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# Physical activity by pregnant women and outcomes for newborns: a systematic review

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## ABSTRACT

A systematic review was carried out aiming at analyzing daily physical activity during pregnancy and the outcomes of birth weight, prematurity, and intrauterine growth restriction. Of 52 articles indexed in Medline, 22 that showed better methodological quality were included. Among the 22 articles analyzed, only two did not detect a significant association between physical activity and the outcomes studied. There was large variation between the indicators of maternal physical activity, which included occupational, household, recreational and, all or some, locomotive activities. Among ten articles that measured total daily physical activity, only one article did not find any association. The results support the hypothesis that both excessive and insufficient physical activity impact negatively on pregnancy outcomes.

**DESCRIPTORS:** Pregnant Women. Motor Activity. Birth Weight. Obstetric Labor, Premature. Review.

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## INTRODUCTION

Low birth weight and its contributing factors, preterm birth and intrauterine growth restriction, have been widely studied due to their known influence on infant mortality and morbidity.<sup>38</sup> Excessive physical exertion has been indicated as one of multiple determinants.<sup>7,36,38</sup> The available studies involve the following general factors potentially associated with low birth weight, preterm birth, and intrauterine growth restriction: (1) energy expenditure, under the supposition that higher caloric expenditures could withhold energy from the fetus; (2) specific postures, for example, maintaining a standing posture for prolonged periods, as potentially reducing uteroplacental blood flow; (3) occupational activities or professional categories (covering physical and psychological aspects); and (4) leisure-time activities, regular exercise, and daily physical activities. Nonetheless, reviews on this topic only focus on occupational activity,<sup>60</sup> maternal physical exercise,<sup>53,63</sup> or both.<sup>16,20</sup> Four meta-analyses about physical exercise<sup>6,37,40,42</sup> and one meta-analysis involving just occupational physical activity<sup>48</sup> were also published. There are no reviews that evaluate physical activity in an all-encompassing manner and go beyond just evaluating occupational activities and physical exercise. De Ver Dye et al<sup>16</sup> recommend the realization of studies that cover physical activity in its four dimensions: occupational, household, leisure-time and commuting.

The objective of this article was to evaluate the influence of daily physical activity on pregnancy outcomes, while covering the different domains (occupational, household, leisure-time and commuting).

## METHODS

During the search of articles indexed in the Medline electronic database, there were no restrictions placed on the type of publication, language or year of publication.

The following descriptors were used for the search strategy on Medline: “pregnancy” combined with “activities of daily living” or with “motor activity” to define the exposure and “birth weight”, “pre-mature infant”, “preterm birth”, “intrauterine growth”, “fetal growth” and “pregnancy outcome” to define the outcome. Each term was matched individually with the others, to guarantee that all related articles would be included. To further ensure that all articles were captured, the keywords “work” and “exercise” were included to help define other types of exposure, with only the articles focused on daily physical activity being included. Additional terms, since they were observed in related studies, were also included, even though they

are not Medical Subject Headings (MeSH) keywords: “pregnant”, “maternal”, “physical activity”, “preterm delivery”, “job” and “occupational”. All the articles that studied the association of daily physical activity during pregnancy with birth weight, length of gestation, and intrauterine growth restriction were considered, regardless of study design and sample size. Articles that analyzed physical training, exercise, or activity through professional categories were included if they actually measured physical activity, instead of making inferences based on professional category.

The search identified 5,102 articles, of which 4,672 were duplicates or unrelated to the theme, resulting in 430 selected articles. In order to select the articles included in this review, an initial reading of abstracts was done, followed by a reading of full texts. This screening did not consider methodological quality. Publications such as letters, commentaries or editorials were excluded, as were 103 articles due to their study type (reviews, meta-analyses, case studies, historical and animal studies). Publications in English, Portuguese or Spanish were selected, thereby excluding 44 articles because of language. Also, 178 articles were excluded because they evaluated different outcomes or exposures than the scope of the review, resulting in 88 potentially relevant articles. After detailed reading, another 36 articles that did not cover the relevant outcomes or exposures were excluded. Finally, 52 articles that studied the association between maternal daily physical activity and low birth weight, preterm birth, or intrauterine growth restriction were selected for review and methodological analysis.

