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# Physical activity during pregnancy and fetal outcomes: a case-control study

# Atividade física durante a gestação e desfechos fetais: um estudo de casos e controles

## ABSTRACT

**OBJECTIVE:** To investigate the relationship between physical activity during the second trimester pregnancy and low birth weight, preterm birth, and intrauterine growth restriction.

**METHODS:** Case-control study including 273 low birth weight newborns and 546 controls carried out in the city of São Paulo, Southeastern Brazil, in 2005. Low birth weight cases were grouped into two subsamples: preterm birth (n=117) and intrauterine growth restriction (n=134), with their related controls. Information was collected by means of interviews with mothers shortly after birth and transcription of medical records. Data were analyzed using conditional multiple and hierarchical logistic regression.

**RESULTS:** Light physical activity for over 7 hours per day was shown to be protective against low birth weight (adjusted OR=0.61; 95% CI 0.39–0.94) with a dose-response relationship (p-value for trend=0.026). A similar trend was found for intrauterine growth restriction (adjusted OR=0.51; 95% CI 0.26–0.97). Homemaking activities were associated as a protective factor for both low birth weight and preterm birth (p-value for trend=0.013 and 0.035, respectively). Leisure-time walking was found to be protective against preterm birth.

**CONCLUSIONS:** Mild physical activity during the second trimester of pregnancy such as walking has an independent protective effect on low birth weight, preterm birth, and intrauterine growth restriction.

**DESCRIPTORS: Pregnant Women. Motor Activity. Low Birth Weight. Premature Birth. Case-Control Studies.**

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## RESUMO

**OBJETIVO:** Analisar a relação entre atividade física durante o segundo trimestre de gestação e baixo peso ao nascer, prematuridade e restrição de crescimento intra-uterino.

**MÉTODOS:** Estudo de caso-controle realizado no município de São Paulo, em 2005. Foram estudados 273 recém-nascidos de baixo peso e 546 controles. Dentre os casos foram selecionadas duas sub-amostras: 117 nascimentos pré-termo e 132 com restrição de crescimento intra-uterino (n=132) e seus respectivos controles. As informações foram obtidas mediante entrevistas com as puérperas e transcrição de dados dos prontuários. Foram realizadas análises de regressão logística múltipla condicional e hierarquizada.

**RESULTADOS:** Foi identificado como fator de proteção para baixo peso ao nascer a realização de atividades leves por mais de sete horas diárias (ORaj:0,61; IC 95%:0,39;0,94), para a qual identificou-se relação do tipo dose-resposta (p de tendência=0,026), e tendência similar na análise da restrição de crescimento intra-uterino (ORaj:0,51; IC 95%:0,26;0,97). A realização de atividades domésticas associou-se como fator protetor tanto contra o baixo peso ao nascer quanto à prematuridade (p de tendência=0,013 e 0,035, respectivamente). Foi detectado efeito de proteção contra prematuridade para a caminhada no lazer.

**CONCLUSÕES:** Atividades físicas leves, como caminhadas, durante o segundo trimestre de gestação exercem efeito protetor independente sobre o baixo peso ao nascer, a prematuridade e a restrição de crescimento intrauterino.



**DESCRITORES: Gestantes. Atividade Motora. Recém-Nascido de Baixo Peso. Nascimento Prematuro. Estudos de Casos e Controles.**


## INTRODUCTION

Low birth weight is an important public health issue in both developed and developing countries. It is the main factor influencing health and nutritional conditions and child survival, and is also associated with occurrence of chronic diseases in adult life.[10]

Over the past two decades – in contrast to the declining trend seen for many health indicators, such as child mortality, postnatal malnutrition, and malnutrition among adult women – prevalence of low birth weight (under 2,500 grams) has remained stable, or even increased in cities of Southern and Southeastern Brazil.[2] Increases in prevalence have also been seen in developed countries such as Canada and the United States, among others.[3]

There are two major processes that can lead to low birth weight: preterm birth and restricted intrauterine growth. In the city of Pelotas, over the last two decades, Barros et al[2] observed a slight increase in the prevalence of low birth weight and a greater increase in preterm birth (6.3% in 1982 to 16.2% in 2004), whereas prevalence of intrauterine growth restriction (IUGR) remained unaltered.

According to Kramer et al,[14] the etiology of low birth weight is multifactorial. Among its determinants are unfavorable socioeconomic conditions, low maternal weight at the beginning of pregnancy, short maternal stature, diseases such as malaria, genital infection or high blood pressure, smoking, absent or insufficient prenatal care, unfavorable reproductive history, multiple pregnancy, illicit drug use, emotional stress, lack of psychosocial support, and excessive physical activity during pregnancy.

Some studies involving maternal physical activity during pregnancy and low birth weight, preterm birth, and IUGR confirmed deleterious effects of excessive physical activities both at work[23,25] and during leisure time.[4,17] Concomitantly, several studies have suggested equally deleterious effects for insufficient leisure-time physical activity[4,17] or even for excessive time spent watching television.[18] These results favor the hypothesis of a U-shaped relationship correlating physical activity with pregnancy outcomes.

The objective of the present study was to examine the relationship between physical activity during the second

trimester of pregnancy (work, housework, leisure, and transportation) and risk of low birth weight, preterm birth, and IUGR among pregnant women.

