The relationship between maternal physical activity during pregnancy and birth weight

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Introduction: Earlier studies in India have demonstrated an inverse relationship between physical activity and birth weight in rural women who had high levels of physical activity related to agricultural and domestic activities. There are no data on urban Indian women from a wide range of socio-economic backgrounds with varying levels of physical activity. This study assessed the role of different domains of physical activity during pregnancy and its relation to birth weight.

Methods: Data on maternal anthropometry and maternal physical activity level were collected at the 1st trimester (baseline), the 2nd trimester and the 3rd trimester of pregnancy. Birth weight for 546 live born babies was measured immediately after delivery.

Results: The time spent in sedentary activities (median “cut-off” of 165 min/d) was significantly associated with maternal body weight in the first trimester of pregnancy (51.2 kg vs. 54.1 kg, \(p<0.001\)). Women in the highest tertile of physical activity level in the 1st trimester were 1.58 times (95% CI: 1.02-2.44) more likely of having a baby in the lowest tertile of birth weight with reference to the first tertile. This significant association continued after adjustment for maternal weight and energy intake.

Conclusion: The present study shows that physical activity in the first trimester is associated with low birth weight in Indian babies.

Key Words: pregnancy, physical activity, low birth weight, nutrition, India

INTRODUCTION

Women from developing countries are at higher risk of poor birth outcomes, including low birth weight, abortions, still births and pre-term deliveries. Maternal and neonatal morbidity are also high in developing countries like India. An association between birth weight and maternal factors such as age, parity, access to primary health, maternal pre-pregnant nutritional status including maternal weight and dietary intake has been demonstrated in some earlier Indian studies. Earlier results from the cohort being studied in the present report have also shown that a low antenatal Vitamin B₁₂ level is significantly associated with low birth weight.

An important additional effect on birth weight could be daily physical activity which is an important and variable factor in the antenatal period, since women have variable physical activities at work outside the house and with domestic household chores. The importance of this is highlighted in studies which have demonstrated that manual physical activity during pregnancy is associated with small for gestation age (SGA) babies and lower birth weights and pregnancy weight gain, particularly when energy intake is sub-optimal. Similarly, strenuous physical work during pregnancy has also been associated with increased rates of abortion and pre-term delivery. Increased household chores have been related to preterm birth, while the evidence for leisure time physical activity suggests that participation in moderate to vigorous activity throughout pregnancy may enhance birth weight, with more intense physical activity regimens resulting in the opposite effect. In India, studies have demonstrated an inverse relationship between daily physical activity and birth weight in a cohort of rural women, the majority of whom had high levels of physical activity related to agricultural and domestic activities. However, there are no data on urban Indian women from a wide range of socio-economic backgrounds with varying levels of physical activity.

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Therefore, this study was conducted to assess the relationship between maternal physical activities in different domains either at home or at the work place as well as of the aggregate PAL in all trimesters of pregnancy, with birth weight, in a cohort of urban Indian women from a wide range of socio-economic backgrounds.

SUBJECTS AND METHODS

Study Design
The study was a prospective cohort study of 546 pregnant women conducted at St John’s Medical College Hospital, Bangalore, India, to determine the association between maternal physical activity during pregnancy and birth weight. This hospital caters to patients from diverse socio-economic status. The Institutional Ethical Review Board at St John’s Medical College Hospital approved all study procedures, and written informed consent was obtained from each study subject at enrollment.

Study population
All pregnant women aged 17-40 years who were below 20 weeks of gestation, and registered for antenatal screening at the Department of Obstetrics and Gynecology at St John’s Medical College Hospital were screened for the study. Details of the study design of this prospective study have been described earlier. In brief, women with multiple pregnancies, a clinical diagnosis of chronic illness such as diabetic mellitus, hypertension, heart disease and thyroid disease as well as women who tested positive for hepatitis B, HIV or syphils infections were excluded from the study. In addition, women who anticipated moving out of the city before delivery were not recruited.

