child. Both exercise and health professional organizations have discipline-specific and endorsed guidelines for physical activity during pregnancy. However, whether interventions exist that translate health evidence of regular physical activity in pregnant women into practice remains unknown.

The purpose of this chapter is to provide exercise and healthcare professionals with a basic understanding of the importance of an active lifestyle, health promotion,[3] and education[4] during the different stages of pregnancy, by emphasizing the benefits, the correlates, and the patterns of physical activity during pregnancy.

1.2 Education for Health and Lifestyle During Pregnancy

1.2.1 Pregnancy as an Opportunity to Promote Health

Assuming the importance of professional health intervention aiming at low-risk pregnancy surveillance, the main components are defined as prenatal care, health education, and preparation for childbirth and parenting [20]. Learning and information sharing must be integrated and permeate all pregnancy care from a health education perspective. Health education is understood as "all intentional activities conducive to learning related to health and disease […]; can facilitate the acquisition of skills; may also lead to changes in behavior and lifestyles" [21]. In other words, health education can be defined as the processes through which people learn about personal health concepts and behaviors [16]. It is necessary here to identify the indicators of differentiation in adulthood that fit the perspective of adult education. Those indicators should be considered in the operationalization of the different components of pregnancy surveillance, in order to support self-development and learning. This perspective is supported by the principles that guide learning within the andragogic model that Knowles defined in the 1970s: The need to know, the concept of self, the role of experience, the willingness to learn, the orientation of learning, and motivation [22, 23]. Adults are only inclined to start and develop a learning process as long as they recognize its applicability, that is, a process that guides them to solving problems and tasks that they encounter in their life. Since pregnancy is a period of profound physical and psychological changes in a woman's life, it is an opportune moment to change lifestyles and improve health behaviors, based on a philosophy of "woman-centered care" [24, 25].

Thus, for health education during pregnancy and in the postpartum period, the goal of health professionals should be to: increase health literacy and develop parental skills; make learning and information sharing components of each prenatal and postnatal surveillance visit with the pregnant woman/couple and family; establish a relationship of trust that facilitates the expression of expectations, fantasies, beliefs,

[3] Health promotion is the process of enabling people to increase control over the determinants of health and thereby improve their health [18].

[4] Health education can be defined as the processes through which people learn about personal health concepts and behaviors [19].

myths, feelings (positive or negative) and competencies related to pregnancy, birth and parenthood; and promote the right to adequate information for a free and informed decision.

Moreover, a routine health promotion program, encompassing education, advice, and general health assessment in the prepregnancy period can be developed for improving pregnancy outcomes by encouraging behavioral change, or allowing early identification of potentially modifiable risk factors, such as smoking, alcohol intake, poor nutrition [26], poor sleep, as well as physical inactivity.

1.2.2 Preparing for Childbirth and Parenting

The preparation for childbirth and the operationalized parenting in formal courses is an important part of health promotion in maternal, obstetric, and gynecological health [27]. These courses allow women and their partners to experience pregnancy, and from their needs, share, express, and clarify fears, doubts, and anxieties, in a group environment and mutual support, in order to enable them to the tasks that pregnancy and parenting require. The courses often include a theoretical component and a practical component. According to Recommendation 2/2012 of the Board of the College of Maternal and Obstetrical Health Nursing Specialty [28], the theoretical component includes the following topics: labor, labor analgesia, breastfeeding, puerperium, childbirth, among others. The following practical components are worth highlighting: exercises to promote the attachment of the pregnant woman/companion/baby during pregnancy; comfort techniques during labor; the role of the companion to promote the comfort of the parturient, placements during labor and delivery, and the pelvic floor toning exercises. It should be noted that this descriptive statement also refers to the creation and use of opportunities in the preconception, pregnancy, and puerperium periods to promote healthy lifestyles, which reinforces the importance of a care centered on the needs of each woman and structured based on the philosophy of the andragogic model.

1.2.3 Health and Lifestyle Promotion

There is growing evidence that regular physical activity during pregnancy contributes positively to physical and psychological health. Moreover, physical activity significantly affects public health as it reduces the risk of chronic diseases (such as cardiometabolic diseases) and provides numerous protective factors related to psychologic (e.g., mood, self-esteem, etc.) and musculoskeletal parameters (e.g., urinary incontinence, low back pain, etc.), during and after pregnancy. Adverse consequences of inactivity may be an important problem especially among pregnant women.

