Physical activity during pregnancy and maternal-child health outcomes: a systematic literature review

Atividade física na gestação e desfechos da saúde materno-infantil: uma revisão sistemática da literatura

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Abstract

A systematic literature review was conducted to investigate the effects of physical activity during pregnancy on selected maternal-child health outcomes. The search included articles published from 1980 to 2005 in the MEDLINE and LILACS databases using key words such as physical activity, physical exercise, pregnancy, *and* gestation. *The methodological quality of 37 selected articles was evaluated. It appears to be a consensus that some light-to-moderate physical activity is not a risk factor and may even be considered a protective factor for some outcomes. However, some studies found an association between specific activities (e.g., climbing stairs or standing for long periods) and inadequate birth weight, prematurity, and miscarriage. Few studies found an association between physical activity and maternal weight gain, mode of delivery, or fetal development. Further research is needed to fill these gaps and provide guidelines on the intensity, duration, and frequency of physical activity during pregnancy.*

Motor Activity; Exercise; Pregnancy; Review

Introduction

Evidence from scientific studies points to the important role of physical activity in health promotion and quality of life and the prevention and control of various diseases [1]. However, for individuals in specific physiological conditions, such benefits may not always occur, or are valid with certain restrictions.

Until a few decades ago, pregnant women were advised to reduce their activities and even interrupt their occupational work, especially in the final stage of pregnancy [1]. However, since the 1990s experts have admitted the positive effect of regular physical activity during gestation and have even encouraged it, as long as the woman does not present specific adverse conditions [2].

In fact, there appears to be a consensus that maintaining light to moderate physical activity during an uncomplicated pregnancy provides various benefits for the woman's health [3]. This is explained by the fact that physical activity causes a thermal response and circulatory redistribution, shifting the blood concentration from the uterus and placenta to the extremities. This process helps reduce and prevent lower back pain, fosters lower liquid retention, reduces cardiovascular stress, increases the oxygenation capacity, decreases blood pressure, reduces the risk of gestational diabetes, prevents thromboses and varicose veins, and helps control gestational weight gain [4,5,6].

The advantages also include emotional aspects, since physical activity helps make the pregnant woman more self-confident and satisfied with her appearance, in addition to raising her self-esteem, thus reducing the risks of postpartum depression [1,3].

However, physical activity during pregnancy still raises some controversy. According to Gallup [7], the published studies and guidelines on physical activity during pregnancy are insufficient. According to Morris & Johnson [8], although limited, the literature suggests that practicing moderate exercise during a pregnancy with no additional risks does not lead to undesirable outcomes for either the mother or the fetus. These authors go on to contend that more studies are necessary.

In addition, the benefits of physical activity during pregnancy do not appear to be widely publicized, and some consider the theme a taboo. Many women believe that the physiological limitations posed by pregnancy prevent them from participating in programs that promote regular exercise [9]. Others believe that to remain rested and relaxed during pregnancy is significantly more important than exercising or maintaining an active lifestyle [10].

Considering the persistent controversies on the theme, the current study aims to conduct a systematic review of the scientific articles on the association between physical activity during pregnancy and the occurrence of maternal-child health outcomes. The review focused specifically on two aspects of pregnant women's physical activity: occupational physical activities and leisure-time physical activities. The former include activities pertaining to the individual's occupation (paid or unpaid), i.e., all activities performed in their place of work, including housework. Leisure-time physical activities include activities performed with the purpose of health promotion or simply for leisure.

Methods

The search was conducted in July 2006, and the articles were identified through a literature search of the MEDLINE and LILACS databases, using the following key words: (*physical activity OR physical exercise*) *AND* (*pregnancy OR gestation*). As the inclusion criteria, the articles had to have been published from 1980 to 2005, in Portuguese, English, or Spanish, and refer to cross-sectional, case-control, or follow-up (cohort) epidemiological studies. The principal outcomes of the studies had to be preeclampsia; gestational arterial hypertension; gestational diabetes mellitus; gestational weight gain; miscarriage; mode of delivery; fetal growth or development; birth weight; length at birth; or prematurity.

The search process initially involved a survey of the references based on the key words, which located 3,313 articles. These references were then sifted using some of the inclusion criteria as search filters: articles with an available abstract (2,703); published from 1980 to 2005 (2,488); with a sample consisting of humans (1,269); females (1,178); and published in English, Portuguese, or Spanish (1,085).

The second stage of the process consisted of reading the remaining 1,085 abstracts, based on which the other inclusion criteria (study design and target outcomes) were verified. After excluding review articles, articles on studies with an experimental design, and those that did not aim to study any of the selected mother-child outcomes, 39 studies were identified as adequate for inclusion in the present study. It was not possible to obtain access to two of these articles, so the final total was 37 studies. Figure 1, based on the proposal of the International Committee of Medical Journal Editors [11], presents a flowchart with a brief demonstration of all the stages in the article selection process for the present review.

To conduct an appraisal of the studies' methodological quality, each of the selected articles received a score, according to the criteria proposed by Downs & Black [12]. The original checklist was adapted, ruling out the criteria related exclusively to intervention studies. Nineteen items were thus evaluated, allowing a maximum score of 20 points. Table 1 shows the items actually evaluated.

The studies were evaluated independently by two of the authors of the present review (E. B. S. and M. M. S.). The concordance in the scores assigned by the evaluators was also assessed using the Intra-Class Correlation Coefficient (ICC). The result was classified according to the scale proposed by Shrout [13] to measure concordance between different evaluation methods. This scale consists of five categories: virtually no concordance (< 0.1); weak (0.11-0.40); reasonable (0.41-0.60); moderate (0.61-0.80); and substantial (0.81-1.0). To rule on possible discordances in assigning scores to the articles, a third author (G. K.) was consulted.

The studies were organized according to the following: year of publication; country of origin; language; study design (cohort, case-control, cross-sectional); physical activity measurement instrument; sample size; maternal-child health outcomes; age of individuals studied (years); results; estimators used in the analysis and scoring of the methodological quality.