Of 923 women who consented to be part of the study, 850 women were recruited into the study; (73 women were excluded for the following reasons: 57 subjects were planning to deliver their babies outside Bangalore area; 1 was diabetic; 5 had twin pregnancies; 7 tested positive for VDRL, Hepatitis B and HIV infections, 2 subjects were not pregnant and 1 subject had chickenpox), 103 were lost to follow up and 113 delivered in a facility outside of St. John’s Medical College Hospital. A total of 634 women delivered at St. John’s Medical College Hospital; 46 of them had fetal losses and the remaining 588 had live births. Birth weights for 547 live born babies were measured within 24 hours of delivery; 20 babies had their birth weights recorded within 48 hours of delivery. Neonates of mothers who had gestational diabetes mellitus (GDM) were excluded from this analysis (proportion of mothers with GDM = 3.7%, n=21), leaving 546 cases in this study set.

Sociodemographic and anthropometric information
Information on age, parity, education, occupation, socio-economic status and tobacco use was collected at recruitment. None of the women consumed tobacco in any form. The exact gestational age was calculated from the reported first day of the last menstrual period (LMP) and confirmed by a subsequent ultrasonographic scan within 2 weeks of the initial visit. In addition, data on maternal anthropometry and maternal physical activity level were collected by trained research assistants at the 1st trimester (baseline, 12.3 ± 3.0 weeks), the 2nd trimester (24.2 ± 1.4 weeks) and the 3rd trimester (34.1 ± 1.5 weeks) of pregnancy. Weight was recorded using a digital balance (Soehnle, Germany) to the nearest 100 g; height was measured using a stadiometer to the nearest 1 cm. Maternal body mass index (BMI) was calculated using weight (kg) and height (m) at baseline (kg/m²). Maternal weight gain in the second trimester was calculated as the average weekly weight gain between the weight measured at baseline and the weight measured at the second trimester of pregnancy. Similarly, weight gain in the third trimester was calculated as the average weekly weight gain between the weight measured at the second trimester and that measured at the third trimester of pregnancy.

Dietary data
Habitual dietary intake for the preceding 3 months of each trimester was assessed using a food frequency questionnaire (FFQ) that was interviewer administered by a trained research assistant. This questionnaire was developed for the urban middle class residing in South India. Nutrient composition of the food item was calculated using standard food conversion tables for the ingredients. Whenever available, Indian data was used. However, for some nutrients, for which Indian data was not available, USDA data in the public domain was used. This FFQ was validated against three 24-h food recalls (n=100) for each of the three trimesters of pregnancy (Dwarkanath et al, unpublished data, 2005).

Physical activity questionnaire
The physical activity information was obtained using a previously validated physical activity questionnaire. This interviewer based questionnaire, designed for urban settings, accounted for the activities (duration and frequency) performed during the day (24 hours). Information was collected for activities in 5 domains – occupational activity outside the house, discretionary exercise, household chores, sedentary activities, hobbies and sleep. If the duration of activities did not add up to 1440 minutes in a day, the residual time was assigned a sedentary activity value. Following this, physical activity ratios (PAR) were assigned for each of the activities reported using comprehensive tables for the cost of physical activities. Where the PAR for an activity was not available, the PAR for the most closely related activity was used.

Physical activity data are expressed as the duration (minutes/day), or as the product of the intensity (PAR) and duration (PAR-min). A composite measure of daily physical activity, the physical activity level (PAL), was also calculated, as the ratio of the total energy expenditure (TEE; kJ/day) and the basal metabolic rate (BMR; kJ/day). Basal metabolic rate was estimated using standard WHO equations, and this was used as the value throughout pregnancy, since earlier work on pregnant urban South Indian women has demonstrated that the BMR expressed per kg body wt/day was not significantly different across the three trimesters of pregnancy. The physical activity questionnaire was assessed for its repeatability and validity. The estimates of physical activity were highly repeatable, when the questionnaire was re-administered within a 4 wk period (e.g., r=0.86, p<0.01 for 24-h energy expenditure). Relative validity was
Table 1. Maternal socio-demographic characteristics at baseline

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>24.4 ± 4.1</td>
<td>546</td>
</tr>
<tr>
<td>Gestational age, (LMP in weeks)</td>
<td>12.3 ± 3.0</td>
<td></td>
</tr>
<tr>
<td>Parity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>327 (59.9)</td>
<td>546</td>
</tr>
<tr>
<td>1-2</td>
<td>204 (37.4)</td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td>15 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Educational level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to middle school</td>
<td>184 (33.7)</td>
<td>546</td>
</tr>
<tr>
<td>High school &amp; Diploma</td>
<td>222 (40.7)</td>
<td></td>
</tr>
<tr>
<td>University degree and above</td>
<td>140 (25.6)</td>
<td></td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed outside the home</td>
<td>159 (29.1)</td>
<td>546</td>
</tr>
<tr>
<td>Housewives</td>
<td>387 (70.9)</td>
<td></td>
</tr>
</tbody>
</table>

