Sex Differences in Birth Weight and Physical Activity in Japanese Schoolchildren

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ABSTRACT

Background: Lower birth weight (BW) is associated with increased chronic disease risk later in life. Previous studies suggest that this may be mediated principally via physical activity (PA). However, the association between BW and PA in children has not been clarified. The purpose of this study was to examine the association between BW and PA in school-aged children in Japan.

Methods: Participants were children from a prospective birth cohort study (Project Koshu) who were born from 1996 through 2002 in rural Japan. BWs were obtained from the Maternal and Child Health Handbook. Data on PA during childhood were collected using a self-reported questionnaire when participants were 9–15 years of age in July 2011. Analysis of covariance was used to evaluate exercise duration; Poisson regression analysis was used to evaluate if the recommended PA amount was met.

Results: Data from 657 children (boys: 54.8%, follow-up rate: 77.6%) were analyzed. Compared with the normal BW group, only girls in the low-BW group had significantly lower PA level (normal BW, 11.4 [standard error, 1.0] hours/week; low BW, 5.8 [standard error, 3.6] hours/week, P = 0.010), and were more likely to not meet the recommended PA level (prevalence ratio 1.57; 95% CI, 1.14–2.16).

Conclusion: Low BW was associated with a lower PA level in school-aged girls but not boys. Earlier consideration of BW may be an important public health strategy to prevent physical inactivity in school-aged girls.

Key words: birth weight; physical activity; school-aged children

INTRODUCTION

Physical activity (PA) is one of the most important contributors to maintaining optimal health, and considerable evidence suggests that sufficient PA has the potential to prevent numerous diseases and provide health benefits to people of all ages.1-4 Studies suggest that school-age PA influences adult PA and health status in later life.5-8 PA promotion may be effective if initiated in childhood or earlier in life.

However, globally, 81% of school-going children and adolescents aged 11–17 years do not meet the recommended guideline9 of at least 60 minutes of moderate-to-vigorous PA daily.1 Among Japanese children, no representative data is available on whether PA levels are being met according to the official national PA guidelines.10,11 According to the Japan sports agency survey, which assessed adequacy of PA based on other criteria (420 min/week), 44.3% of boys and 67.3% of girls in 5th grade (aged 10–11 years) and 15.8% of boys and 39.5% of girls in the second year of junior high (aged 13–14 years) engaged in exercise for less than 420 min per week, not including that in physical education classes.12 Hence, the majority of Japanese school-aged children do not achieve PA recommendations.

Therefore, to develop effective public strategies promoting PA in children and adolescents, a better understanding of its intrinsic and extrinsic determinants is required. To date, a broad range of factors has been investigated, including interpersonal, demographic, biological, psychological, social, cultural, and environmental factors.13-16 In addition, recently, it has been suggested that birth weight (BW) is associated with PA later in life.17-19 Numerous epidemiological studies substantiated a close association between low BW and an increased risk of chronic diseases.20-22 A meta-analysis suggested a lower probability of undertaking leisure-time PA in adolescent and adults with a low or high BW,23 which indicated that the association between BW and higher risk of metabolic diseases in adulthood could partly be explained by lower rates of PA in childhood.19,23 Meanwhile, not all studies have consistently confirmed the association between BW and PA among children and adolescents.24 Moreover, to the
best of our knowledge, no studies have investigated this
association in Japanese school-aged children.

The aim of this study was to examine the association between
BW and PA in school-aged children in Japan.

METHODS
Study participants
The study participants comprised children born in the Enzan area
of Koshu City, Yamanashi Prefecture, Japan between April 2, 1996 and April 1, 2002. The participants were from Project
Koshu, a community-based prospective birth cohort study. Project Koshu is an ongoing study started in 1988, in which all expectant mothers who responded to a survey during the
obligatory visit at the city office for pregnancy registration were
recruited into the cohort. The children were followed from birth
onwards. Further details of the project have been reported
elsewhere. The data of the present study were based on a
follow-up study carried out during 2011.

This study was approved by the Ethics Review Board of the
University of Yamanashi School of Medicine and conducted in
accordance with the Guidelines Concerning Epidemiological Research, with cooperation of Health Promotion Division and
Board of Education of the Koshu City administration office.
Informed consent was obtained from the participants.