## METHODS

A case-control study was carried out in three large public hospitals in the city of Sao Paulo, Southeastern Brazil (one of which is a reference center for high-risk pregnancy). The sample included 273 cases (newborns weighing less than 2,500 grams at birth) and 546 controls (newborns weighing 2,500 grams or more). This sample size allowed for 80% power to detect an odds ratio lower than or equal to 0.55 at a significance level of 5% for exposures affecting between 30% and 50% of controls.[9] A subsample of low birth weight newborns was selected to investigate preterm birth, totaling 117 cases (newborns weighing less than 2,500 grams with gestational age under 37 weeks) paired with two non-preterm controls per case (n=234). Another subsample of low birth weight newborns was selected to investigate IUGR, comprising 132 cases (newborns weighing less than 2,500 grams and below percentile 10 for gestational age and sex[26]) paired with two non-IUGR controls per case (n=264). The smaller sample size for these analyses allowed for 80% power to detect odds ratios lower than 0.4 at 5% significance level for exposures affecting between 30% and 50% of controls.[9]

Cases were selected from delivery registration books of obstetric centers and both controls for each case were obtained from the same hospital. Controls were randomly drawn from deliveries that have taken place within 48 hours (from 24 hours before to 24 hours after) of the case birth from among all live births weighing 2,500 grams or more. Exclusion criteria for both groups included twin pregnancy, mother's age under 18 years, stillbirth, or congenital malformation detected at birth.

Information was obtained by means of interviews with the mothers of cases and controls while they were still in the hospital using a pre-tested questionnaire. A questionnaire on physical activity[22] was used to assess the exposure variables. The physical activity studied refers to a typical week of the second semester of pregnancy when influence of physical activity on fetal growth is at its height.[18] Complementary information was transcribed from medical records of mothers and newborns. Interviews were carried out by six trained female interviewers. Data collection was supervised by the first author who carried out a partial quality control of 5% of interviews that were randomly selected.

Information on birth weight was collected from delivery records of obstetric centers. Information on gestational age was obtained from the interviews as well as from medical records. Information on gestational age was missing for 3.7% of newborns due to lack of biological plausibility when comparing reported gestational age with birth weight.[12] For 83.3% of newborns, gestational age was determined based on the date of the mothers' last period (DLP), obtained during the puerperal interview and transcribed from medical records, whenever there were no inconsistencies and DLP was compatible with birth weight given the adopted criteria[12] (4 standard deviations from the reverence curve[13] in either direction). For 11.4% of newborns, information from ultrasound examinations carried out before week 20 of pregnancy was used. Data were transcribed from ultrasound results and the mother's prenatal care records. For 5.7% of newborns, gestational age was determined by examining the infant (Capurro et al[5]). Preterm birth was defined as gestational age under 37 weeks, and IUGR as birth weight below percentile 10 for gestational age and sex.[26]

We evaluated physical activity during housework, work outside home, leisure time, and transportation.[22] Time spent on each of these activities was calculated by multiplying frequency by duration, expressed in min or hours per day. The compendium of physical activities[1] was used to determine energy cost and classify activities. Initially, we quantified time spent on each physical activity according to its intensity in metabolic equivalent of task (METs). Activities were grouped by intensity into sedentary (<1.5 METs); light (1.5–2.9 METs); moderate (3.0–6.0 METs); and vigorous (>6.0 METs). Next, modes of physical activity were classified into housework, work, leisure, and transportation. Daily METs were calculated, and women were classified according to level of physical activity during pregnancy, expressed in multiples of the basal metabolic rate[27]. The analysis considered time spent on each of these categories, obtained by multiplying frequency of each activity by its duration (expressed in min or hours per day). Data are generally presented as quartiles or tertiles based on the distribution of the control group.

We also collected information on potential confounders, including socioeconomic conditions (per capita income, mother's schooling, and living with a partner), reproductive variables (age, parity), skin color (self-reported), number of prenatal care visits, behavioral factors (smoking, alcohol and illicit drug use, family planning, and sexual activity during pregnancy), and self-reported diseases and health conditions potentially associated with exposure and outcome (high blood pressure, untreated infections, bleeding, premature rupture of membranes, depression, sadness, resting at home following medical advice or otherwise, use of oral or intravenous medication, and hospitalization). Behavioral factors such as coffee, alcohol, and illicit drug use were analyzed as dichotomous variables, positive answers being defined as use in any amount and during any stage of pregnancy. For caffeine

consumption analysis, only coffee ingestion was considered. This variable was not associated with the outcomes in the first analysis, and was thus not considered in further analysis. Having a paid job was also dichotomized. A more in-depth analysis of occupational activities related to physical effort was undertaken in the physical activity questionnaire, especially with regard to the second semester of pregnancy. As direct measurement of post-delivery height and weight could not be carried out due to the physical condition of mothers at the time of the interview, recalled information on pre-gestational weight, height, and weight gain were collected, but they were excluded from the analysis due to inconsistencies. Obstetric history of previous outcomes was not included in the analysis because previous pregnancies could have been influenced by similar factors.