These 52 articles were evaluated according to the criteria proposed by Downs & Black,<sup>17</sup> through scoring of methodological quality. The authors’ proposed scoring system is composed of 27 questions regarding the clarity of the article’s writing, external validity, internal validity (presence of bias), control of confounding factors, and statistical power for detecting important clinical effects. The tool was adapted as described in a systematic review by Monteiro & Victora.<sup>48</sup> The adaptation was necessary because the criteria were originally designed for the evaluation of clinical trials; therefore, four questions only applicable to clinical trials were excluded. The question about statistical power was also modified to have a minimum statistical power of 80% for detecting outcomes. Each question was scored 0 or 1 (except question 5, which could receive up to two points). Therefore, each article could receive up to 24 points. Two evaluators scored the articles in a confidential and independent way. Later, the scoring was compared until obtaining a consensus.

## RESULTS

### Methodological aspects

The most common methodological deficiencies in the studies were the lack of information on statistical power and the non-blinding of subjects and interviewers.<sup>a</sup> Additionally, other methodological problems detected were: failing to consider lost cases in the results or discussion sections and the use of a non-representative sample.

The mean methodological score of the 52 articles was 16.9 points (SD=3.4). The following studies were not included because they were considered inadequate: 11 studies<sup>1,3,4,13,18,30,34,36,45,56,57</sup> with lower methodological scores (under 16) had greater deficiencies in regards to (internal and external) validity and statistical analysis; another 11 studies,<sup>15,25,29,33,39,41,49,50,52,65,69</sup> due to how physical activity was measured, even though they had scores greater than 16; and seven studies<sup>5,10,12,22,24,32,67</sup> because the measured outcome variables were not consistent with the study's objectives.

The principal characteristics of the studies evaluated (n=23) are presented in the Table. Among the studies with acceptable measures for exposure and for outcomes, the mean score was 18.6 (SD=1.5), with all studies scoring 17 or higher.

Only one study<sup>51</sup> did not utilize a questionnaire, opting instead for these three tools to estimate physical activity: accelerometer (a sensor of movement), heart rate monitor and recall. Only one study<sup>55</sup> discussed the procedures used in developing and validating and in designing the scoring system for, the questionnaire on daily physical activity. Other studies,<sup>2,31,46,60,64</sup> despite not using questionnaires specific to pregnant women, showed care in defining the indicators for each type of physical activity, as well as in systematizing and simplifying the questionnaire to promote ease of understanding by pregnant women.

The search for one indicator to classify physical activity was based on different criteria. The studies on occupational and household activity utilized questions about the activity's characteristics, such as carrying weight, standing, and performing other difficult postures (bending, crouching, lifting the arms above the shoulders). They used a scoring system<sup>21,58,59,62</sup> and used estimates of duration and/or energy expenditure<sup>44,60</sup> as a way to express the intensity of physical exertion.<sup>21,58,66</sup> The studies about leisure-time activities mainly studied the frequency, duration and type of leisure-time activity. The majority of cohort studies presented the results for each trimester. Only five studies<sup>8,11,23,43,62</sup>

did not describe the gestational period for exposure, and another four studies restricted the measurement of exposure to the first<sup>21,58</sup> or third trimester.<sup>60,68</sup>

Birth weight was presented continuously and categorically. The majority used a dichotomous categorization, identifying newborns with low birth weight (<2,500 g). Also, the duration of gestation was generally presented in a dichotomous fashion: full-term or preterm (<37 weeks). The gestational age was obtained from the date of last menstrual period (LMP), ultrasound and clinical evaluation.<sup>9</sup>