Pregnancy is a period *par excellence* to identify, modify, and adopt habits and behaviors for healthy lifestyles. The pregnant woman is often motivated to learn when she understands the advantages and benefits of learning. The health

professional should seek the congruence between the adult's learning process, its particularity, and the need for personal development within the life cycle. Moreover, the promotion of physical activity may represent an important prevention strategy for public health, and it implies an interaction among several professionals from health and wellbeing settings [29].

We stress the importance of healthcare professionals in promoting the benefits of physical activity, and advising women on a healthy and active lifestyle during pregnancy, referring them to a prenatal exercise specialist. It is also necessary to show that exercise specialist and instructors are well informed regarding the implementation of tailored exercise programs or the inclusion of pregnant women in regular group fitness classes. The best service is for sure provided by multidisciplinary professional groups, including exercise professionals, midwives, physiotherapists, and doctors, who can coach pregnant women to exercise properly.

However, a review by Nascimento et al. [30] reported that most pregnant women are not receiving physical activity and exercise guidance from healthcare providers, during prenatal care meetings, and some pregnant women were told to stop exercise [31]. The latter particularly applies to women pregnant with twins or triplets, who are often classified as contraindicated to physical activity and advised bed rest [32]. Several barriers experienced by healthcare providers have been identified to explain this lack of promotion of physical activity, such as a lack of time and resources and insufficient skills [33]. Nascimento et al. [30] provide suggestions to improve the quality of exercise guidance for pregnant women including the participation of a multidisciplinary team in providing educational strategies, support groups, and education about exercise benefits and safety for both pregnant women and medical professionals involved in prenatal care.

Exercise guidance and recommendations given to pregnant women in prenatal care is a particular issue in health and lifestyle promotion, since women who received some counseling were three times more likely to exercise than those who received no guidance [32, 34]. Indeed, Krans et al. [35] found that the probability that a woman exercised during pregnancy was increased if her obstetrician encouraged her to exercise.

1.3 Public Health and Physical Activity During Pregnancy

1.3.1 Impact of Maternal Physical Activity on Chronic Disease Risk

The recommendations for physical activity in pregnancy are mostly based on the evidence that maternal physical activity reduces the risk of pregnancy and birth complications. Sufficient physical activity in pregnancy may reduce the risk of the great obstetric complications (i.e., preeclampsia, gestational diabetes mellitus, hypertension, preterm, large for gestational age (LGA), small for gestational age (SGA), and other (e.g., varicose veins, deep vein thrombosis, fatigue, stress, anxiety, and depression)) [1, 3, 4, 7, 10, 11, 36].

However, for public health, not only pregnancy and birth outcomes are of relevance, but also the long-term health of both mother and offspring. Although physical activity has beneficial effects for some pregnancy outcomes, in this part the focus will be on four health parameters that are highly relevant for public health: weight status, glucose metabolism, cardiovascular health, and quality of life. The first three are influenced by both pregnancy and physical activity. Quality of life is related to the other health parameters and therefore indirectly influenced.

Pregnancy is obviously associated with weight gain. Gestational weight gain (GWG) is comprised of the accretion of water, protein (fat-free mass), and fat mass in the fetus as well as the placenta, uterus, and amniotic fluid, and expansion of maternal blood volume, mammary gland, and maternal adipose tissue [37]. How much weight women gain and are recommended to gain is dependent on their prepregnancy body mass index (BMI = weight (kg)/height $(m)^2$) [38]. However, many women gain more than the recommended weight, especially overweight and obese women [37]. Excessive GWG in pregnancy is associated with a reduced risk for preterm birth, but increases the risk for cesarean section, large for gestational age, and macrosomia [39]. Furthermore, excessive GWG is related to a higher risk of obesity in the offspring [40]. The prevention of excessive GWG is therefore relevant for both mother and child. There is a high level of evidence that a higher level of physical activity in pregnancy is related to a lower risk of excessive GWG [41–43].