Unadjusted and adjusted odds ratios and their related 95% confidence intervals for the studied outcomes were estimated by conditional logistic regression analysis, considering pairing (matching) by hospital.[20] Multiple analysis was performed in a hierarchical model as described by Victora et al[24] with adjustment for covariables associated with the response variables with $p<0.20$ in the univariate analysis. The statistical significance of variables included in the models was assessed using the maximum likelihood ratio test, with a critical p-value of 5%. Linear trend tests were performed when appropriate.[7]

The theoretical model for determining factors associated with low birth weight developed by Santos et al[19] was adapted and guided the order of inclusion of variable blocks for modeling (Figure). The factors from the most distal block (socioeconomic variables) were the first to be included in the model. Factors that remained associated ($p<0.20$) with the outcome were kept as adjustment variables for lower hierarchical blocks. Likewise, variables from maternal biological and reproductive groups that remained significantly associated with the response variable for both the factors in the same block and the factors in the socioeconomic block were kept, thus becoming control variables for subsequent analyses. A similar procedure was adopted for the two most proximal blocks (variables related to morbidity, maternal behavior, and prenatal care).

Written informed consent was obtained from each subject before the interview. The present study was approved by the Research Ethics Committees of the *Faculdade de Saúde Pública* and hospitals where the study was carried out.

## RESULTS

Table 1 presents the results of the univariate analysis of the association between control variables and low birth weight. Low maternal schooling, not living with a partner, age over 35 years, and black skin color were more common among cases. Among socioeconomic, biological, and behavioral factors, only per capita income, parity, and alcohol consumption, respectively, were not associated with low birth weight. All other socioeconomic, biological, reproductive, and maternal behavior variables were included in the subsequent multiple analysis of low birth weight. Losses were found for only two variables: income (10%) and skin color (4%); however, the frequency of losses was similar between cases and controls.

In addition to the variables not associated with low birth weight, in the subsample analysis, preterm birth was not associated with skin color, smoking, or reduced sexual activity (data not shown). Furthermore, living with a partner, having a paid job, and premature rupture of membranes were also not associated with IUGR (data not shown).

Of the variables included in the maternal behavior block, smoking, and reduced sexual activity were selected for multivariate analysis for both low birth weight and IUGR, and work was selected for analysis of preterm birth only. All variables in the maternal morbidity and prenatal care block were also selected (except for resting at home) for subsequent low birth weight analyses. Medically advised rest or reduction of physical activity were not selected for preterm birth and IUGR analyses. All variables related to morbidity, smoking, and low frequency of prenatal care visits were more common among cases. Reduced sexual activity was more frequently seen among controls.

Table 2 shows the results of unadjusted analysis of the association between physical activity variables and low birth weight. There was a protective effect of light activity against low birth weight. This was a dose-response relationship with a p-value for trend of 0.001. Adjustment for confounding variables, as presented in Table 5, confirmed the trend of this protective effect, although there was a reduction in statistical significance (p for linear trend = 0.026). In univariate analyses, leisure-time walking showed a protective effect that did not reach statistical significance in the multiple analysis (p for linear trend of 0.072). Light activities represented nearly half (46%) of all daily physical activities of women in the control group. Sedentary activities accounted for less than 27%, while moderate activities accounted for 15%. Among activities classified as of light intensity, the following were noteworthy: cooking and dish washing (40%), light cleaning (21%), and laundry/clothing care (16%).

A negative association between duration of homemaking activities and low birth weight was seen in the univariate analysis. This association increased after