### Effects of physical activity on gestational outcomes

In the majority of the studies from 1993-2008, an association was found between occupational activity and outcomes. When analyzing birth weight in a continuous manner, Hatch et al<sup>26</sup> found a reduction of 351 g (95% CI: -686;-17) in newborns from women, who worked more than 40 hours per week with high exertion scores (standing, walking and carrying objects). Escribá-Agüir et al<sup>21</sup> also found a greater risk of preterm birth for women, who carried over 5 kg in occupational activities (OR= 1.73, 95% CI: 1.17;2.57). Rabkin et al,<sup>54</sup> though, when analyzing the combination of occupational and household activities, did not confirm this tendency after adjusting for confounding factors. Saurel-Cubizolles & Kaminski<sup>58</sup> found a positive association between strenuous work conditions and low birth weight (prevalence equaled 4.5% in the absence of the adverse condition and 8.5% in the presence of three or more adverse conditions). In the case of preterm birth, these same situations corresponded to prevalence of 4.0% and of 8.2%, respectively. Spinillo et al<sup>62</sup> analyzed intrauterine growth restriction and found a risk in moderately vigorous physical exertion at work in healthy pregnant women (adjusted OR=2.54, 95% CI: 1.43;4.50).

While studying work conditions, Fortier et al<sup>23</sup> and Cerón-Mirelles et al<sup>11</sup> found an association between infants being born small for gestational age and mothers standing for more than six hours per day, with odds ratio greater than 1.42 (95% CI: 1.02;1.95). Henriksen et al<sup>31</sup> also showed harmful effects from women exposed to uninterrupted standing, with birth weight lower by 113 g (IC 95%: -263;0). Takito et al<sup>64</sup> analyzed inadequate birth weight and the combination of daily activities that require standing for more than 2.5 hours per day and found a risk equal to 3.23 (95% CI: 1.30;7.99).

Wergeland et al,<sup>68</sup> in turn, verified a risk of low birth weight equal to 4.0 (95% CI: 1.5;10.1), in women who carried weight (10-20kg) several times per day. A similar result was obtained by Tuntiseranee et al,<sup>66</sup> who also identified increased risks of low birth weight when

<sup>a</sup> The table with the classification of the studies, according to the criteria from Downs & Black, is available for review in the online version of this article, at [www.scielo.br/rsp](http://www.scielo.br/rsp)

**Table.** Characteristics of the analyzed studies in regards to origin, design, domain and outcome of physical activity, and methodological quality.

Author/Year/Country	Design (n)	Domain of physical activity	Outcome	Results	Score <sup>a</sup>
Alderman et al <sup>2</sup> 1998 USA	Retrospective(291)	Daily	LGA, SGA PTB	Higher score of physical activity NS	17
Campbell & Mottola <sup>8</sup> 2001 Canada	Case-control (529)	Leisure-time	SGA	Exercise in the third trimester – greater risk: Less than 3 and 5 times per week	17
Cerón-Mireles et al <sup>11</sup> 1996 Mexico	Prospective (2623)	Occupational	SGA PTB	Higher risk of SGA when standing more than 7 hours per day PTB NS	19
Dwarkanath <sup>19</sup> 2007 India	Prospective (546)	Daily (occupational, household, sedentary, exercise, leisure-time & rest)	BW GA	Higher third of physical activity related to lower third BW after adjusting for maternal education = NS	18
Escribá-Agüir et al <sup>21</sup> 2001 Spain	Case-control (576)	Occupational and commuting	PTB	Higher risk of PTB for greater occupational scores Carrying weight (+5kg) risk of preterm birth (22 -32 weeks)	17
Fortier et al <sup>23</sup> 1995 Canada	Retrospective (4390)	Occupational	SGA	SGA: greater risk from working 6 or more hours per day PTB: NS	23
Hatch et al <sup>28</sup> 1993 USA	Prospective (462)	Leisure-time/Household	PTB	Higher BW with low-moderate intensity exercises and vigorous intensity exercises compared with not exercising	19
Hatch et al <sup>26</sup> 1997 USA	Prospective (717)	Leisure-time	BW	Lower BW: work less than 40 hours (1st trimester) and higher score (standing/walking/carrying objects); Inadequate birth weight (<3000g) NS BWNS	17
Hatch et al <sup>27</sup> 1998 USA	Prospective (557)	Occupational	BW PTB	Low-moderate exercise=NS Vigorous exercise: protection, with increased protection against preterm birth.	19
Henriksen et al <sup>31</sup> 1995 Denmark	Prospective (4249)	Leisure-time	BW	Higher birth weight: walking (2-5hr/day) Lower birth weight: exposure to uninterrupted standing	19
Magann et al <sup>44</sup> 2002 Australia	Prospective (750)	Exercício	BW PTB IUGR	Lower BW with vigorous and mandatory exercise PTB and IUGR NS	19
Magann et al <sup>43</sup> 1996 Australia	Prospective (2743)	Occupational Leisure-time	BW PTB IUGR	BW and PTB: higher risk associated with lower energy expenditure RCIU NS	17
Misra et al <sup>46</sup> 1998 USA	Prospective (719) and Retrospective (469)	Occupational Household Leisure-time Rest	PTB	Higher risk of PTB: Climbing stairs, commuting activity and watching television (>42hr/week) Lower risk of PTB: Leisure-time (number of days) Occupational: NS; sleep NS	18
Perkins et al <sup>51</sup> 2007 USA	Prospective (51)	Daily	PN CF	Physical activity inversely related with fetal growth GA S	19