From a public health perspective, it is especially worrying that excessive GWG is also associated with more weight retention postpartum. Weight retention is the difference between prepregnancy and postpartum weight. Women with excess GWG retain the most weight postpartum, and the excess weight gained in pregnancy is still retained up until 20 years later [44]. Therefore, limiting GWG in pregnancy has a long-lasting effect on the weight development of women and reduces the risk of becoming overweight or obese [45]. Since physical activity in pregnancy reduces the risk of excessive GWG, it seems logical to assume it will also reduce postpartum weight retention. However, currently, there is no convincing evidence that physical activity interventions alone in pregnancy are effective in reducing weight retention, with some studies finding reduced weight retention after antenatal intervention [46, 47] and others finding no reduction [48, 49]. However, there are relatively few studies that evaluated physical activity interventions that were initiated in pregnancy for the effect on postpartum weight retention. In contrast, there is good evidence that physical activity interventions initiated postpartum are effective in reducing weight retention [50].

Insulin sensitivity is highly influenced by pregnancy (see Chap. 3 [51], "Physiological Changes"). When women cannot "cope" with the increased insulin resistance in pregnancy with a sufficient increase in insulin secretion, they develop gestational diabetes (GDM). Women who start pregnancy with increased insulin resistance (e.g., due to obesity), or those with compromised insulin secretion, are at higher risk of developing GDM [52]. Pregnancy is therefore considered a metabolic "stress test." Women with GDM during pregnancy have an elevated risk of developing type 2 diabetes postpartum [53].

Many studies on the prevention of gestational diabetes have been conducted in recent years, most of them evaluating an intervention that included a physical activity component. Systematic reviews and meta-analyses of these studies generally conclude that physical activity interventions in pregnancy are effective in reducing the risk of gestational diabetes [43, 54]. However, there are some indications that interventions initiated in the first trimester are effective, but those initiated in the second trimester or later are not [55]. Prevention of GDM does not automatically mean that the women will not develop type 2 diabetes later in life, but that they will have a reduced risk of type 2 diabetes if they maintain their increased physical activity levels. Therefore, continued support and counseling on physical activity after a pregnancy complicated by GDM are needed. Unfortunately, this is not routinely implemented in clinical care and the most effective strategy is unclear yet. A review reported inconsistent findings of the 12 studies that addressed the effectiveness of postpartum interventions for the prevention of type 2 diabetes among women with a history of GDM [56].

Also for the cardiovascular system, pregnancy is a stress test. Gestational hypertensive disorders, including gestational hypertension and preeclampsia, are one of the leading causes of maternal morbidity and mortality [57]. Women who develop preeclampsia are at increased risk for chronic hypertension and cardiovascular disease in later life [58]. There is evidence that physical activity interventions in pregnancy reduce the risk of hypertension in pregnancy [42, 59], but have no effect on the risk of preeclampsia [59]. In contrast, observational studies show that physical activity before or in early pregnancy might be related to a lower risk of preeclampsia [60].

Given the evidence of beneficial effects of physical activity in pregnancy on maternal health, it is not surprising that it also has a positive effect on quality of life of the women during pregnancy. Physical activity has been reported to have a positive effect on quality of life, mainly with regards to physical and pain components [61–63], and maternal perception of health status [64]. Whether physical activity in pregnancy also influences the quality of life later in life is unknown, since no information on the long-term consequences for maternal quality of life is available.

1.3.2 Impact of Maternal Physical Activity on Offspring Health

Also in this part, the focus is mostly on the long-term consequences of maternal physical activity on offspring health, since this has the most implications for public health. Important neonatal outcomes, related to health outcomes in later life, are preterm birth (e.g., [65, 66]), and small- or large-for-gestational age (SGA and LGA, respectively) [67, 68], and body composition [69].

Physical activity in pregnancy is related to a reduced risk of preterm birth [42, 70–72]. Physical activity might also be related to birth weight, although results might depend on the physical intensity level, on which measure of birth weight are used as the outcome and study design. A recent meta-analysis found a small increase in mean birth weight for moderate levels of maternal physical activity and a

reduction in birth weight in high maternal levels of physical activity compared to lower levels [73]. Structured exercise interventions showed small reductions in mean birth weight, and reduced the risk of LGA, without influencing the risk of SGA newborns [74].