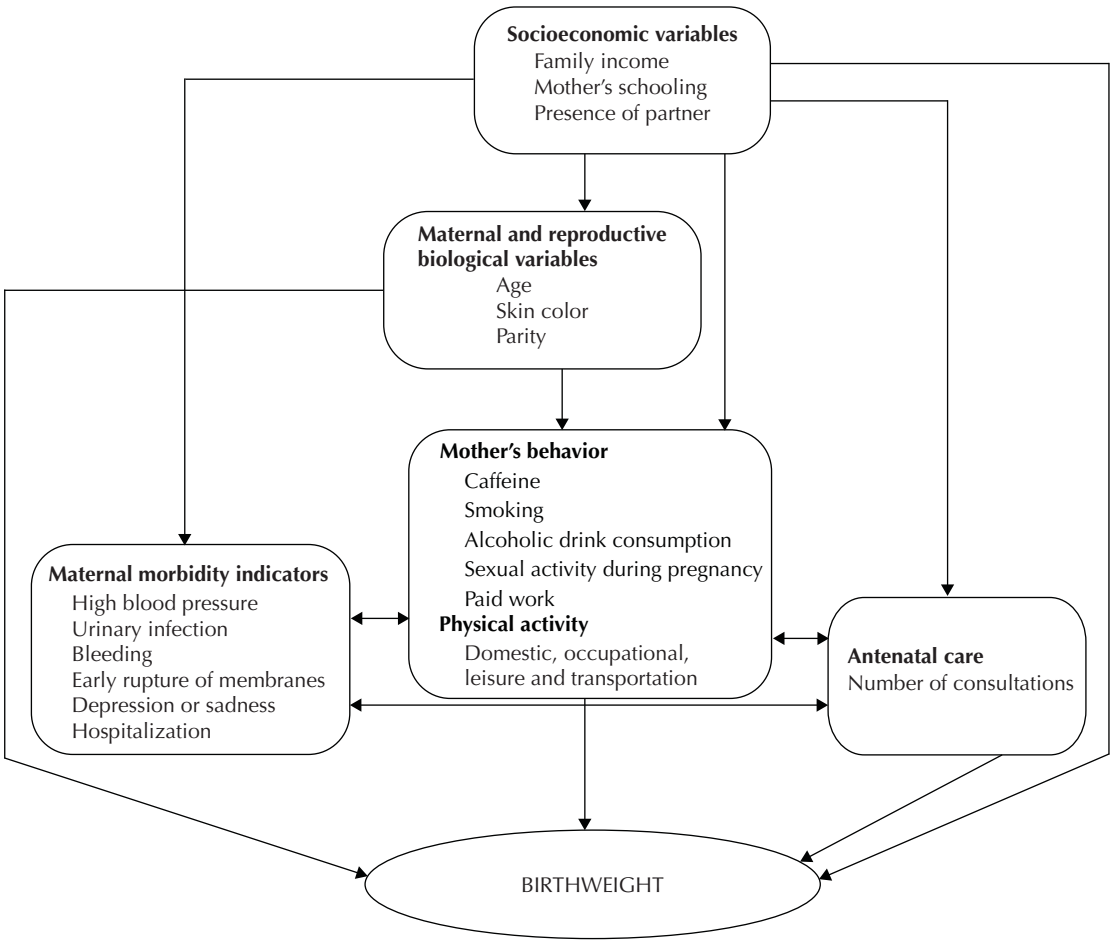


**Figure.** Theoretical model for causes of low birthweight.

adjustment for confounding variables, with a p-value for linear trend of 0.013.

For the preterm subsample (Table 3), variables selected for adjustment were the same as those included in the multiple analysis with birth weight as an outcome for socioeconomic and biological variable blocks. For the morbidity block, the variables high blood pressure, bleeding, premature rupture of membranes, and hospitalization were kept in the model. Paid job remained as a confounder in the behavioral block.

In the univariate analysis (Table 3), a statistically significant negative association was found between duration of light activities and preterm birth. However, this association lost statistical significance after adjustment for confounding variables. A protective effect of leisure-time walking was also seen in the univariate analysis. This was a dose-response relationship, with a p-value for trend of 0.023. Adjustment for confounding variables made this protective effect even more evident (Table 5). The univariate analysis also showed a negative dose-response association between duration of homemaking activities and preterm birth, with a p-value for trend of 0.053. This association remained after adjustment for confounding variables (p=0.035).

Fewer variables were selected for adjustment in the subsample of IUGR infants and their related controls. Accordingly, only light physical activity was associated with IUGR (Table 4).

The remaining variables – duration of sedentary and moderate activities, television watching, walking, and intensity of physical activity (as assessed by multiples of basal metabolic rate) – were not associated with outcomes in the crude analysis.

## DISCUSSION

The present study identified a protective effect of daily physical activity on fetal outcomes.

Even though several precautions were taken to minimize systematic error, certain limitations of the

**Table 1.** Distribution of low birth weight newborns (cases) and controls according to maternal socioeconomic, biological, reproductive and behavioural characteristics, morbidity indicators and antenatal care. São Paulo, Southeastern Brazil, 2005.

| Variable | Case | | Control | | Unadjusted | 95% CI | p |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | OR | | |
| Maternal socioeconomic characteristics | | | | | | | |
| *Per capita* income (minimum salaries) | | | | | | | |
| <0.5 | 62 | 25.6 | 119 | 24.2 | 1.3 | 0.82;2.07 | 0.612 |
| 0.5 to 0.9 | 82 | 33.9 | 153 | 31.2 | 1.3 | 0.84;2.01 | 0.283[a] |
| 1.0 to 1.4 | 47 | 19.4 | 98 | 20.0 | 1.3 | 0.79;2.13 | |
| ≥1.5 | 51 | 21.1 | 121 | 24.6 | 1 | | |
| Partner | | | | | | | |
| No | 67 | 24.5 | 108 | 19.8 | 1.34 | 0.95;1.88 | 0.093 |
| Yes | 206 | 75.5 | 438 | 80.2 | 1 | | |
| Schooling (years) | | | | | | | |
| <8 | 98 | 35.9 | 158 | 29.2 | 1.4 | 1.03;1.91 | 0.035 |
| ≥8 | 175 | 64.1 | 383 | 70.8 | 1 | | |
| Maternal biological and reproductive characteristics | | | | | | | |
| Age (years) | | | | | | | |
| ≥35 | 47 | 17.2 | 51 | 9.4 | 2.08 | 1.35;3.21 | 0.001 |
| <35 | 226 | 82.8 | 494 | 90.6 | 1 | | |
| Skin color | | | | | | | |
| Black | 75 | 28.5 | 124 | 23.5 | 1.26 | 0.91;1.76 | 0.170 |
| Non-black | 188 | 71.5 | 404 | 76.5 | 1 | | |
| Parity | | | | | | | |
| Primipara | 61 | 23.1 | 107 | 20.4 | 1.21 | 0.81;1.81 | 0.355 |
| Multipara | 203 | 76.9 | 418 | 79.6 | 1 | | |
| Maternal behaviour | | | | | | | |
| Smoking (number of cigarettes per day) | | | | | | | |
| ≥5 | 50 | 18.3 | 51 | 9.3 | 2.09 | 1.38;3.16 | 0.002 |
| <5 | 23 | 8.4 | 45 | 8.2 | 1.12 | 0.64;1.95 | 0.038[a] |
| No | 200 | 73.3 | 450 | 82.4 | 1 | | |
| Alcohol consumption | | | | | | | |
| Yes | 32 | 11.7 | 59 | 10.8 | 1.1 | 0.68;1.77 | 0.685 |
| No | 241 | 88.3 | 487 | 89.2 | 1 | | |
| Work | | | | | | | |
| Yes | 129 | 47.3 | 279 | 51.1 | 1.17 | 0.88;1.57 | 0.053 |
| No | 144 | 52.7 | 267 | 48.9 | 1 | | |
| Sexual activity | | | | | | | |
| Reduced | 133 | 48.7 | 312 | 57.1 | 0.7 | 0.49;1.02 | 0.285 |
| None | 68 | 24.9 | 115 | 21.1 | 1.01 | 0.67;1.54 | |
| Unchanged | 72 | 26.4 | 119 | 21.8 | 1 | | |
| Indicators of maternal morbidity | | | | | | | |
| Hospitalisation | | | | | | | |
| Yes | 68 | 24.9 | 66 | 12.1 | 2.3 | 1.59;3.34 | <0.001 |
| No | 205 | 75.1 | 479 | 87.9 | 1 | | |
| Resting at home | | | | | | | |
| Yes | 98 | 35.9 | 212 | 39.0 | 1.13 | 0.84;1.52 | 0.424 |
| No | 175 | 64.1 | 332 | 61.0 | 1 | | |

