Correlation of month and season of birth with height, weight and degree of obesity of rural Japanese children

Hisako Tanaka¹, Masako Sei¹, Tran Quang Binh¹,², Hokuma Munakata¹, Kyoko Yuasa¹, and Yutaka Nakahori¹

¹Department of Human Genetics and Public Health, Institute of Health Biosciences, The University of Tokushima Graduate School, Tokushima, Japan; and ²National Institute of Hygiene and Epidemiology, Vietnam

Abstract: Month and season of birth are thought to influence height, weight and degree of obesity in schoolchildren. A cross-sectional study was designed to measure the height and weight of all children aged 6-15 years attending primary and junior high schools in Tokushima Prefecture, Japan. Data were standardized (z-scores) and analysed separately by gender and age. The mean z-score for height and weight were the highest in subjects born during the months of spring and the lowest in those born during the months of winter ($p < 0.0001$), whereas the means were significantly higher in children born during the months of summer than in those born during the months of autumn ($p < 0.0001$). A gradually decreasing trend of height and weight was observed in children of both genders born between May and Mar (from spring to winter). There was no significant difference in degree of obesity among the four seasons of birth for boys and girls. The highest prevalence of obese boys have born during spring (among 6-year-old boys) and summer (among 7-year-old boys), whereas the highest prevalence of obese girls have born during spring (among 6-year-old girls) and winter (among 10-year-old girls). Our findings suggest that month and season of birth influence height and weight of schoolchildren in Tokushima but not their degree of obesity. J. Med. Invest. 54: 133-139, February, 2007

Keywords: month of birth, height, weight, degree of obesity, schoolchildren

INTRODUCTION

Obesity in children is one of the most serious public health problems in Japan (1). The prevalence of obese children has been increasing remarkably each year (2), and a large proportion (54.7%) of obese Japanese children aged 6-15 years develop adulthood overweight or obesity (3). Overweight and obesity are particularly serious in Tokushima Prefecture, a rural area located in Shikoku Island, where about 15% of boys and 14% of girls were obese (unpublished data, 2000). Among Tokushima children aged 6-16 years, 1.85% were severely obese; of these, 80.4% showed at least one of eight complications (hypercholesterolaemia, low serum high-density lipoprotein cholesterol, hypertriglyceridaemia, hyperuricaemia, hyperglycaemia, hyperinsulinaemia, liver dysfunction and hypertension) (4). To deal with these problems, a committee (Committee for Prevention Strategy against Lifestyle-related Disease) was set up by the Tokushima Prefecture Medical Association in 2000 to collect data on physical growth and obesity for better interventions. Since then, the physical growth of schoolchildren and obesity have been
studied from several aspects, including geographical, environmental and lifestyle factors. One aspect that needs to be taken into account is the effect of month of birth on physical growth (height, weight) and degree of obesity in Tokushima schoolchildren.

The apparent influence of birth month on many human traits has been reported in several studies. Birth month affects human conceptions and births (5), sex ratio at birth (6), menarche (7), lifespan (8) and the probability of falling ill (9), such as the risks of breast cancer (10) and cerebrovascular diseases (11). Month of birth has also been shown to influence the later height and weight of both children and adults in various countries (12-15). However, these findings are inconsistent owing to small sample size, geographical and socioeconomic differences, and lack of analysis stratified by gender and age. It is necessary to conduct researches in different geographical locations, climates and cultures. Therefore, we performed a cross-sectional study in a large sample to investigate the effects of month and season of birth on height, weight and degree of obesity in Tokushima schoolchildren.

SUBJECTS AND METHODS

Subjects

This cross-sectional study, a part of the activities of the Committee for Prevention Strategy in Tokushima Prefecture, was carried out from Apr to Jun 2003 in all 269 primary schools and 94 junior high schools of Tokushima Prefecture, Japan. A total of 69,693 schoolchildren (35,884 boys and 33,809 girls) aged 6-15 years were enrolled in this study.

Measurements

Data on region, school, grade, sex, birthday, height and weight were collected using the methods recommended by the Japanese government (16). School nurses (Yogo-teacher) took all the anthropometrical measurements. Height was measured to the nearest 0.1 cm, with the subject standing without shoes. Weight was measured to the nearest 0.1 kg with only underclothing. Because the standard body mass index (BMI) varies with the stage of growth, we adopted the degree of obesity as the criterion for being obese, which was calculated by the method described by Murata, et al. (17) and the Japan Society for the Study of Obesity (18): degree of obesity (DOB) = (weight - standard weight)/standard weight × 100.