Finally, the studies were grouped that found similar results as to a given outcome, with the objective of systematizing and facilitating the understanding of all the reviewed articles' findings. Next, the mean of the scores assigned to the studies included in each group was calculated. No articles were rejected because of methodological limitations, but the findings were considered more consistent in the studies that received higher scores.

Results

As shown in Table 2, the largest concentration of published articles (20) was in the 1990s. However, there was also an upward trend in publications on the subject, given that 11 studies were published in the first five years of the current decade. The majority of the studies were from the United States, and the only one conducted in Brazil [14] was also the only one not published in English.

Among the observational studies that evaluated possible associations between physical activity and maternal-child health outcomes, those with a prospective cohort design were the most common. Questionnaires were the most widely used instruments, reinforcing this as the most feasible option for measuring physical activity in epidemiological studies [15]. The sample sizes varied from 67 to 21,342.

Table 3 shows that of the 37 articles reviewed, 15 used birth weight as the dependent variable, making this the most widely studied outcome. Among the articles that informed the participants' age (26), only five reported having included pregnant women younger than 18 years in their sample.

The mean methodological quality score was 15.8 points, with 9 and 20 points as the minimum and maximum obtained, respectively. The result of the comparison between the scores assigned to the studies by the different evaluators (ICC = 0.898; 95%CI: 0.835-0.961) indicates a high level of concordance, having been classified as the highest (substantial concordance) in the qualification scale used.

Table 4 provides a synthesis of the principal results of the current review. Physical activity does in fact appear to reduce the risk of preeclampsia and gestational diabetes. The results were conflicting for other outcomes, like miscarriage and gestational weight gain control. The same was true for the fetal and childhood outcomes. Some studies do not describe a harmful association between physical activity in pregnancy and inadequate weight gain or prematurity, however some specific activities, like climbing stairs or working

Figure 1

Flowchart for article selection.

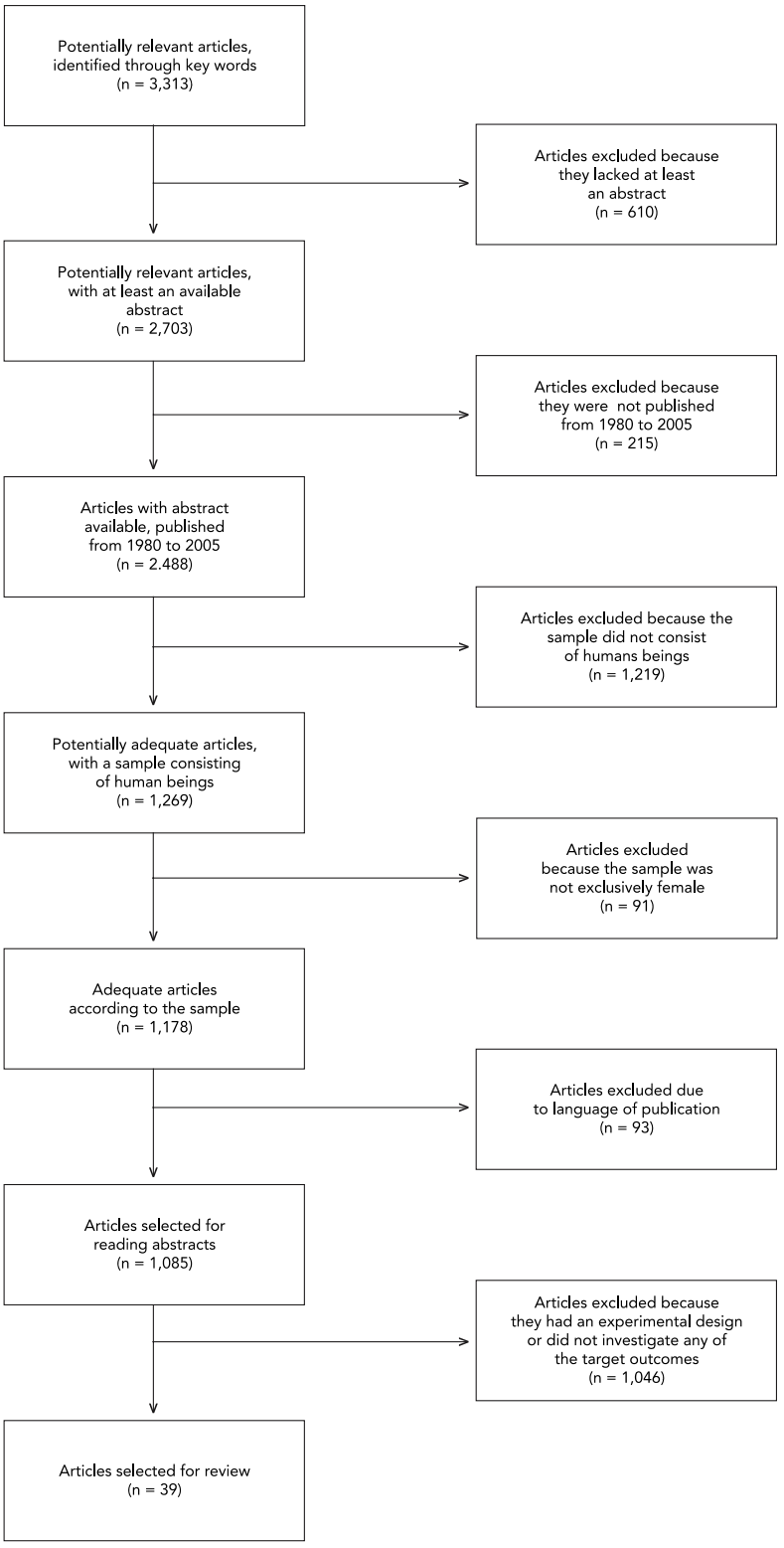

Table 1

Downs & Black criteria [12] used in the methodological evaluation of the articles.