To be continued

Table 1 continuation

| Variable | Case | | Control | | Unadjusted OR | 95% CI | p |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | | | |
| Medical recommendation: rest or reduction of physical activity | | | | | | | |
| Yes | 158 | 57.9 | 284 | 52.2 | 1.3 | 0.96;1.77 | 0.090 |
| No | 115 | 42.1 | 260 | 47.8 | 1 | | |
| Bleeding | | | | | | | |
| Yes | 80 | 29.3 | 102 | 18.7 | 1.85 | 1.31;2.63 | <0.001 |
| No | 193 | 70.7 | 443 | 81.3 | 1 | | |
| Untreated infections | | | | | | | |
| Yes | 21 | 7.7 | 20 | 3.7 | 2.25 | 1.18;4.31 | 0.014 |
| No | 252 | 92.3 | 526 | 96.3 | 1 | | |
| Early rupture of membranes | | | | | | | |
| Yes | 46 | 16.8 | 36 | 6.6 | 3.11 | 1.89;5.11 | <0.001 |
| No | 227 | 83.12 | 510 | 93.4 | 1 | | |
| High blood pressure | | | | | | | |
| Yes | 71 | 26.1 | 99 | 18.2 | 1.68 | 1.17;2.41 | 0.005 |
| No | 201 | 73.9 | 445 | 81.8 | 1 | | |
| Depression or sadness | | | | | | | |
| Always | 20 | 7.3 | 12 | 2.2 | 3.69 | 1.74;7.81 | 0.006 |
| Sometimes | 20 | 7.3 | 35 | 6.4 | 1.24 | 0.71;2.19 | 0.007[a] |
| Rarely | 88 | 32.2 | 181 | 33.2 | 1.09 | 0.78;1.51 | |
| Never | 145 | 53.1 | 318 | 58.2 | 1 | | |
| Some medication taken (during pregnancy) | | | | | | | |
| Yes | 178 | 65.2 | 296 | 54.3 | 1.63 | 1.20;2.21 | 0.002 |
| No | 95 | 34.8 | 249 | 45.7 | 1 | | |
| Antenatal care | | | | | | | |
| Number of consultations | | | | | | | |
| <6 | 108 | 39.6 | 124 | 22.7 | 2.26 | 1.63;3.12 | <0.001 |
| ≥6 | 165 | 60.4 | 422 | 77.3 | 1 | | |

[a] Maximum likelihood ratio test; p for linear trend

present study should be considered when interpreting the present data. Considering the multifactorial etiology of the outcomes analyzed, we included in the hierarchical multivariate model only determinants that could be measured either by interviewing subjects immediately after delivery or through transcription of medical records. However, a certain degree of residual confounding may have remained.

Interviewing mothers shortly after delivery in order to obtain information related to the second trimester of pregnancy may result in recall bias. We sought to minimize this bias by means of adequate interviewer training. Although subjects were unaware of the study hypothesis, interviewer blinding was not possible since she was also responsible for selecting cases and controls from maternity records.

Comparing the present results with previous studies is complicated due to the diversity of methods available to evaluate physical activity and scarcity of studies addressing the four dimensions of physical activity: work, housework, leisure, and transportation.

The linear trend towards protection against low birth weight and IUGR with increasing time spent on light physical activities suggests that complete cessation of physical activity during pregnancy should not be recommended. Maggan et al,[16] in an evaluation of the energy expenditure during occupational and leisure activities, found increased risk of preterm birth among less active women.