To be continued

Table continuation

Author/Year/Country	Design (n)	Domain of physical activity	Outcome	Results	Score <sup>a</sup>
Rabkin et al <sup>54</sup> 1990 England	Prospective (1507)	Occupational and household	BW GA	BW NS GA NS	18
Rao et al <sup>55</sup> 2003 India	Prospective (797)	Daily Rest Household and other activities (farm work)	PTB BW	PTB: NS Physical activity score, household activity and difficult activities inversely associated with BW Farm work: higher risk of LBW	21
Saurel-Cubizolles & Kaminski <sup>56</sup> 1987 France	Retrospective (2387)	Occupational	LBW PTB	Three or more adverse conditions at work associated with a higher frequency of LBW and PTB	18
Saurel-Cubizolles & Kaminski <sup>59</sup> 1991 France	Retrospective (875)	Occupational	PTB	PTB associated with less qualified occupations, in this study the work conditions lose significance because there is a greater prevalence of adverse conditions in the work groups with lower qualifications	18
Schramm et al <sup>60</sup> 1996 USA	Case-control (2378)	Leisure-time (exercise) Occupational & household activities	LBW VLBW	Exercising at least 3 times per week: protection against LBW Carrying for pre-school children: protection against VLBW and LBW	19
Spinillo et al <sup>62</sup> 1996 Italy	Case-control (1047)	Occupational	IUGR	Working in health services, manual labor and moderate-vigorous strain associated with increased risk of IUGR	21
Takito et al <sup>64</sup> 2005 Brazil	Prospective (152)	Occupational, Household, Leisure-time, and Commuting	IBW	Protection from walking up to 50 min/day Elevated risk with remaining standing, specifically while washing clothes	18
Tuntiseranee et al <sup>66</sup> 1998 Thailand	Prospective (1797)	Occupational	LBW SGA PTB	Elevated risk of LBW from carrying weight, mainly at the height of the thorax Increased risk of SGA from crouching for more than 5 hours per day and walking more than 30 minutes per day Risk of PTB only for walking fast Household activities NS	19
Wergeland et al <sup>68</sup> 1998 Norway	Retrospective (5388)	Occupational	LBW	Higher risk of LBW associated with carrying weight and housewives Walking and standing for more than half the day increases risk Working for 35 or more hours per day and working bent over reduces average birth weight Physical activity score NS	19

<sup>a</sup> Score for methodological quality proposed by Downs & Black.<sup>17</sup>

BW: Birth weight (continuous variable)

IBW: Inadequate birth weight (<3000 g)

LBW: Low birth weight (<2500g)

VLBW: Very Low birth weight (<1500g)

GA: Gestational age

SGA: Small for gestational age (varying cut off points between 10 and 15 percent)

LGA: Large for gestational age (above the 90 percentile)

FC: Fetal growth, expressed by the relation between birth weight and gestational age according to the standard curve

PTB: Preterm birth (GA < 37 weeks)

IUGR: Intrauterine growth restriction (< 10 percentile)