	Criteria
1.	Clarity in the description of the study hypothesis or objective(s)
2.	Definition of the target outcomes in the introduction or methods section
3.	Description of the characteristics of the individuals included in the study
4.	Description of principal confounders
5.	Clarity in the description of the study's principal findings
6.	Information on random data variability for the principal results
7.	Description of characteristics of individuals lost to follow-up
8.	Information on the real probability values for the principal results
9.	Representativeness of planned sample
10.	Representativeness of sample of individuals included in study
11.	Clarity in the description of results not based on a priori hypotheses
12.	Adjustment of analyses for different lengths of follow-up
13.	Adequacy of statistical tests used to evaluate the principal results
14.	Accuracy of the instruments used to measure the principal outcomes
15.	Comparability among individuals from different groups
16.	Equal recruitment periods for individuals from different groups
17.	Inclusion of adjustment for principal confounders in the analysis
18.	Consideration of losses to follow-up
19.	Study power sufficient to detect an important effect, with a 5% significance level

All items scored 0 or 1, except for description of principal confounders, scored 0, 1, or 2.

for extended time on one's feet were identified as risk factors for these outcomes.

Few studies were identified on the effects of physical activity during pregnancy on fetal growth or development, length at birth, and mode of delivery.

Discussion

The production of scientific material on physical activity in pregnancy and its effects on maternal-child health outcomes has increased substantially, mainly in the last decade. According to some authors [3,8,16,17], light-to-moderate exercise also provides health benefits during pregnancy, so women should be encouraged to maintain an active lifestyle during gestation. The results of some of the reviewed articles corroborate the opinion of these authors.

Considering both light and moderate leisure-time and occupational physical activities, physically active pregnant women show a decreased risk of developing preeclampsia [18,19,20], hypertension [18,20], and gestational diabetes mellitus [21,22,23]. However, in relation to the other maternal outcomes, the results tend to be conflicting. Four studies analyzed leisure-time physical activity in relation to miscarriage [24,25,26,27], and their results did not indicate an increased risk of this outcome among physically active pregnant women. Importantly, however, the studies that pointed to high-intensity occupational activity as a risk factor for miscarriage [28,29] were precisely those that showed greater methodological care, among other reasons because they based their conclusions on stratified analyses rather than crude data.

In a recent study [30], physical activity was identified as one of three behavioral determinants for gestational weight gain control. However, the studies reviewed here did not agree as to the hypothesis of greater control of weight gain among pregnant women who exercise regularly. Five of the articles reviewed [27,31,32,33,34] studied this relationship, and three of them [27,32,33] did not support the hypothesis. However, the three were precisely the ones with the lowest methodological quality scores or which failed to report the method used to evaluate this outcome.

Only four articles evaluated the effect of physical activity on mode of delivery, of which three [27,32,33] failed to show significant differences between caesarian rates in women with and without exercise during pregnancy. Only one study [39] showed an association between physical activity and mode of delivery, suggesting a considerably increased risk of caesarian among sedentary pregnant women.

As for fetal and childhood outcomes, the results also failed to show a consensus, but once again light or moderate physical exercise was not identified as a risk factor. As for birth weight, numerous studies [25,32,33,36,37,38,39,40,41,42] showed that there is no increased risk of low birth weight for pregnant women who practice leisure-time physical activities.

Among the studies that analyzed physical activity as a predictive factor for low birth weight, some [27,34,43] showed a subtle association, but the mean weight of the newborns was not inadequate in any of the groups studied. However, other studies [42,44] identified some specific activities (e.g., doing laundry on standing on one's feet for hours on end), but not regular physical activity in general, as risk factors for inadequate birth weight.

The same was observed in studies in which the principal outcome was gestational age at delivery. Numerous articles either found no association or reported a protective effect for physical activity during pregnancy in relation to premature birth [27,32,33,34,36,40,42,45,46,47]. Again, some specific activities, like climbing stairs and occupational activities that require standing for prolonged periods or cause fatigue and require

Table 2

Year, country of origin, language, design, instrument for measuring physical activity, and sample size of selected studies on physical activity in pregnancy and maternal-child health outcomes, 1980-2005.