LMP = Last menstrual period; 1Mean ± SD; 2N (%)

Table 2. Maternal anthropometric and physical activity characteristics at baseline

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>52.6 ± 9.6</td>
<td>546</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.55 ± 0.06</td>
<td>546</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.0 ± 3.9</td>
<td>546</td>
</tr>
<tr>
<td>PAL</td>
<td>1.47 ± 0.16</td>
<td>546</td>
</tr>
<tr>
<td>PAL Domains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupation (PAR-min)</td>
<td>275 ± 468</td>
<td>546</td>
</tr>
<tr>
<td>Household Chores (PAR-min)</td>
<td>511 ± 290</td>
<td>546</td>
</tr>
<tr>
<td>Sleep (min)</td>
<td>493 ± 56</td>
<td>546</td>
</tr>
<tr>
<td>Sedentary activity (min)</td>
<td>175 ± 102</td>
<td>546</td>
</tr>
<tr>
<td>Discretionary exercise (PAR-min)</td>
<td>25.1 ± 53.7</td>
<td>546</td>
</tr>
<tr>
<td>Weight gain (kg/week)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-24 wk gestation</td>
<td>0.39 ± 0.20</td>
<td>405</td>
</tr>
<tr>
<td>24-34 wk gestation</td>
<td>0.49 ± 0.25</td>
<td>335</td>
</tr>
</tbody>
</table>

Mean ± SD; Numbers of subjects for each measurement vary because of missing values later in pregnancy.

Table 3. Maternal weight in relation to levels of physical activity in the three trimesters of pregnancy.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maternal weight (kg)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trimester 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary activity</td>
<td>53.5 ± 10.2</td>
<td>198</td>
</tr>
<tr>
<td>Moderate activity</td>
<td>51.8 ± 9.0</td>
<td>150</td>
</tr>
<tr>
<td>Trimester 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary activity</td>
<td>57.4 ± 10.2</td>
<td>150</td>
</tr>
<tr>
<td>Moderate activity</td>
<td>59.7 ± 10.4</td>
<td>100</td>
</tr>
<tr>
<td>Trimester 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary activity</td>
<td>62.7 ± 10.7</td>
<td>183</td>
</tr>
<tr>
<td>Moderate activity</td>
<td>61.3 ± 9.9</td>
<td>88</td>
</tr>
</tbody>
</table>

Mean ± SD; Numbers of subjects for each measurement vary because of missing values later in pregnancy; No significant differences in body weight between women with sedentary and moderate activities in each trimester of pregnancy

assessed by comparing energy intake (using repeated 24 h dietary recalls) and expenditure (using the physical activity questionnaire) over the same period. A correlation between the two measures was; r=0.33, p<0.05. 17

Birth data
The baby birth weight was measured to the nearest 10 g soon after delivery on a standard beam scale balance.

Statistical analysis
All analyses were done with the SPSS program (version 13.0, SPSS, Chicago, IL). Results are presented as mean ± SD. Logistic regressions models were used to identify the significant predictors of birth weight among maternal physical activity domains during pregnancy. For logistic regression, the birth weight was divided into tertiles and further divided into two groups to obtain a binary variable; group 1 (lowest tertile) and group 2 (higher two tertiles). A multivariate model (with 3 covariates) was developed with maternal weight, energy intake and education level. Two-sided p values <0.05 were considered statistically significant. For analysis, the exercise domain was treated as a categorical variable (presence or absence) among the mothers in the three trimesters. Those mothers who exercised during their pregnancy, were further classified as low or high exercisers using 105 PAR-min (median value) as the cut off. Similarly, the work domain was also treated as a categorical variable (working or not working). Women who worked outside the home were assigned to low or heavy categories using a median value of 975 PAR-min as the cut-off. The household chores domain was expressed in terms of PAR-min while the sedentary activity and sleep domains were expressed in terms of duration.