The same protective trend against low birth weight and preterm birth was found among pregnant women who did housework (35% of total daily activities). Cavalliand Tanaka,[6] in an analysis of pregnant multiparas, found that subjects who did housework by themselves were protected against preterm birth compared to those who received some help. Launer et

**Table 2.** Variables of maternal physical activity and low birth weight: unadjusted analyses. São Paulo, Southeastern Brazil, 2005.

| Variable | Case (n=273) | | Control (n=546) | | Unadjusted | 95% CI | p |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | OR | | |
| Sedentary activities (hours/day) | | | | | | | |
| <2.4 | 90 | 33.0 | 183 | 33.5 | 1 | | 0.977 |
| 2.4 to 4.9 | 95 | 34.8 | 190 | 34.8 | 1,00 | 0.71;1.41 | 0.865[a] |
| ≥5 | 88 | 32.2 | 173 | 31.7 | 1.03 | 0.72;1.49 | |
| Light activities (hours/day) | | | | | | | |
| <3.5 | 99 | 36.3 | 140 | 25.6 | 1 | | 0.005 |
| 3.5 to 6.9 | 93 | 34.1 | 199 | 36.5 | 0.67 | 0.47;0.95 | 0.001[a] |
| ≥7 | 81 | 29. 7 | 207 | 37.9 | 0.55 | 0.38;0.79 | |
| Moderate activities (hours/day) | | | | | | | |
| <1 | 96 | 35.2 | 192 | 35.2 | 1 | | 0.501 |
| 1 to 2.4 | 71 | 26.0 | 163 | 29.9 | 0.88 | 0.60;1.29 | |
| ≥2.5 | 106 | 38.8 | 191 | 34.0 | 1.1 | 0.77;1.56 | |
| Watching television (hours/day) | | | | | | | |
| <1.5 | 35 | 29.9 | 66 | 28.2 | 0.93 | 0.54;1.61 | 0.802 |
| 1.5 to 3.9 | 40 | 34.2 | 83 | 35.5 | 1 | | |
| ≥4 | 42 | 35.9 | 85 | 36.3 | 0.9 | 0.51;1.61 | 0.731 |
| Walking in groups (min/day) | | | | | | | |
| No walking | 37 | 13.6 | 49 | 9.0 | 1.55 | 0.92;2.6 | 0.280 |
| <20 | 69 | 25.3 | 148 | 27.1 | 0.97 | 0.64;1.48 | |
| 20 to 50 | 66 | 24.2 | 137 | 25.1 | 1 | | |
| ≥50 | 101 | 37.0 | 212 | 38.8 | 0.99 | 0.68;1.45 | |
| Leisure walks (min/day) | | | | | | | |
| None | 146 | 53.5 | 252 | 46.2 | 1 | | 0.139 |
| <20 | 69 | 25.3 | 156 | 28.6 | 0.76 | 0.53;1.08 | 0.086[a] |
| ≥20 | 58 | 21.2 | 138 | 25.3 | 0.73 | 0.51;1.05 | |
| Domestic activities (hours/day) | | | | | | | |
| < 2 | 77 | 28.2 | 112 | 20.5 | 1 | | 0.108 |
| 2 to 3.9 | 88 | 32.2 | 185 | 33.9 | 0.7 | 0.48;1.03 | 0.033[a] |
| 4 to 5.9 | 56 | 20.5 | 127 | 23.3 | 0.65 | 0.42;0.99 | |
| ≥ 6 | 52 | 19.1 | 122 | 22.3 | 0.63 | 0.41;0.97 | |
| Multiples of Basal Metabolic Rate | | | | | | | |
| Sedentary | 187 | 68.5 | 352 | 64.5 | 1.24 | 0.82;1.88 | 0.412 |
| Little activity and active | 38 | 13.9 | 85 | 15.6 | 1 | 0.61;1.70 | |
| Very active | 48 | 17.6 | 109 | 20.0 | 1.01 | | |

[a] Maximum likelihood ratio test; p for linear trend

al[15] reported a risk of 1.7 of being small for gestational age among infants born to mothers who did not get any help with housework. Women who receive help in their housework are likely to be excluded from vigorous or extenuating physical activities.

Vigorous physical activity was virtually absent in the present study, confirming a previous cohort survey[21] including 153 low-income pregnant women attending public prenatal care facilities in the city of Sao Paulo. We were therefore unable to compare our data with those studies that detected associations between moderate to vigorous physical exercise/exertion and maternal-fetal health.

The variable that groups the different dimensions of walking was not associated with any of the outcomes studied. In contrast, Misra et al[18] found a twofold higher

**Table 3.** Variables of maternal physical activity and preterm delivery: unadjusted analyses. São Paulo, Southeastern Brazil, 2005.