Author	Year	Country	Language	Design	Instrument	Sample
Jarrett & Sppelacy [36]	1983	USA	English	Cohort	Questionnaire	67
Berkowitz et al. [45]	1983	USA	English	Case-control	Questionnaire	175 */313 **
Marcoux et al. [18]	1989	Canada	English	Case-control	Questionnaire	172 */254 */505 **
Clapp et al. [24]	1989	USA	English	Cohort	PEC	49 */ 41 */29 **
Rabkin et al. [37]	1990	UK	English	Cohort	Questionnaire	1,507
Klebanoff et al. [25]	1990	USA	English	Cohort	Questionnaire	7,101
Rose et al. [38]	1991	USA	English	Cohort	Questionnaire	21.342
Hatch et al. [39]	1993	USA	English	Cohort	Questionnaire	462
Florack et al. [28]	1993	Netherlands	English	Cohort	Questionnaire	170
Bell et al. [43]	1995	Australia	English	Cohort	Questionnaire	58 */41 **
Clapp & Little [31]	1995	USA	English	Cohort	CM	79
Henriksen et al. [48]	1995	Denmark	English	Cohort	Questionnaire	4,259
Koemeester et al. [49]	1995	Netherlands	English	Cohort	Questionnaire	116
Sternfeld et al. [32]	1995	USA	English	Cohort	Questionnaire	388
Florack et al. [40]	1995	Netherlands	English	Cohort	Questionnaire	128
Henriksen et al. [44]	1995	Denmark	English	Cohort	Questionnaire	4,249
Spinillo et al. [58]	1995	Italy	English	Case-control	Questionnaire	160 */320 **
Horns et al. [33]	1996	USA	English	Cohort	Questionnaire	48 */53 **
Schramm et al. [41]	1996	USA	English	Case-control	Questionnaire	450 */782 **/802 */794 **
Spinillo et al. [50]	1996	Italy	English	Case-control	Questionnaire	349 */698 **
Dye et al. [21]	1997	USA	English	Cross-sectional	Questionnaire	12,799
Misra et al. [46]	1998	USA	English	Cohort	Questionnaire	1,172
Hatch et al. [47]	1998	USA	English	Cohort	Questionnaire	325 */232 **
Alderman et al. [52]	1998	USA	English	Case-control	Questionnaire	22 */37 */232 **
Latka et al. [26]	1999	USA	English	Case-control	Questionnaire	173 */173 **
Bungun et al. [35]	2000	USA	English	Cohort	Questionnaire	137
Campbell & Mottola [59]	2001	Canada	English	Case-control	Questionnaire	164 */365 **
El Metwalli et al. [29]	2001	Egypt	English	Case-control	Questionnaire	562 */1,200 **
Magann et al. [27]	2002	USA	English	Cohort	Questionnaire	750
Carmichael et al. [51]	2002	USA	English	Case-control	Questionnaire	414 */417 **
Leiferman & Evenson [42]	2003	USA	English	Cross-sectional	Questionnaire	9,089
Rao et al. [34]	2003	India	English	Cohort	Questionnaire	797
Sorensen et al. [19]	2003	USA	English	Case-control	Questionnaire	201 */383 **
Dempsey et al. [22]	2004	USA	English	Cohort	Questionnaire	909
Saftlas et al. [20]	2004	USA	English	Cohort	Questionnaire	44 */172 */2,422 **
Dempsey et al. [23]	2004	USA	English	Case-control	Questionnaire	155 */386 **
Takito et al. [14]	2005	Brazil	Portuguese	Cohort	Questionnaire	152

PEC: portable electrocardiography; CM: cardiac monitor.

* Group of cases;

** Group of controls.

agility, were identified as risk factors for premature birth [25,48,49].

Little is known about the effects of physical activity on fetal development. Only two studies with this focus were identified, one with the objective of evaluating the effects of occupational activities on intrauterine growth retardation [50] and the other on leisure-time physical activities and the occurrence of neural tube defects [51]. Apparently, light occupational activities do not cause problems with the fetal growth rate, but the same was not reported for women who maintained moderate or high-intensity activities. According to the authors of the second

Table 3

Principal outcomes, participants' age, principal results, and estimators of methodological score for selected studies on physical activity in pregnancy and maternal-child health outcomes, 1980-2005.

Author	Outcomes	Age (years) *	Results	Estimators	Score **
Jarrett & Spellacy [36]	Birth weight; prematurity	24-36 30±0.4	No statistically significant correlation between leisure-time physical activity (total km run) during either pregnancy as a whole, or in the third trimester only, and birth weight (r = 0.089 and r = 0.145, respectively; p not significant for either). Leisure-time physical activity during pregnancy also failed to show a statistically significant correlation with gestational age at delivery (r = 0.060; p not significant). No report on method used to estimate gestational age. Sample included premature newborns.	Mean correlation	11
Berkowitz et al. [45]	Prematurity	NR	Women who maintained their occupational physical activities during pregnancy showed lower risk (OR = 0.68; 95%CI: 0.46-1.01) of having premature newborns. The same was true for women who practiced leisure-time physical activity during the year prior to pregnancy (OR = 0.67; 95%CI: 0.46-0.97) and during pregnancy (OR = 0.53; 95%CI: 0.36-0.78), as compared to women who did not practice any leisure-time physical activity. No report on method used to estimate gestational age	OR	16
Marcoux et al. [18]	Preeclampsia; gestational hypertension	26±4.8 26.2±4.3 26.2±4.2	Women with leisure-time physical activity during the first 20 weeks of pregnancy showed lower risk of preeclampsia (RR = 0.67; 95%CI: 0.46-0.96) and gestational hypertension (RR = 0.75; 95%CI: 0.54-1.05). The risk decreased as the intensity of the leisure-time physical activities increased, both for preeclampsia (RR = 1.00 [light]; 0.77 [moderate]; 0.57 [vigorous]; p = 0.01) and gestational hypertension (RR = 1.00 [light]; 0.81 [moderate]; and 0.71 [vigorous]; p = 0.08)	RR	18
Clapp et al. [24]	Miscarriage	25-38 31±3	Miscarriage rates were 17%, 18%, and 25% for pregnant women who practiced jogging, dance, and no leisure-time physical activity, respectively, but the differences were not statistically significant.	Incidence	9
Rabkin et al. [37]	Birth weight	≥ 15	No evidence that occupational or domestic physical activities in pregnant women were associated with low birth weight adjusted for gestational age. After adjusting for confounders, occupational physical activity (full-time employment) was associated with increased birth weight (12g; 95%CI: -39 to 63g). Sample did not include premature newborns.	β (linear regression)	20
Klebanoff et al. [25]	Birth weight; prematurity	≥ 16	Physical activity (occupational, domestic, and leisure-time) was not associated with birth weight after adjusting for confounders. Working on one's feet for 8 hours or longer showed a slight increase in the risk of prematurity (OR = 1.31; 95%CI: 1.01-1.71). Gestational age was estimated based on date of last menstrual period and confirmed by some clinical parameter (ultrasound or fetal heart sounds). Did not report whether the sample included premature newborns.	OR	14
Rose et al. [38]	Birth weight; miscarriage	25.6	Low birth weight rates were 4.9%, 4.3%, and 4.3% for pregnant women classified according to intensity of physical activities as light, moderate, or vigorous, respectively, but these differences were not statistically significant. The same was observed for fetal death rates (1.3%; 1.0%, and 1.3%, respectively). Did not report whether the sample included premature newborns.	Mean incidence	11
Hatch et al. [39]	Birth weight	≥ 18 27.1±4.3 27.9±4.6	Pregnant women with light or moderate leisure-time physical activity showed an increase of some 100g in birth weight (117g; 95%CI: 17-217g), compared to sedentary pregnant women. Pregnant women who reported more vigorous exercise (energy expenditure approximately 2,000kcal/week) showed an increase of some 300g in birth weight (276g; 95%CI: 54-497g). Did not report whether the sample included premature newborns.	β (linear regression)	17