No conclusive evidence is available for an effect of PA on neonatal body composition, mostly because it is studied relatively little [73]. Observational studies indicate that maternal physical activity might reduce neonatal body fat mass at birth [75–78]. However, one intervention study with high compliance with the exercise intervention did not find a change in offspring fat mass but a reduced lean mass in the intervention group [79]. A systematic review of lifestyle interventions in overweight or obese women reported no effect on neonatal adiposity, but only four studies were included in the review [80].

Long-term relationship of maternal physical activity in pregnancy with offspring obesity [81, 82], or fat percentage [76] has been reported. Other long-term health effects of maternal physical activity are plausible, for instance, through epigenetic changes in the offspring; however, such effects have not been demonstrated in humans yet.

1.4 Correlates of Physical Activity Among Pregnant Women

Given its numerous health benefits for both pregnant women and their children, national and international guidelines have recommended regular PA for all healthy pregnant women since the 1980s [83]. However, only a small proportion of women achieve the recommended levels of PA during pregnancy [33, 84]. In addition, longitudinal studies have shown a decline in PA levels as pregnancy progresses and PA levels are also lower in pregnant women compared to their nonpregnant counterparts [85, 86].

Therefore, identifying and understanding the factors that explain why some women are regularly physically active during pregnancy while others are not is of utmost importance to public health research. Physical activity is a complex behavior determined by the interaction of a large number of personal, social, and environmental factors specific to populations, setting, and type of physical activity. Furthering the understanding of the factors that influence physical activity behavior in specific populations such as pregnant women will aid the development of effective, tailored intervention strategies aimed at increasing the prevalence of physical activity among the pregnant population.

The terms *correlates* and *determinant* are often used synonymously in the literature. *Correlates* are factors statistically associated with or predictive of physical activity but do not imply a causal relationship. Determinants are defined as causal factors and derived from experimental or longitudinal studies [87, 88]. Most studies including pregnant women have only assessed the impact of individual correlates (i.e., psychological and biological) on physical activity during pregnancy [89]. Information on interpersonal, societal, environmental, policy, and global factors have barely been studied in pregnant populations.

Correlates and determinants of physical activity may change as pregnancy progresses due to massive bodily changes associated with pregnancy. If we assume that most women reduce their physical activity levels toward the end of their pregnancy, we may also expect correlates of PA to change. It seems that pregnant women shift from high-intensity exercise (i.e., running, ball games, and fitness training) to moderate and low-intensity exercise such as swimming and bicycling.

1.4.1 Identifying Physically Active Pregnant Women

Women who are regularly physically active before pregnancy are much more likely to continue to be regularly physically active during pregnancy [89–94]. Physically active pregnant women also tend to be older, primiparous, and have higher education [92, 93, 95–99], compared to those not meeting the recommended levels of physical activity or who are inactive during pregnancy. In addition, overweight or obesity status before pregnant and pregnancy-related weight gain are shown to be independently associated with regular exercise during pregnancy [91, 92, 98].

In nonpregnant populations, a negative association between age and physical activity has repeatedly been documented [87]. Depending on the outcome of interest, studies including pregnant women have reported both positive and negative associations with maternal age and physical activity [95, 100, 101].

1.4.2 Identifying Physically Inactive Women

Pregnancy-related factors such as gestational length, multiple pregnancies, pelvic girdle pain, nausea with or without vomiting, assisted reproduction, sub fecundity, sick leave, and other musculoskeletal pain are found to be associated with less likelihood of regular physical activity during pregnancy [92, 94, 97].

Correlates of sedentary behavior among pregnant women overlap but are not the same as for physical activity: smoking [102], having a sitting job, fewer children less than 5 years of age in the household [103], and younger age [102, 103] were related to more sedentary behavior during pregnancy.

1.5 Physical Activity Patterns Among Pregnant Women

There is a lack of information on the specific guidelines and real strategies of adaptation of several recreational and sports activities that might be adapted to healthy pregnant women. These issues are further addressed in Chaps. 7, 8, and 9 [104–106]. However, we believe that in order to better develop safe and effective exercise programs, it is necessary to understand, among other variables: the physical activity patterns of pregnant women; the motivations for exercise during pregnancy; and the

characteristics of proper exercise. This information will be useful to develop recommendations for pregnancy-specific exercise programs.