| Variable | Case (n=117) | | Control (n=234) | | Unadjusted | 95% CI | p |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | OR | | |
| Sedentary activities (hours/day) | | | | | | | |
| <2.4 | 38 | 32.5 | 78 | 33.3 | 0.91 | 0.52;1.57 | 0.654 |
| 2.4 to 4.9 | 42 | 35.9 | 73 | 31.2 | 1.16 | 0.69;1.95 | 0.747[a] |
| ≥5 | 37 | 31.6 | 83 | 35.5 | 1 | | |
| Light activities (hours/day) | | | | | | | |
| <3.5 | 42 | 35.9 | 58 | 24.8 | 1 | | 0.049 |
| 3.5 to 6.9 | 41 | 35.0 | 82 | 35.0 | 0.71 | 0.42;1.19 | 0.014[a] |
| ≥7 | 34 | 29.1 | 94 | 40.2 | 0.5 | 0.28;0.87 | |
| Moderate activities (hours/day) | | | | | | | |
| <1 | 41 | 35.0 | 90 | 38.5 | 1 | | 0.460 |
| 1 to 2.4 | 26 | 22.2 | 60 | 25.6 | 0.96 | 0.52;1.77 | |
| ≥2.5 | 50 | 42.7 | 84 | 35.9 | 1.31 | 0.78;2.21 | |
| Watching television (hours/day) | | | | | | | |
| <1.5 | 35 | 29.9 | 66 | 28.2 | 0.93 | 0.54;1.61 | 0.940 |
| 1.5 to 3.9 | 40 | 34.2 | 83 | 35.5 | 1 | | |
| ≥4 | 42 | 35.9 | 85 | 36.3 | 0.9 | 0.51;1.61 | |
| Walking in groups (min/day) | | | | | | | |
| No walking | 14 | 12.0 | 20 | 8.6 | 1.37 | 0.61;3.07 | 0.763 |
| <20 | 28 | 23.9 | 62 | 26.5 | 0.88 | 0.46;1.68 | |
| 20 to 50 | 32 | 27.4 | 63 | 26.9 | 1 | | |
| ≥50 | 43 | 36.8 | 89 | 38.0 | 0.95 | 0.54;1.67 | |
| Leisure walks (min/day) | | | | | | | |
| None | 70 | 59.8 | 111 | 47.4 | 1 | | 0.068 |
| <20 | 28 | 23.9 | 64 | 27.4 | 0.71 | 0.42;1.21 | 0.023[a] |
| ≥20 | 19 | 16.2 | 59 | 25.2 | 0.52 | 0.29;0.95 | |
| Domestic activities (hours/day) | | | | | | | |
| < 2 | 37 | 31.6 | 44 | 18.8 | 1 | | 0.075 |
| 2 to 3.9 | 34 | 29.1 | 83 | 35.5 | 0.5 | 0.27;0.90 | 0.053[a] |
| 4-5.9 | 24 | 20.5 | 53 | 22.7 | 0.54 | 0.28;1.04 | |
| ≥ 6 | 22 | 18.8 | 54 | 23.1 | 0.51 | 0.27;0.97 | |
| Multiples of the basal metabolic rate | | | | | | | |
| Sedentary | 80 | 68.4 | 155 | 66.2 | 1.06 | 0.58;1.94 | 0.906 |
| Little activity and active | 19 | 16.2 | 42 | 18.0 | 1 | 0.43;2.01 | |
| Very active | 18 | 15.4 | 37 | 15.8 | 0.92 | 0.48;2.06 | |

[a] Maximum likelihood ratio test; p for linear trend

risk of preterm birth (OR=2.10; 95% CI:1.38–3.20) among women who engaged in purposeful walking four or more times per week. Tuntiseranee et al[23] reported increased risk of preterm birth for brisk walking in the work dimension of physical activity (OR=2.4; 95% CI:1–5.7). Our study contrasts with the aforementioned reports in that fast walking was a rare event among our subjects.

Leisure-time walking (strolling or walking for exercising) showed a protective effect against preterm birth, with a 50% or greater reduction in risk for women who walked less than 20 min per day and a roughly two-thirds reduction for those who walked 20 min or more per day. Other studies that analyzed (intentional or not) walking found a similar protective effect against inadequate birth weight (OR=0.44; 95% CI:0.20; 0.98)[21] or

**Table 4.** Variables of maternal physical activity and intrauterine growth restriction: unadjusted analyses. São Paulo, Southeastern Brazil, 2005.

| Variable | Case (n=132) | | Control (n=264) | | Unadjusted | 95% CI | p |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | OR | | |
| Sedentary activities (hours/day) | | | | | | | |
| <2.4 | 53 | 40.2 | 93 | 34.5 | 0.76 | 0.45;1.29 | 0.305 |
| 2.4 to 4.9 | 44 | 33.3 | 91 | 35.2 | 0.85 | 0.52;1.39 | 0.588[a] |
| ≥5 | 35 | 26.5 | 80 | 30.3 | 1 | | |
| Light activities (hours/day) | | | | | | | |
| <3.5 | 47 | 35.6 | 68 | 25.8 | 1 | | 0.090 |
| 3.5 to 6.9 | 44 | 33.3 | 92 | 34.8 | 0.69 | 0.41;1.16 | 0.030[a] |
| ≥7 | 41 | 31.1 | 104 | 39.4 | 0.55 | 0.32;0.95 | |
| Moderate activities (hours/day) | | | | | | | |
| <1 | 42 | 31.8 | 83 | 31.4 | 1 | | 0.661 |
| 1 to 2.4 | 36 | 27.3 | 83 | 31.4 | 0.86 | 0.49;1.50 | |
| ≥2.5 | 54 | 40.9 | 98 | 37.1 | 1.09 | 0.64;1.83 | |
| Watching television (hours/day) | | | | | | | |
| <1.5 | 53 | 40.2 | 88 | 33.3 | 1.11 | 0.65;1.91 | 0.369 |
| 1.5 to 3.9 | 43 | 32.6 | 91 | 34.5 | 1 | | |
| ≥4 | 36 | 32.2 | 85 | 32.2 | 1.44 | 0.85;2.43 | |
| Walking in groups (min/day) | | | | | | | |
| No walking | 19 | 14.4 | 23 | 8.7 | 1.78 | 0.84;3.76 | 0.347 |
| <20 | 36 | 27.3 | 68 | 25.8 | 1.16 | 0.63;2.12 | |
| 20 to 50 | 28 | 21.2 | 61 | 23.1 | 1 | | |
| ≥50 | 49 | 37.1 | 112 | 42.4 | 0.95 | 0.54;1.98 | |
| Leisure walks (min/day) | | | | | | | |
| None | 72 | 54.5 | 120 | 45.5 | 1 | | 0.205 |
| <20 | 33 | 25.0 | 75 | 28.4 | 0.72 | 0.43;1.21 | 0.103[a] |
| ≥20 | 27 | 20.5 | 69 | 26.1 | 0.64 | 0.37;1.10 | |
| Domestic activities (hours/day) | | | | | | | |
| <2 | 30 | 22.7 | 60 | 22.7 | 1 | | 0.527 |
| 2 to 3.9 | 48 | 36.4 | 81 | 30.7 | 1.07 | 0.56;2.01 | 0.634[a] |
| 4 to 5.9 | 27 | 20.5 | 65 | 24.6 | 1.29 | 0.71;2.33 | |
| ≥6 | 27 | 20.5 | 58 | 22.0 | 0.88 | 0.46;1.71 | |
| Multiples of the basal metabolic rate | | | | | | | |
| Sedentary | 87 | 65.9 | 164 | 62.1 | 1.26 | 0.69;2.44 | 0.4165 |
| Little and active | 17 | 12.9 | 41 | 15.5 | 1 | | |
| Very active | 28 | 21.2 | 59 | 22.4 | 1.15 | 0.55;2.40 | |