(continues)

Table 3 (continued)

Author	Outcomes	Age (years) *	Results	Estimators	Score **
Florack et al. [28]	Miscarriage	18-39	The duration (in hours) and speed demanded by occupational physical activities were not associated with miscarriage. However, occupational physical activities involving high biomechanical loads were associated with increased miscarriage rate (OR = 3.1; 95%CI: 1.1-8.9).	OR	16
Bell et al. [43]	Birth weight	31.8±2.7 31.6±4.7	Mean birth weight was lower among newborns in women who practiced leisure-time physical activities more than 4 times a week (3.049kg vs. 3.364kg; $p < 0.02$), as compared to the control group. However, mean birth weight was higher among newborns of women who exercised up to 3 times a week (3.682kg vs. 3.36kg; $p < 0.01$) as compared to the control group. Incidence of low birth weight was higher in women who practiced leisure-time physical activities more than 4 times a week than in those who exercised up to 3 times (22% vs. 3%; $p = 0.03$). Sample included premature newborns.	Mean incidence	12
Clapp & Little [31]	Gestational weight gain	31±0.3	The difference between mean weight gain in the group of pregnant women who practiced leisure-time physical activity (13kg±0.5) as compared to the control group (16±0.7) was statistically significant. The correlations between the amount of exercise and gestational weight gain were weak and non-significant ($r < 0.15$ for the 15-23, 23-30, and 30-37-week intervals). Weight gain was monitored since before conception.	Mean correlation	15
Henriksen et al. [48]	Prematurity	NR	Pregnant women who did not report occupational physical activities that required standing or walking more than 4 hours showed higher odds of preterm delivery (OR = 3.3; 95%CI: 1.4-8.0) as compared to those who reported 2 hours or less. Gestational age was estimated based on ultrasound (when available), date of last menstrual period, or as recorded on the birth certificate.	OR	18
Koemeester et al. [49]	Prematurity	21-46	Daily duration (number of hours) of high-intensity occupational physical activity showed a negative and statistically significant association with age at birth ($\beta = -0.49$; $p < 0.004$). However, mean gestational length gestational (in days) was not equal to prematurity for any of the groups studied. Did not report the method used to estimate gestational age	Mean β (linear regression)	14
Sternfeld et al. [32]	Birth weight; prematurity; weight gain; mode of delivery	18-42 31.7±5.0	No statistically significant difference in mean birth weight for children of women who practiced different levels of leisure-time physical activity, before or during pregnancy (first, second, or third trimester) (largest difference observed: 121g; $p = 0.29$). Likewise, mean length of pregnancy and mean weight gain were similar between the different groups of pregnant women. The caesarean rate also did not vary according to the level of maternal physical activity. Gestational age was estimated based on the date of last menstrual period. Gestational weight gain was calculated by subtracting the weight at the first prenatal visit from weight at hospital admission for delivery, adjusted by the newborn's weight. Did not report whether the sample included premature newborns.	Mean	14
Florack et al. [40]	Prematurity; birth weight	18-39	High-intensity occupational physical activities and those causing fatigue showed the greatest effect on duration of pregnancy (minus 18 days), when the pace of activities was high. None of the aspects of the occupational activities showed a relevant influence on birth weight. Did not report the method used to estimate gestational age. Did not report whether the sample included premature newborns.	β (linear regression)	15
Henriksen et al. [44]	Birth weight	NR	Reduction (-119g; 95%CI: -230 to -8g) in mean birth weight of newborns of pregnant women who reported occupational physical activities that required standing or walking for more than 5 hours as compared to pregnant women reporting 2 hours or less. Sample included premature newborns.	β (linear regression)	19
Spinillo et al. [58]	Preeclampsia	28.4±5.4 27.7±4.4	Pregnant women with moderate or vigorous occupational physical activities were more susceptible to preeclampsia (OR = 2.08; 95%CI: 1.11-3.88) than women performing light activities.	OR	18

(continues)

Table 3 (continued)