Some studies report the prevalence of physical activity during pregnancy, but little references in the literature report the pattern of exercise and leisure-time physical activity using well-validated measures [84, 86, 89, 92, 96, 107–116]. Although there are international guidelines for physical activity during pregnancy recommending regular physical activity for healthy pregnant women, either sedentary or previously active, the results of such studies conducted in different countries are not favorable. A deep review of these studies is out of the scope of this chapter but the respective analysis, in general, allow to formulate key ideas, as follows.

Regarding the prevalence of physical activity, a high percentage of pregnant women are sedentary; few pregnant women are meeting the international guidelines for physical activity during pregnancy (i.e., completing the minimum of 150 min of aerobic exercise per week); and there is an increasing decline of exercise, leisure time, and work-related physical activities across pregnancy, in comparison with the prepregnancy period, especially in the first and third trimesters. Considering that the prevalence of PA is lower in the first and the third trimesters, and higher in the second trimester, only few women remain active throughout pregnancy, in accordance with the latest review on the topic, by Nascimento et al. [117]. Tavares et al. [118] and Lynch et al. [119] reported that women tend to replace moderate-intensity activities with light-intensity or sedentary activities during pregnancy. Furthermore, the reduction in physical activity level occurred not only in the level of exercise but also in daily activities, such as housework, childcare, transportation, and occupational activities [43]. According to Gaston and Vamos [32], results indicate that promoting physical activity during pregnancy should remain a public health priority.

Regarding the pattern of physical activity and exercise during pregnancy, walking is the most commonly reported form of exercise, followed by water exercise, swimming, and aerobics. Nevertheless, other types of exercise are also reported, such as dancing, cycling, jogging, resistance training, Pilates, yoga, stretching, and pelvic floor exercises. Although there is insufficient data in the literature to assess the specific effects of these types of exercise, there seems to be a consensus that they are safe, effective, and allow a broad span of intensity and complexity to be adapted to pregnant women. Further development of this topic is provided in Chaps. 7, 8, and 9 [104–106].

1.6 Measuring Physical Activity, Sedentary Behavior, and Sleep Pattern

When analyzing physical activity patterns with the aim to investigate its relationship with health, we should take into account that physical activity is part of the activity behaviors that integrate the daily activity of a person. During years, research has mainly studied the potential effect that some activity behavior in isolation, such as

physical activity or sedentary activity, has for heath. For instance, scientific evidence has shown how physical activity have potential benefits to reduce the risk of developing hypertension, obesity, or adverse psychological and neonatal outcomes [3, 120–122]; or how sedentary behaviors have potential negative effects on glucose tolerance, mental distress, and pregnancy outcomes [123–126].

Scientific evidence highlights that each activity behavior has unique potential effect on health and also that one activity behavior could influence the other behaviors [126], what supposes the need of a global assessment of all behaviors rather than the assessment of them in isolation. Consequently, it has been required the introduction, for first time, of advice for sedentary behaviors in the update of the World Health Organization guidelines on physical activity [15]; or the integration of physical activity, sedentary behavior, and sleep in the update of the Canadian guidelines [127]. This perspective is related with the concept of healthy lifestyle, which is defined by the American Psychological Association's Thesaurus of Psychological Index Terms as "a pattern of behavior involving lifestyle which ensures optimum health" [128].

To reach a global conclusion when analyzing the effect of activity behavior on health, it is necessary to take into account all activity behaviors. For instance, a pregnant woman could be categorized as physically active, by meeting physical activity recommendations, but also spent a higher amount of time on sedentary activities [129]. If we only focus on the assessment of one behavior in isolation, a possible lack of information could avoid us to lead a conclusion about the influence on health that activity behaviors have.

Additionally, the finite nature of the day, 24 h, makes activity behaviors exhaustive and mutually exclusive components of a person's 24-h day [130]. This nature implies that the time spent in one behavior necessarily has to be displaced from another behavior within the 24-h day. So when analyzing the health effect of an activity behavior, the rest of activity behaviors must not be ignored because they are an influence of the studied behavior and as aforementioned a unique effect on health.