RESULTS
Maternal socio-demographic information is presented in Table 1. The mean age of the study subjects was 24.4 ± 4.1 years, ranging from 17 to 40 years, and the mean gestational age was 12.3 ± 3.0 weeks at enrolment. About 60% of the mothers were primiparous; educational status of the women was very variable. A large proportion of the women were housewives (71%). The mean birth weight was 2812 ± 471 g with a mean gestational age of 38.5 ± 1.6 weeks. Maternal energy intake during pregnancy was 2058 ± 603 (n=545), 2189 ± 510 (n=410) and 2234 ± 635 (n=411) kcal/d, respectively, in the three trimesters.

Maternal anthropometry and PAL of the mothers at recruitment are presented in Table 2; the mean weight and height of the women was 52.6 ± 9.6 kg and 1.55 ± 0.06 m respectively. About one in six mothers had a low BMI at recruitment (< 18.5 kg/m2). The mean PAL of the mothers at recruitment was 1.47 ± 0.16. Since physical activity and maternal body weight are expected to be inversely associated, and this association is a link between physical activity and birth weight, we assessed maternal weight at each trimester with respect to activity groupings based on the PAL (sedentary and mild activity PAL ≤ 1.40, moderate activity PAL ≥ 1.55). There was no significant difference in maternal weight between the activity groups based on PAL throughout the pregnancy (Table 3). In terms of specific domains of activity, the time spent in sedentary activities (using a cutoff of 165 min as a median) was significantly associated with maternal body weight in the first trimester of pregnancy (51.2 kg vs. 54.1 kg, p<0.001). This association did not persist as the pregnancy progressed. The time spent on household chores and duration of sleep also did not affect maternal body weight. Birth weight was associated with maternal weight in the 1st trimester as well as with gestational...
weight gain in the 2nd trimester. Women in the lowest tertile of weight in the 1st trimester were 2.16 times (95% CI: 1.01-2.44) more likely to have a baby in the lowest tertile of birth weight.

A direct link between physical activity and birth weight was also assessed. Maternal PAL was assessed for associations with birth outcomes (Table 4); by univariate analysis, women belonging to the highest tertile of PAL in the first trimester had significantly higher odds (OR: 1.58, 95% CI: 1.02-2.44) of having a baby in the lowest tertile of birth weight (p<0.05). This significant association continued when adjusted for maternal weight (OR: 1.57, 95% CI: 1.01-2.44), and energy intake (OR: 1.57, 95% CI: 1.01-2.44). However after adjusting for maternal education, PAL in the 1st trimester was not a significant predictor of low birth weight (OR = 1.07-3.34, p=0.028).

**DISCUSSION**

In developing countries like India, women are responsible for a wide range of household work and childcare duties, as well as work outside the home. These women are also the women at highest risk for a poor birth outcome. The present study assessed associations between birth weight and maternal physical activity, but since maternal weight in the first trimester and gestational weight gain is associated with birth weight, associations between physical activity and these maternal anthropometric indices were also assessed. Physical activity can be assessed through an integrated index such as PAL, assessed through the administration of a physical activity recall questionnaire, or, through the assessment of the time spent in, and the intensity of, different activities in the domains of work, domestic chores, transport, leisure and sleep. The instrument used in the present study to measure physical activity, and by extension, energy expenditure, was an interviewer administered questionnaire, which is admittedly a relatively crude measure. However, its strengths lay in its simplicity and its ease of use across different settings and populations. Ideally, one would require an instrument that was tested against a gold standard for total energy expenditure, however, there was no such instrument available at this time in India.

The relationship between physical activity and birth weight might be expected to operate through the maternal...
weight either at the first trimester, or in terms of gesta-
tional weight gain, since these variables are associated
with birth weight. In this framework, relationships might
be expected between physical activity and maternal
weight or gestational weight gain; in sequence, these an-
thropometric variables might have a subsequent relation-
ship with birth weight, and finally, a direct relationship
between maternal physical activity and birth weight might
also be demonstrated. If this latter relationship were ad-
justed for maternal weight, it suggests that maternal
physical activity has a direct association with birth weight,
independent of its effects on maternal weight gain. In the
present study, women who had moderate/heavy physical
activity in the 1st trimester of pregnancy had a signifi-
cantly higher odds of giving birth to lower birth weight
babies as compared to women who had sedentary physical
activity. This significant relationship could not be
completely demonstrated for the 2nd and 3rd trimesters.