Author	Outcomes	Age (years) *	Results	Estimators	Score **
Horns et al. [33]	Weight gain; birth weight; prematurity; mode of delivery	20-30 27.2±3.8 28.4±4.1	No statistically significant differences in mean weight gain (16.3 ± 5.26kg vs. 17.3±5.85kg; p > 0.05), birth weight (2.496±486g vs. 3.467±434g; p > 0.05), gestational age at delivery (39.9±1.4 vs. 39.2±4.3 weeks; p > 0.05), or caesarean rate (25% vs. 32%. p > 0.05) between groups of pregnant women with leisure-time physical activity and sedentary pregnant women. Did not report methods used to estimate gestational age or pre-gestational weight. Sample included premature newborns.	Mean chi-squared	11
Schramm et al. [41]	Birth weight	NR	The association between leisure-time physical activity and very low birth weight showed a downward trend during the first (OR = 0.70; 95%CI: 0.53-0.92), second (OR = 0.54; 95%CI: 0.40-0.74), and third (OR = 0.33; 95%CI: 0.20-0.53) trimesters. Sample included premature newborns.	OR	17
Spinillo et al. [50]	Fetal growth retardation	27.6±4.8 27.6±4.3	After adjusting for confounders, the risk of intrauterine growth retardation was similar for women who were unemployed versus employed at beginning of pregnancy (OR = 1.26; 95%CI: 0.86-1.83). However, risk of intrauterine growth retardation was significantly higher in pregnant women who reported moderate or vigorous occupational physical activity (OR = 2.4; 95%CI: 1.36-4.21), as compared to those reporting light activities.	OR	18
Dye et al. [21]	Gestational diabetes mellitus	NR	After stratifying for pre-gestational BMI, leisure-time physical activity was associated with a reduction in gestational diabetes mellitus only in pregnant women with BMI > 33kg/m^2 (OR = 1.9; 95%CI: 1.2-3.1)	OR	16
Misra et al. [46]	Prematurity	NR	After adjusting for confounders, the odds of preterm birth increased for pregnant women who reported climbing stairs more than 10 times a day (OR = 1.60; 95%CI: 1.05-2.46) or walking 4 or more days a week (OR = 2.10; 95%CI: 1.38-3.20) during the second trimester. However, leisure-time physical activity (60 or more days in the first and second trimesters combined) had a protective effect against preterm birth (OR = 0.51; 95%CI: 0.27-0.95). Gestational age was estimated from date of last menstrual period and confirmed by some clinical parameter (ultrasound, uterine fundal height).	OR	16
Hatch et al. [47]	Prematurity	≥ 18 27.2±4.5 27.7±4.5	No association observed between light or moderate leisure-time physical activities and duration of pregnancy. Women who practiced vigorous leisure-time physical activities showed a reduced risk (RR = 0.11; 95%CI: 0.02-0.81) of preterm delivery as compared to women who did not exercise. Gestational age was estimated based on date of last menstrual period or ultrasound, when available.	RR	17
Alderman et al. [52]	Birth length	NR	Moderate or vigorous leisure-time physical activity 2 hours a week or more in any month of pregnancy was associated with decreased risk of large-for-gestational-age newborns (OR = 0.3; 95%CI: 0.2-0.7), but was not associated significantly with risk of small-for-gestational-age newborns (OR = 0.8; 95%CI: 0.3-2.3). Sample included premature newborns.	OR	14
Latka et al. [26]	Miscarriage	30,9±4.8 32.2±5.8	Leisure-time physical activity during pregnancy was a protective factor against miscarriage (OR = 0.6; 95%CI: 0.3-0.9)	OR	15
Bungun et al. [35]	Mode of delivery	17-40 29.6±3.3 28.4±4.6	After adjusting for confounders, there was an increased risk of caesarean delivery for sedentary women (OR = 4.48; 95%CI: 1.2-16.2) as compared to those with leisure-time physical activity during pregnancy.	OR	14
Campbell & Mottola [59]	Birth weight	NR	Compared to pregnant women with leisure-time physical activity 3 to 4 times a week in the third trimester, the odds of low birth weight were higher for those who exercised twice or less (OR = 2.64; 95%CI: 1.29-5.39) and 5 times or more(OR = 4.61; 95%CI: 1.73-12.32) per week. Did not report whether the sample included premature newborns.	OR	18

(continues)

Table 3 (continued)

Author	Outcomes	Age (years) *	Results	Estimators	Score **
El Metwalli et al. [29]	Miscarriage	28.2±7.3 27.7±6.4	Intensity (OR = 3.35; 95%CI: 2.71-4.12), pace (OR = 2.24; 95%CI: 1.74-2.89), duration in hours (OR = 1.57; 95%CI: 1.25-1.97), and fatigue (OR = 2.93; 95%CI: 2.26-3.81) caused by occupational physical activities were identified as risk factors for miscarriage in the sample of pregnant women.	OR	18
Magann et al. [27]	Various maternal-child outcomes	23.7±4.9 24.1±5 25.4±4.7 24.7±5.4	No significant difference in the proportion of cases of hypertension (p = 0.611); gestational diabetes; fetal death (p = 0.232); premature births (p = 0.414); caesareans (p = 0.621); mean weight gain (p = 0.391); or weeks of pregnancy (p = 0.231) between groups of pregnant women who exercised versus did not exercise. On average, newborns of pregnant women who practiced vigorous exercise were 86.5g lighter (p < 0.001) than those of pregnant women who did not exercise. However, mean birth weight was not inadequate for any of the groups. Did not report methods used to estimate gestational age or pre-gestational weight. Sample included premature newborns.	Mean chi-squared	18
Carmichael et al. [51]	Neural tube defects	NR	Newborns of pregnant women who practiced leisure-time physical activity showed a 30-50% lower risk of neural tube defects as compared to sedentary pregnant women. After adjusting for potential confounders, this association was limited to pregnant women who did not use vitamin/mineral supplements during the pre-gestational period; according to the physical activity score: 1 (OR = 0.94; 95%CI: 0.89-0.99), 5 (OR = 0.72; 95%CI: 0.56-0.94), or 10 (OR = 0.52; 95%CI: 0.31-0.89).	OR	18
Leifeman & Evenson [42]	Birth weight; prematurity	15-49	Women with no leisure-time physical activity before and during pregnancy were more susceptible to having newborns with very low birth weight (OR = 1.75; 95%CI: 1.50-2.04) as compared to women who practiced leisure-time physical activity before and during pregnancy. Previously active women who stopped their leisure-time physical activities during pregnancy were more prone to low birth weight (OR = 1.28; 95%CI: 1.05-1.56), or very low birth weight (OR = 2.05; 95%CI: 1.69-2.48) as compared to those who remained active during pregnancy. No significant association between leisure-ime physical activity and gestational age at time of delivery. Did not report method used to estimate pre-gestational weight. Sample did not include premature newborns.	OR	17
Rao et al. [34]	Various maternal-child outcomes	15-40 20.8±2.9	Physical activity showed an inverse association with weight gain after the 28th week of pregnancy (p = 0.002). Vigorous physical activity before and during pregnancy was associated with lower mean birth weight (p = 0.05 and 0.02, respectively); newborn head circumference (p = 0.005 and 0.009, respectively), and newborn arm circumference (p = 0.03 and 0.01, respectively). However, mean birth weight was not inadequate for any of the groups. Physical activity did not influence the incidence of prematurity or neonatal death. Gestational age was estimated from the date of last menstrual period (or ultrasound, if there was more than a 2 week discrepancy). Gestational weight gain was monitored since before conception. Sample did not include premature newborns.	Mean	15
Sorensen et al. [19]	Preeclampsia	NR	Women with leisure-time physical activity during the first 20 weeks of pregnancy showed a 35% reduction in risk of preeclampsia (OR = 0.65; 95%CI: 0.43-0.99) as compared to those classified as inactive. Women with leisure-time physical activity during the year prior to pregnancy showed a slightly lower reduction (OR = 0.67; 95%CI: 0.42-1.08). For those with leisure-time physical activity before and during pregnancy, the reduction in risk of preeclampsia was significantly greater (OR = 0.59; 95%CI: 0.35-0.98)	OR	18
Dempsey et al. [22]	Gestational diabetes mellitus	≥ 18	Compared to women classified as inactive, those with leisure-time physical activity during the year prior to pregnancy showed a 66% reduction in risk of gestational diabetes mellitus (RR = 0.44; 95%CI: 0.21-0.91). Women with leisure-time physical activity during pregnancy showed a 31% reduction in risk of gestational diabetes mellitus, but this association was not statistically significant (RR = 0.69; 95%CI: 0.37-1.29). Women with leisure-time physical activity before and during pregnancy showed a larger reduction in risk of gestational diabetes mellitus (RR = 0.31; 95%CI: 0.12-0.79).	RR	16