Measurements
Assessment of BW
Data regarding the sex of the infants, BW and birth length, and
gestational age at delivery were obtained from the data recorded
in the Maternal and Child Health Handbook by the obstetrician
or midwife in charge of delivery. This handbook is an official
publication containing guidelines for obstetric professionals and
pregnant women. These data were based on birth registration.
Low BW was defined as BW <2,500 g. As a previous study
provides evidence that low (<2,500 g) and high (≥3,500 g) BWs
are associated with a lower probability of undertaking leisure-
time PA. BW was categorized into the following three groups:
low (<2,500 g), normal (2,500–3,499 g), or high (≥3,500 g).

Assessment of PA
Data concerning PA was obtained from children using a self-
reporting questionnaire conducted in July 2011. The following
question was used to obtain PA levels: “How many hours per
week do you usually spend on PA except for physical education
class (for example, school club activity, sports club activity, or
swimming or tennis school, etc)?” This simple question has been
used for other studies in children and has shown acceptable
validity. To investigate whether there is a difference between
BW and PA in children who did and did not meet the guideline
for PA for Japanese children, participants were classified into
two groups according to whether they met the recommended
guidelines (>60 min/day; ie, ≥7 hours/week).

Assessment of covariates
Gestational age, age in months, body mass index (BMI) during
childhood, and parental educational levels were identified as
potential confounders based on previous studies. Age and
BMI of children were collected via physical measurements taken
during medical checkups conducted at elementary and junior high
schools, which are measured annually in April for each grade, in
accordance with Japanese School Health and Safety Law. BMI
(kg/m²) was calculated from height and weight. Participants were
classified as overweight (equivalent to BMI ≥25 kg/m² at 18
years old) or non-overweight based on age- and sex-specific
international cut-off points for BMI. The highest parental
educational levels were collected from mothers using a self-
reported questionnaire at pregnancy registration. The responses
were collapsed into two categories by number of education years:
≤12 years (up to high school) and ≥13 years (college or higher).
A variable was then created combining the highest education
level by each parent as follows: ≤12 years (both parents), ≥13 years
(only father), ≥13 years (only mother), and ≥13 years (both
parents).

Statistical analysis
Data were analyzed separately for boys and girls based on the
results of a previous study that revealed sex difference in PA
levels. Analysis of covariance was used to compare the mean
PA time across BW groups. When prevalence of an outcome is
common in the study population (>10%), the odds ratio derived
from logistic regression tends to overestimate the strength of
an association. The prevalence of children not meeting the
recommended guideline for PA was high. Therefore, Poisson
regression analyses with robust variance estimators were
carried out. The associations between BW and PA were
conducted to examine the associations between BW and the
proportion not meeting recommended PA, and prevalence ratio
(PR) was used instead of odds ratio. Then, the analyses were
adjusted for gestational age, age in months, age- and sex-specific
BMI categories (overweight or non-overweight), and parental
education levels.

All statistical analyses were performed using SPSS statistical
software version 19.0 (SPSS Inc., Chicago, IL, USA). A P-value
<0.05 (two-sided) was considered statistically significant.

RESULTS
Characteristics of participants
During the study period, maternal information during pregnancy
and BW were collected from 847 children. Of these, the complete
follow-up data in 2011 were collected from 657 children (boys:
54.8%). Therefore, the follow-up rate at 9–15 years of age was
77.6%. Table 1 shows the characteristics of the participants. The
range of BW, birth length, and gestational age was 1,404–4,336 g,
33–58 cm, and 33–42 weeks, respectively.

There was no significant difference in birth data between boys
and girls, except for gestational age. Height and PA time of boys
were significantly higher than those of girls; thus, girls were more
likely not to meet the recommended PA (Table 1).

Differences in PA time according to BW categories
No significant differences were found in PA time among BW
categories in boys (Figure 1A). There was a significant difference
in PA time spent between the low-BW and normal-BW groups
in girls (Figure 1B). No significant differences were observed
between normal- and high-BW groups and high- and low-BW
groups in girls.