[a] Maximum likelihood ratio test; p for linear trend

on birth weight as a continuous variable, with a mean increase of 35 [8;63] grams.[11] Domingues & Barros,[8] in a cross-sectional study of the population of the city of Pelotas carried out in 2004, reported a protective effect against preterm birth of engaging in leisure-time physical activity during pregnancy. Walking was the activity of choice in approximately 80% of pregnant women in this study.[8]

In regard to the hypothesis of a U-shaped relationship between physical activity and pregnancy outcomes, our results provide evidence for the extreme left side of this curve – increased risk of low birth weight and preterm birth among less active women who spend less time on general mild activities, housework, and leisure walks. The other extreme of the curve could not be tested as vigorous physical activity was rare among our subjects.

**Table 5.** Variables of maternal physical activity and outcomes: adjusted analyses.maternal physical activity and intrauterine growth restriction: unadjusted analyses. São Paulo, Southeastern Brazil, 2005.

| Variable | Low birth weight[a] | | | Preterm birth[b] | | | IUGR[c] | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR adjusted | 95% CI | p[d] | OR adjusted | 95% CI | p[d] | OR adjusted | 95% CI | p[d] |
| Light activities (min/day) | | | | | | | | | |
| <210 | 1 | | 0.070 | 1 | | 0.422 | 1 | | 0.114 |
| 210 to 420 | 0.71 | 0.47;1.08 | 0.026* | 0.78 | 0.40;1.54 | 0.192* | 0.73 | 0.39;1.35 | 0.040* |
| ≥420 | 0.61 | 0.39;0.94 | | 0.61 | 0.29;1.29 | | 0.51 | 0.26;0.97 | |
| Leisure walking (min/day) | | | | | | | | | |
| None | 1 | | 0.185 | 1 | | 0.007 | | | |
| <20 | 0.76 | 0.50;1.15 | 0.072* | 0.44 | 0.21;0.90 | 0.003* | | | |
| ≥20 | 0.7 | 0.46;1.08 | | 0.36 | 0.16;0.78 | | | | |
| Domestic activities (hours/day) | | | | | | | | | |
| < 2 | 1 | | 0.066 | 1 | | 0.114 | | | |
| 2 to 3.9 | 0.67 | 0.43;1.06 | 0.013* | 0.5 | 0.23;1.09 | 0.035* | | | |
| 4 to 5.9 | 0.6 | 0.36;0.98 | | 0.56 | 0.25;1.27 | | | | |
| ≥6 | 0.53 | 0.31;0.89 | | 0.38 | 0.17;0.89 | | | | |

[a] Low birth weight adjusted for variables from the previous blocks: presence of a partner and schooling (socioeconomic), age and skin colour (maternal biological); and from the same level: smoking (behavioural), high blood pressure, bleeding, untreated infection, early rupture of membranes, hospitalisation and use of medications (variables indicating morbidity), antenatal consultations (antenatal care).
[b] Preterm birth adjusted for maternal schooling and presence of a partner (socioeconomic), age (maternal biological), paid work (behavioural), high blood pressure, bleeding, early rupture of membranes and hospitalisation (morbidity indicators) and antenatal consultations.
[c] Intrauterine growth restriction adjusted for schooling (socioeconomic), age and skin colour (maternal biological); smoking (behavioural), high blood pressure, untreated infection, depression, hospitalisation and use of medications (morbidity indicators).
[d] Maximum likelihood ratio test; p for linear trend

Our main finding was the protective effect of leisure-time walking on low birth weight and preterm birth. Further studies are needed to confirm these findings and to evaluate the risks and benefits of physical activity before and during pregnancy. In particular, there is a need for conducting randomized intervention studies focusing on reducing physical inactivity and stimulating leisure-time walking that could provide input for designing programs aimed at promoting physical activity among pregnant women, and thus improving maternal-fetal health.

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