NS: No significance



carrying weight, from OR of 2.5 (95% CI: 1.1;5.9) to 3.5 (95% CI: 1.4;8.3), when considering the position of the weight in relation to the height of the thorax. They found an increased chance of growth restriction associated with a squatting posture (OR=8.7, 95% CI: 3.1;24.2). The negative association between the duration of physically burdensome occupational tasks and gestational age is confirmed in other studies.<sup>21,58,59</sup> In a case-control study, Escribá-Aguir et al<sup>21</sup> concluded that the greater the score of occupational activities, the greater the risk of preterm birth. For preterm birth at 22-32 weeks, a medium score had OR= 1.59 (95% CI: 1.05;2.39) and a high score had OR= 2.31 (95% CI: 1.43;3.73). For preterm birth at 33-36 weeks, a medium score had OR= 1.73 (95% CI: 1.11; 2.68) and a high score had OR= 2.35 (95% CI: 1.41; 3.94). On the other hand, Magann et al<sup>43</sup> found that low birth weight (-60g,  $p=0.017$ ) and increased risk of preterm birth (OR=1.61, 95% CI: 1.15;2.26) were associated with daily energy expenditures less than 2,500 kcal.

Regarding leisure-time physical activity or physical exercise, the tendency of excessive exertion harming fetal growth was confirmed by Magann et al<sup>44</sup> in a cohort study of 750 workers of the armed forces. Birth weight was lower by 86.5 g (SD= 43.7,  $p=0.048$ ), when the mandatory and vigorous physical training exercises were maintained past 28 weeks. On the other hand, studies that analyzed the regular practice of exercise found a positive association with fetal growth. Hatch et al<sup>28</sup> detected increased birth weight in women, who exercised at low intensities, with respective weight gain of 97 g (95% CI:1-;184) and 86 g (95% CI: -1;174) in the second and third trimesters. In analyzing only women without a history of obstetric problems, the authors found an increase in birth weight of 124 g (95% CI: -6;255) with the performance of moderate exercise and 276 g (95% CI: -6;255) with vigorous physical exercise during gestation. In another study by the same authors,<sup>27</sup> the practice of vigorous exercise by the mother was a protective factor for preterm birth. Schramm et al<sup>60</sup> observed significant protection for women, who exercised at least three times per week for at least 15 minutes (first trimester: OR=0.70, 95% CI: 0.53;0.92; second trimester: OR=0.54, 95% CI: 0.4;0.74; and third trimester: OR=0.33, 95% CI: 0.20;0.53). In this study, there was also protection against low birth weight and very low birth weight among women, who cared for a child of pre-school age (OR= 0.81 and 0.74, respectively). Campbell & Mottola<sup>8</sup> conducted a case-control study on the weekly frequency of physical exercise. It involved the regular practice of physical exercise, considering intensity, volume, duration and the goal of improving physical ability. They detected increased risk of low birth weight when 401 women, without contraindications to physical activity, exercised less than three times per week (adjusted OR=2.37, 95% CI: 1.14-4.91)

and exercised five or more days per week (adjusted OR=4.54, 95% CI: 1.63;12.62), compared to those that exercised three or four days per week. Hatch et al<sup>27</sup> considered vigorous exercise in leisure-time activities that resulted in energy expenditures equal to or greater than 1,000 kcal. Previously active women, who practiced vigorous exercise, were protected against preterm birth in comparison to inactive women, with a relative risk for birth before week 36 of 0.11 (95% CI 0.02;0.81), and they also found increased protection for earlier gestational age groups (weeks 34 and 32).<sup>27</sup>

The practice of walking presented controversial results and generally includes 3 or more domains of physical activity. Henriksen et al<sup>51</sup> found a birth weight increase of 35 g (95% CI: 8;63) for the group of women, who walked (occupation and leisure-time) from two to five hours per day. Similarly, Takito et al<sup>64</sup> found a protective effect on inadequate birth weight from the practice of walking (occupational, household, commuting and leisure-time) for up to 50 minutes daily (OR=0.44, 95% CI: 0.20;0.98). On the other hand, when analyzing the frequency of walking intentionally (not necessarily leisure-time) four or more times per week, Misra et al<sup>46</sup> found a doubled risk of premature birth (OR=2.10, 95% CI: 1.38;3.20). The results remained similar, when pregnant women with some complication were excluded (OR=2.16, 95% CI: 1.31;3.57). A study by Tuntiseranee et al,<sup>66</sup> observing only the occupational domain, analyzed fast walking and found an increased risk of preterm birth, with OR= 2.4 (95% CI: 1.0;5.7), and of low weight for gestational age, with OR= 4.9 (IC 95%: 1.0;23.4)