The significant association between maternal activity
and birth weight continued even after adjusting for ma-
ternal weight. Gestational age was not adjusted for in this
relationship since we found that the gestational age did
not vary between the tertiles of physical activity in the
mother. This is in agreement with an earlier study and a
meta analysis in which the length of gestation was
shown not to be associated with maternal physical activity.
It is not clear as to what the maternal weight-
indipendent relationship between physical activity and
birth weight implies. It could be related to the body com-
position of the mother linked to different amounts of en-
ergy stores.

Since the PAL is an aggregate index of all physical ac-
tivities, it is worth analyzing maternal physical activity in
separate activity domains with respect to birth weight.
Leisure time exercise was not significantly associated
with maternal weight during the first and second trimes-
ters and this remained even with categories of low/medium or heavy exercise. Moreover leisure time
activity was reported only in a small proportion of women
(abput 27%) and hence this relationship of non signifi-
cance could be related to the small numbers.

In the domain of household chores, earlier studies have
shown correlations between activity in this domain and
preterm births. Mothers who did half or less of their
household chores delivered 9.4 % of the preterm babies
compared with the 4.9 % delivered by the mothers who
completed all chores. In the present study, there was
no effect of household activity on the maternal weight,
weight gain, or with birth weight. In addition, sleep was
not related to baby birth weight, but this might also be
due to a very small scatter of the number of hours re-
ported to be spent in sleep. We also quantified the dura-
tion of time spent in sedentary activities, and could not
demonstrate a direct relationship with birth weight. This
is in contrast to studies that have been able to demonstrate
a direct effect between maternal rest (greater than 21 days
in the last trimester) and birth weight and birth length.

The present study has shown that heavy work outside
the home in any of the trimesters was not associated with
birth weight. However there was a trend of higher birth
weight among women who reported light work outside
home in the third trimester as compared to those reported
heavy work. Few studies have shown association of work
in the third trimester and preterm births and low birth
weight. In one study, a 150g – 400 g decrease in birth
weight occurred in women who continued to work out-
side the home during the third trimester compared with
those who remained at home during pregnancy. A simi-
lar, non-significant, decrease of 181 g in birth weight for
babies of women who worked in a heavy mode outside
the home during the third trimester was observed in the
present study. Reports from Africa also show that hard
physical work by women during pregnancy can retard
fetal growth and increase fetal/neonatal mortality. Indeed,
the detrimental effect of third trimester work upon birth weight has been reported to be exacerbated if
pregnant women worked in a standing position, were hy-
ptensive, were poorly nourished, or had other young
children at home. These parameters were not assessed in
the present study.

In conclusion, the present study shows that physical ac-
tivity in the first trimester of pregnancy is an important
factor in determining birth weight in Indian babies, even
after accounting for baseline maternal weight, energy
intake and educational status. Significant associations of
higher maternal weight or gestational weight gain with
lower physical activity were not found in the present
study, and it is possible that physical activity may have as
yet unexplained direct effects on birth weight.

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AUTHOR DISCLOSURES
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Original Article

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婦女懷孕期間的體能活動與嬰兒出生體重的相關性

前言：印度早期的研究指出，從事大量與農業以及家事的鄉村婦女，其體能活動與嬰兒出生體重為負相關。目前還沒有印度城市地區，較大範圍的社經背景及各種強度的體能活動量的婦女的相關數據。本研究評估婦女懷孕期間，不同狀況的體能活動量與對其嬰兒出生體重的角色。方法：收集婦女妊娠第一期、第二期與第三期的體位資料及體能活動量。在分娩後立即測量 546 名活產嬰兒之出生體重。結果：花費在靜態活動的時間(中位數切點為 165 分/天)與婦女妊娠第一期時的體重顯著相關(51.2 公斤 vs. 54.1 公斤，p<0.001)。當妊娠第一期的體能活動量位在最高三分位，其產下的嬰兒出生體重在最低三分位的機會為在體能活動量最低三分位者的 1.58 倍。在校正婦女體重與熱量攝取量之後，仍然顯著性。結論：本研究顯示第一孕期的體能活動量與印度嬰兒低出生體重相關。

關鍵字：懷孕、體能活動、低出生體重、營養、印度。