(continues)

Table 3 (continued)

Author	Outcomes	Age (years) *	Results	Estimators	Score **
Saftlas et al. [20]	Preeclampsia; gestational hypertension	31.4±4.4 30.8±4 30.5±4.7	Reduced risk of preeclampsia in pregnant women with leisure-time physical activity (OR = 0.66; 95%CI: 0.35-1.22) or non-sedentary occupational physical activities (OR = 0.71; 95%CI: 0.37-1.36). No association between leisure-time or occupational physical activity and gestational hypertension.	OR	17
Dempsey et al. [23]	Gestational diabetes mellitus	NR	Women with any type of leisure-time physical activity in the year prior to pregnancy showed a 55% reduction in risk of gestational diabetes mellitus (OR = 0.45; 95%CI: 0.28-0.74), compared to sedentary women. Women with leisure-time physical activity during the first 20 weeks of pregnancy showed a 48% reduction in risk of gestational diabetes mellitus (OR = 0.52; 95%CI: 0.33-0.80), and women with leisure-time physical activity before and during pregnancy showed the largest reduction in risk of gestational diabetes mellitus (OR = 0.40; 95%CI: 0.23-0.68).	OR	17
Takito et al. [14]	Birth weight	> 18	After adjusting for confounders, leisure-time physical activity (walking for at least 50 minutes a day) in the first trimester of pregnancy was identified as a protective factor against inadequate birth weight (OR = 0.44; 95%CI: 0.20-0.98). Standing for more than 2.5 hours at a time during the second trimester showed a sharp risk for inadequate birth weight (OR = 3.23; 95%CI: 1.30-7.99). Among the occupational physical activities that require erect posture, only doing laundry 3 or more times a week in the second trimester was significantly associated with inadequate birth weight (OR = 3.49; 95%CI: 1.59-7.64). Did not report whether the sample included premature newborns.	OR	16

BMI: body mass index; NR: not reported; OR: odds ratio; RR: relative risk.

* Information on participants' age was not provided in a standardized way by the studies. Such information was available as age brackets, mean age (for the different target groups or the entire sample), and standard deviations, when possible;

** Methodological quality score of the reviewed studies, according to the Downs & Black criteria [12].

study, leisure-time physical activity appears to play a protective role against the occurrence of neural tube malformations.

As for length at birth, only one study was located [52], showing a decreased risk of large-for-gestational-age neonates among physically active pregnant women, but the study's methodological quality score was not one of the highest.

Two selected articles were not included in the present review due to lack of access to the full text. One of the articles [53] investigates the effects of physical activity during pregnancy on labor among mothers of premature infants. Based on the results, the authors suggest that physical activity in pregnancy can substantially reduce (by up to 32 minutes) the duration of the second stage of labor, as well as the risk of obstetric complications in this group of women. The second article [54] describes the results of two studies that investigated the effects of jogging during pregnancy. In the first, no significant differences were observed between the groups of mothers who jogged (versus those who did not jog) in relation to gestational weight gain and birth weight. Few obstetric complications were also observed in the group of women who jogged during pregnancy. The second study refers to the effects of jogging on maternal and fetal heart rates, and was outside the scope of the current review.

Although more than a decade has transpired since the first recommendation by the American College of Obstetricians and Gynecologists (ACOG) [2] in favor of physical activity during pregnancy, little knowledge has been accumulated on the effects of this continuous practice on outcomes like fetal development, length at birth, miscarriage, mode of delivery, and gestational weight gain control. However, for other outcomes like birth weight and prematurity, a consensus appears to be taking shape that light or moderate leisure-time or occupational physical activities do not constitute a risk factor, and in some cases may be considered a protective factor.

Although displaying some important limitations, several studies received high scores for their methodological quality. The internal consistency of the scores assigned to the studies gave greater robustness to this evaluation. Among the Downs & Black criteria [12] considered here, the principal limitations observed in the studies were: failing to commenting on the sample's representativeness, not presenting the list of

Table 4

Number of studies and their mean score # according to type of association observed between physical activity in pregnancy and maternal-child health outcomes, 1980-2005.