In a prospective study involving the diverse domains of daily physical activity, Perkins et al<sup>51</sup> found a negative association between energy expenditure in relation to birth weight adjusted for gestational age ( $r: -0.43$ ,  $p < 0.02$ ). When analyzing quartiles of physical activity, they found an average lower birth weight of 203 g for the quartile with most physical activity.<sup>51</sup> Analogously, in the study by Rao et al<sup>55</sup> the daily activities of Indian women in rural zones (predominantly household activities) were inversely associated with birth weight (i.e. not performing strenuous activities increased birth weight by 112g). Typical physical activities in rural areas, like carrying water from the well to the residence, increased the risk of low birth weight when performed both in the 18<sup>th</sup> and the 28<sup>th</sup> gestational weeks, with respective OR=1.93 (95% CI: 1.47;2.39) and OR= 1.63 (95% CI: 1.21;2.05). Dwarkanath et al<sup>19</sup> analyzed the different domains of physical activity and found that women in the top third for physical activity, when compared to women from the lowest third for physical activity, showed a risk 1.58 times greater (95% CI: 1.02;2.44) of having a newborn in the bottom third for birth weight.

Among the studies that analyzed the diverse domains of daily physical activities, Misra et al<sup>46</sup> found an increased risk of preterm birth for both more vigorous activities, like climbing stairs more than ten times per day, with OR=1.6 (95% CI: 1.05;2.46), and for less active women, who watched television for more than 42 hours per week, with OR=3.06 (95% CI: 1.74;5.40). In women without obstetric complications, the results for climbing stairs and for watching television persisted, with respective OR=2.04 (95% CI: 1.23;3.36) and OR=2.73 (95% CI: 1.40;5.33).

## DISCUSSION

The use of the criteria proposed by Downs & Black<sup>17</sup> to methodologically evaluate the reviewed articles allowed for greater objectivity and homogeneity. These characteristics are necessary to adequately compare heterogeneous articles, especially in regards to their methodological design, sample size, measures of exposure, definitions of outcomes, statistical analysis, and the control of potential confounding variables. The clear and adequate description of methods should be improved, especially in regards to the measures of exposure and outcomes, since the lack of this information caused a large number of articles to be rejected.

The oldest articles selected, published in the 1980s, are focused on the occupational dimension.<sup>58,69</sup> In the middle of the 1990s studies appeared that also tried to analyze other domains of physical activity, such as leisure-time activities, exercises, household activities and commuting activities. Even then, the main focus remained on the occupational dimension. Among the analyzed articles from the current decade, analyses were still restricted to occupational activities<sup>5,15,21,24</sup> or solely to the physical activities of recreation or physical exercise.<sup>8,33,41,44</sup>

In developed countries, there are a greater number of studies related to the regular practice of physical activity (exercise). In developing countries, the lower involvement of women in the practice of exercise leads attention to occupational and domestic activities, whose physical and psychological tolls are specific to each country or region, which makes methodological comparisons more difficult. Socioeconomic status is associated as much with the outcomes studies as with the exposure variables, since women exposed to higher levels of physical work (occupational and household) are generally those in worse social conditions. Control for these variables was done in only some studies; however, this issue is minimized in the majority of studies because they involve homogenous samples and identify important associations at a population-level between physical activity and the outcomes. This can directly influence the undesirable outcome (preterm birth or low birth weight), due to the potential bias.

Twelve studies<sup>2,19,23,27,31,43,46,51,55,60,64,67</sup> measured different domains of daily physical activity by pregnant women: occupational, household, leisure-time and commuting.