BW and attainment of recommended PA
In girls, when compared with the normal-BW group, those in
the low-BW group were more likely not to meet the recommended
PA (Table 2). This association remained when adjusted for all
confounders. For the high-BW group, no significant association
was observed. No significant associations were found for boys.
that children aged 12 years with low BW participate in less outdoor PA. Although the exact mechanisms for the difference in time spent in PA between low- and normal-BW individuals are unknown, previous studies have shown that low BW could be related to reduced physical capacity, including reduced muscle strength, and insufficient anaerobic capacity. These negative physiological factors could reduce the willingness to participate in competitive PA because of early fatigue and a reduced ability to perform PA.\textsuperscript{18,23} However, our study found this association only in girls. It is unclear why this sex difference was observed; we speculate that it may be explained by the difference in time spent in sports activities and PA between boys and girls. In Japan, available opportunities for girls to participate in sports or PA are limited compared to boys. Parents spend less money on sports activities and PA for girls than boys, whereas they spend three times more on artistic activities for girls.\textsuperscript{37} Therefore, girls with low BW who are thought to have poor exercise capacity may have been participating in non-exercise activities, such as music and the arts (eg, piano lessons). In addition, animal studies have indicated that intrauterine growth restriction leads to low BW and causes decreased PA, especially in female mouse offspring.\textsuperscript{18} Although it is unclear why this occurred, the mechanism of sex-specific alterations in epigenetic regulation in the hypothalamus and other regions of the central nervous system has received attention;\textsuperscript{30} it has been suggested that androgen-mediated masculinization of the male mouse brain (which occurs during late fetal development) protects the central nervous system against the deleterious effects of fetal growth restriction.\textsuperscript{40} It is uncertain whether similar processes occur in humans; thus, extensive future studies are required to elucidate the molecular mechanism by which fetal growth restriction may lead to a lack of PA participation.

Meanwhile, other studies that objectively measured PA with an accelerometer did not confirm the association between BW and PA in children and adolescents.\textsuperscript{24,34} It is possible that objective measures of PA and self-reported PA are capturing different aspects of PA. A previous study suggested that self-reported PA may capture only specific types of exercise and leisure-time PA, whereas accelerometers measure all body movement throughout a measurement period.\textsuperscript{41} Although sex was adjusted for in all of
Table 2. Association between birth weight categories and not meeting the recommended physical activity at aged 9–15 years

<table>
<thead>
<tr>
<th>Birth weight categories</th>
<th>Physical activity (≥7 hours/week), %</th>
<th>Crude PR (95% CI)</th>
<th>Adjusted PR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (&lt;2,500 g)</td>
<td>25.9</td>
<td>0.96 (0.50–1.87)</td>
<td>0.83 (0.43–1.61)</td>
</tr>
<tr>
<td>Normal (2,500–3,499 g)</td>
<td>27.0</td>
<td>1.00 (reference)</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>High (≥3,500 g)</td>
<td>12.5</td>
<td>0.46 (0.20–1.08)</td>
<td>0.50 (0.22–1.16)</td>
</tr>
<tr>
<td><strong>Girls</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (&lt;2,500 g)</td>
<td>68.2</td>
<td>1.57 (1.14–2.16)</td>
<td>1.59 (1.12–2.26)</td>
</tr>
<tr>
<td>Normal (2,500–3,499 g)</td>
<td>45.4</td>
<td>1.00 (reference)</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>High (≥3,500 g)</td>
<td>38.7</td>
<td>0.89 (0.56–1.42)</td>
<td>0.96 (0.65–1.43)</td>
</tr>
</tbody>
</table>

CI, confidence interval; PR, prevalence ratio.
*Adjusted for age in months, age- and sex-specific body mass index category (overweight or non-overweight), gestational age, and parental education level.

In conclusion, this study found that Japanese school-aged girls, but not boys, with low BW were less likely to spend time in PA at aged 9–15 years old. Although further prospective studies are needed, our study suggests that low BW may be an early predictor of physical inactivity in childhood. Therefore, parents of low-BW children should encourage them to be active and to participate in noncompetitive PAs. Additionally, to prevent physical inactivity in childhood, especially for girls, an important public health strategy should be implemented that is aimed at encouraging participation in PA for low-BW children. These may lead to prevention of chronic disease in adulthood.

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