Outcomes	Beneficial effect				No effect				Harmful effect			
	Leisure-time physical activity		Occupational physical activity		Leisure-time physical activity		Occupational physical activity		Leisure-time physical activity		Occupational physical activity	
	n	Mean score	n	Mean score	n	Mean score	n	Mean score	n	Mean score	N	Mean score
Preeclampsia	3	17.7	1	17.0	-		-	-	-	-	1	18.0
Gestational hypertension	1	18.0	-	-	2	17.5	1	17.0	-	-	-	-
Gestational diabetes	3	16.3	-	-	1	18.0	-	-	-	-	-	-
Miscarriage	1	15.0	-	-	4	13.2	3	14.0	-	-	2 *	17.0
Weight gain	2	15.0	1	15.0	3	14.3	-	-	-	-	-	-
Mode of delivery	1	14.0	-	-	3	14.3	-	-	-	-	-	-
Fetal growth & development	1	18.0	-	-	-	-	-	-	-	-	1 *	18.0
Birth length	1	14.0	-	-	-	-	-	-	-	-	-	-
Birth weight	6	16.2	1	20.0	7	13.4	5	15.0	2 **	15.0	2 **	17.5
Prematurity	3	16.3	1	16.0	7	14.7	2	14.5	1 *	16.0	4 ****	15.7

Methodological quality score of reviewed studies, according to Downs & Black criteria [12].

* Refers to studies that identified moderate to vigorous leisure-time physical activity or certain characteristics of occupational physical activities, for example, standing for long hours, as a risk factor, but not physical activities as a whole. The number of asterisks represents the studies with this characteristic.

Note: the same study can appear in more than one box in the Table.

the principal confounders and/or not including them in the analysis or not making this clear in the text, and not presenting the study's power to detect differences between the groups. The lowest scores were assigned to articles from the first two decades, suggesting that current studies are possibly being developed and reported with greater methodological care. Since this review was conducted in databases with rigorous indexing criteria, incorporating only articles published in certain languages, a publication bias cannot be ruled out.

Importantly, the description was rather precarious for the individuals comprising the samples in some of the studies reviewed here. Gottlieb [55], in a brief communication, suggests that some of the contradictions observed in the results of studies on physical activity in pregnancy may result from the different methodologies, particularly differences among the individuals comprising the samples.

In relation to the sample group, Dye & Oldenettel [56] already indicated that analyses based on special groups like elite athletes may lead to an error in their comparison with sedentary pregnant women. The present review did not include studies that specifically analyzed pregnant athletes. Even so, it is not difficult to imagine that physically fit pregnant women, with physical activity incorporated into their lives as a daily practice since before pregnancy, may constitute a particular group, quite different from sedentary pregnant women. The results of some of the studies reviewed here even demonstrated these peculiarities by presenting different effects for groups of pregnant women who practiced leisure-time physical activities before pregnancy and those who began exercising during gestation. Therefore, the knowledge should be interpreted in light of this consideration.

Another aspect that merits reflection is the fact that the Downs & Black criteria [12] do not include any assessment of the quality of the research instruments or the exposure measurement process. Since most of the studies used questionnaires to assess the target phenomena, it would be interesting for future reviews to systematically incorporate these important methodological aspects.

The authors of the current review believe that the ACOG recommendations, especially those referring to care in the monitoring and follow-up of pregnant women, should be considered the baseline for any proposal to encourage a more active lifestyle for women experiencing the unique physiological moment of pregnancy.

In addition, the information presented here on what are considered risk activities for the oc-

currence of certain maternal-child health outcomes should be widely publicized and especially incorporated into prenatal care guidelines. We were only able to find vague guidelines from the Brazilian Ministry of Health concerning physical activity during pregnancy. The Ministry's technical handbook for prenatal care and postpartum follow-up [57] suggests that physical activities should be encouraged to assist control of blood pressure and that pregnant women presenting gestational diabetes mellitus should exercise regularly. However, there was no recommendation for pregnant women as to exercise modality or even frequency.

Although light-to-moderate physical activity does not appear to be significantly associated with increased risk, more studies are needed to fill the gaps identified here. Most studies in the current review lacked any kind of standardization as to the type of activities evaluated, merely defining them as either leisure-time or occupational physical activities. It thus becomes practically impossible to compare the studies' results, so that discussion of the findings becomes basically descriptive.

The definition of physical activity encompasses a series of aspects including all voluntary activities, like leisure-time, domestic, occupational, and commuting activities [60]. When counseling the pregnant woman as to physical activity during pregnancy, it is thus necessary to mention the frequency, intensity, and duration of such activities. These are the points that appear to lack the most information, since neither the ACOG nor the Brazilian Ministry of Health guidelines mention such specifications.

Resumo

Realizou-se uma revisão sistemática da literatura com o objetivo de investigar o efeito da prática de atividade física durante a gestação em desfechos da saúde materno-infantil. A busca contemplou artigos publicados entre 1980 e 2005 nas bases de dados MEDLINE e LILACS utilizando-se as palavras-chave: physical activity; physical exercise; pregnancy e gestation. *Foi feita uma avaliação da qualidade metodológica dos 37 artigos selecionados. Parece consenso que a prática de atividades físicas de intensidade leve ou moderada não consiste em fator de risco para alguns desfechos e pode representar fator de proteção. Contudo, alguns estudos encontraram associação entre atividades específicas, como subir escadas ou permanecer de pé por períodos prolongados e o peso inadequado do recém-nascido, prematuridade e aborto espontâneo. Poucos estudos encontraram associação entre a prática de atividades físicas e o ganho ponderal, tipo de parto e o desenvolvimento fetal. Novos estudos devem ser desenvolvidos com o objetivo de preencher essas lacunas, bem como propor recomendações acerca da intensidade, duração e freqüência das atividades físicas a serem realizadas durante a gestação.*

Atividade Motora; Exercício Físico; Gravidez; Revisão

Contributors

M. M. Schlüssel participated in all stages of the study, from planning the review to the literature survey, article selection, Downs & Black scoring, analysis of the results, and drafting of the article. E. B. Souza contributed to the literature review, Downs & Black scoring, and revisions of all the versions of the manuscript. M. E. Reichenheim collaborated in the methodological review and final revision of the article. G. Kac participated in planning the review and orientation and revision of all versions of the article.

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