The exposure variables are a potential source of measurement bias. The majority of studies utilized interviews or self-completion questionnaires, without adequate verification for their validity. Despite this, the study by Rao et al,<sup>55</sup> which received a high score for methodological quality, included a description of the questionnaire design and presented the results for its validation. Perkins et al,<sup>51</sup> in turn, seeking to accurately measure daily physical activity, monitored physical activity by means of a heart rate monitor, an accelerometer and recall of physical activity.

The majority of studies that analyzed the two domains of physical activity, confirm the harmful effects of excessive physical exertion at work on gestational outcomes, such as birth weight,<sup>26,58,66,68</sup> gestational age<sup>21,58,59</sup> or fetal growth.<sup>11,23,62,66</sup> The only exception was the study by Rabkin et al,<sup>54</sup> which analyzed occupational and household activity.

In regards to leisure-time physical activity, the studies that analyze the intensity of physical exercise showed different effects. Magann et al<sup>44</sup> found that vigorous exercise during pregnancy was associated with lower birth weight. Various studies found that physical activity at low/moderate intensity had a protective effect upon low birth weight.<sup>28</sup> A similar effect was observed in relation to preterm birth and activities of vigorous intensity.<sup>27</sup> These results are supported by the physiological aspects related to vigorous exercise/physical exertion during pregnancy, which point to the occurrence of compensatory mechanisms parallel to the reduction of intrauterine blood flow, such as the reduction of partial pressure oxygen and modest reductions in fetal pH (while recovering from exercise).<sup>28</sup> In regards to the protective effect for the fetus, concentrations of maternal and fetal hemoglobin increase, which raises the capacity for oxygen transport and diffusion, maintaining the oxygen supply to the fetus. Despite this, the maintenance of high intensity exercise for a prolonged period of time, increasing even body temperature, can suppress these mechanisms,<sup>14</sup> as shown in a result obtained by Magann et al.<sup>44</sup> Even though Campbell & Mottola<sup>8</sup> did not measure the intensity of physical exercise, their results support the contraindication of excessive physical exercise at a frequency greater than five days a week. Their study concomitantly found an equally harmful effect on fetal growth in the group of women who exercised little.<sup>8,60</sup> Along the same lines, Magann et al<sup>43</sup> found that less energy expenditure, at work and during leisure-time, was associated with an increased risk of preterm birth and low birth weight.

These results were supported by the studies analyzing more dimensions of daily physical activity, as higher

scores/indices of daily physical activity were inversely associated with fetal growth<sup>44</sup> and birth weight.<sup>55</sup> The cohort study by Misra et al<sup>46</sup> detected an important change from occupational activity, sleep, and climbing stairs, during the first two trimesters, and a small change from sedentary activities and leisure-time exercise. In a group of pregnant women, both vigorous activities, like climbing stairs for long periods, and physical inactivity, such as watching television in excess, are risk factors for preterm birth.<sup>46</sup>

When measuring daily physical activity in pregnancy, it is necessary to include the different domains (occupational, household, leisure-time and commuting) to adequately appreciate their influence upon outcomes. It is worth noting the absence of questionnaires that include household activities and are adapted for use in Brazil. Socioeconomic and cultural differences restrict the usage of recently published questionnaires on physical activity during pregnancy because they were created in developed countries and deal with physical activity and recreational sports, which are rarely practiced by women of low socioeconomic level, who are predominantly occupied with household physical activities.<sup>35,59,62,66,68</sup>

Even though the studies analyzed are often limited by the quality of their measure of exposure, such as the segmented analyses of physical activity and the differences regarding how exposure was classified, these studies support the hypothesis of a U-shaped curve, in which both excessive and insufficient physical activity are associated with increased risk of unfavorable pregnancy outcomes. It is plausible to suppose that physical activity, done at an appropriate level for the physical condition of the woman, is beneficial to fetal growth, with the extremes being inactivity/sedentarism and prolonged duration of vigorous intensities, which are potentially harmful to the supply of necessities for adequate fetal growth.

Therefore, it is important to perform intervention studies that intend to test this hypothesis and attempt to identify the most appropriate levels for intensity, duration and frequency of physical exercise during pregnancy. Studies should consider the four domains of daily physical activity and utilize tools that reliably measure exposure variables. Such studies would provide valuable information for recommendations about physical activity during pregnancy.

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