The design of the assessment procedure is very important to guarantee that it fulfills the research objective and do not lead us to misleading results. At first, it is essential to establish the dimensions of the activity behaviors that we want to analyze and to select the most appropriate instruments to obtain the activity behavior's data. In this sense, the research could focus on activity intensity (sleep, sedentary activity, light, moderate, and vigorous physical activity), activity type (walking, working, leisure, etc.), or the posture (reclining, sitting, and standing). Objective instruments such as accelerometry-based devices obtain a measurement of pregnant women's activity intensity [131, 132], while inclinometer-based devices obtain a measure of pregnant women's posture [133]. Subjective instruments such as diaries and questionnaires allow obtaining a measure of the type of activity developed by pregnant women [134–137].

Subsequently, the selection of the most appropriate statistical approach based on the characteristics of the data obtained is also very important. Traditional linear regression models, which allow analyze the relationship between a set of explanatory variables and an outcome, or traditional isotemporal substitution, which allows analyze the

theoretical effect of displaced a fixed time between behaviors, show some inconvenient that impossibilities to properly analyze all activity behaviors together, i.e., multicollinearity[5] [138]. To overcome the multicollinearity problem derived from the codependent nature of activity behaviors, compositional log-ratio transformation techniques[6] have been proposed [138]. For instance, the compositional isometric log-ratio transformation allows expressing the time spent in one behavior relative to the time spent in the rest of behaviors [130], which solve the codependency problem when the research applies compositional linear regression and compositional isotemporal substitution models [139]. However, the analysis of the collinearity is still required to ensure that there is an absence of collinearity in the linear regression model [137]. The multivariate pattern analysis, which describes the pattern of associations for the descriptors with the outcome accounting for the correlated structure of the data, is another technique that allows overcoming collinearity problems [140]. However, there is a limitation in the interpretation of the results because it does not allow quantifying time exchange between descriptors or adjusting the regression models [137].

Researchers have to deeply analyze what is the best procedure to answer the research question and reach this objective. The selection of most suitable instruments and statistical approach is required to properly interpret the results and get global conclusions when analyzing the effects of activity behaviors on health.

1.7 Further Research

Although beneficial effects of physical activity in pregnancy on maternal and offspring health are established, some open questions remain. First and foremost, no consensus is reached on the type and intensity of physical activity required, especially for women who start pregnancy obese or with a low fitness level. Second, there is some evidence that the timing of physical activity (intervention) is relevant, with better outcomes for early physical activity (intervention). However, this needs to be studied more systematically. Furthermore, most studies in this field are from developed countries, and voluntary physical activity might have different effects on pregnancy outcomes than nonvoluntary physical activity (e.g., at work or for transport). Reducing physical activity levels according to developing pregnancy and possible pregnancy complaints is not always an option for women in from low-to-middle income (LMIC) countries. Whether this type of physical activity in pregnancy has the same beneficial effect on maternal and offspring outcomes is grossly understudied.

[5] Multicollinearity occurs when independent variables in a regression model are correlated, which is a problem when the degree of correlation between variables is high enough because it can cause problems when fitting the model and interpreting the results.

[6] Log-ratio transformation techniques allow to transfer compositional data from the constrained simplex space to the unconstrained real space, where traditional multivariate statistics may be applied.

Although there are international guidelines for physical activity during pregnancy recommending regular physical activity for healthy pregnant women, little is known about the pattern of exercise and physical activity of pregnant women worldwide. Hence, national surveillance studies of physical activity in the population should include pregnant women. Well-designed longitudinal investigations reporting pregnancy-related changes in physical activity by trimester of pregnancy would also help to fill this gap. Not only the various designs but also the various instruments used in the studies limit comparisons of studies on the practice of exercise during pregnancy. It would be of particular importance that researchers would use same precise, reliable, acculturated, and validated instruments for physical activity and exercise measurement whenever applicable, in what concerns to quantity and quality.

Moreover, results indicate a need for more information and motivation for moderate exercise before and throughout pregnancy. Pregnant women is a heterogeneous group, which implies that different women need different approaches. Promoting physical activity remains a priority in public health policy, and pregnant women or those planning a pregnancy should be encouraged to maintain an active lifestyle or to adopt a tailored exercise routine during pregnancy in order to avoid sedentary- and obesity-associated risks.

Research on better and more effective physical activity and exercise interventions that improve long-term compliance to a physically active lifestyle during and after pregnancy is needed. The methods of increasing physical activity in this special population must be developed, implemented, and evaluated.

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