A child was classified as obese if his or her DOB was ≥ 20%. According to the Japanese calendar, the four seasons are spring (Apr to Jun), summer (Jul to Sep), autumn (Oct to Dec) and winter (Jan to Mar).

Statistical analysis

To nullify the effect of child’s age being taken as a confounding factor, height and weight were standardized (z-scores) with respect to the Tokushima School Health Statistics reference. Data were then analysed separately by gender and age. Since the z-score for height was normally distributed, multiple group comparisons were made by one-way ANOVA and group differences were assessed using Tamhane’s T2 post hoc test. Because the z-score of weight and DOB was not normally distributed after transformation, we performed the Kruskal-Wallis test and Dunn’s procedure to investigate the relationship of month and season of birth to z-score of weight and DOB. p < 0.05 was considered statistically significant. We also used the χ²-test to evaluate the relationship between month, season of birth and obesity. The adjusted residual was then calculated, and values of adjusted residual ≥ +2 or ≤ -2 were regarded as statistically significant (19). All statistical procedures were performed using SPSS version 11.0 (SPSS, Inc., Chicago, IL).

RESULTS

Trend in anthropometrical measurements according to month and season of birth

Data on height, weight and DOB of the schoolchildren by gender according to the month of birth are presented in Table 1. As shown in Fig. 1a,b, average z-scores of height and weight increased from Apr, reached a peak for births in May and then gradually decreased in children born between May and Mar. This tendency was repeated annually, with a peak in May or Jun during eight consecutive years (1989-1996), when we analysed data by year of birth (data not shown). Further comparative analyses showed statistically significant differences in height and weight z-scores among months of birth (p < 0.0001). The average z-scores of height and weight were the highest for the months of spring (May and Jun) and the lowest for the months of winter (Jan, Feb and Mar) compared with other seasons (p < 0.0001). These values were significantly higher in the months of summer (Jul and Aug) than those during autumn (Nov and Dec) (p < 0.0001).
The above analyses led to the hypothesis that season of birth affects growth in height and weight among children. In view of this, we next evaluated the relationship of season of birth with height and weight (Fig. 2a, b). The average z-scores of height and weight in both genders were the highest during spring and the lowest during winter compared with others, whereas values during summer compared with others, whereas values during summer were significantly higher than those during autumn.

### Relationship of obesity with month and season of birth

The fluctuation of DOB with the month of birth is shown in Fig. 3. The DOB reached a peak for boys born in Dec and for girls born in May. However,

<table>
<thead>
<tr>
<th>Month of birth</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Height (cm)</td>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Apr</td>
<td>2970</td>
<td>143.2</td>
</tr>
<tr>
<td>May</td>
<td>3036</td>
<td>143.9</td>
</tr>
<tr>
<td>Jun</td>
<td>3108</td>
<td>143.0</td>
</tr>
<tr>
<td>Jul</td>
<td>3205</td>
<td>142.3</td>
</tr>
<tr>
<td>Aug</td>
<td>3209</td>
<td>142.0</td>
</tr>
<tr>
<td>Sep</td>
<td>3035</td>
<td>141.6</td>
</tr>
<tr>
<td>Oct</td>
<td>2942</td>
<td>140.7</td>
</tr>
<tr>
<td>Nov</td>
<td>2867</td>
<td>140.5</td>
</tr>
<tr>
<td>Dec</td>
<td>3009</td>
<td>139.8</td>
</tr>
<tr>
<td>Jan</td>
<td>2969</td>
<td>138.7</td>
</tr>
<tr>
<td>Feb</td>
<td>2746</td>
<td>138.7</td>
</tr>
<tr>
<td>Mar</td>
<td>2788</td>
<td>138.4</td>
</tr>
<tr>
<td>Total</td>
<td>35884</td>
<td>141.1</td>
</tr>
</tbody>
</table>

DOB: degree of obesity

![Fig. 1](image1.png)  
**Fig. 1.** Average z-score of height and weight by sex according to month of birth in schoolchildren aged 6-15 years.

![Fig. 2](image2.png)  
**Fig. 2.** (a) Pair-wise comparison of z-score of height by ANOVA test, *p* < 0.0001. (b) Pair-wise comparison of z-score of weight by Dunn procedure, *p* < 0.0001. **p** < 0.05. Data are presented as mean ± SE.

![Fig. 3](image3.png)  
**Fig. 3.** Average degree of obesity by sex according to month of birth.
we did not find any significant differences in DOB among months and seasons (data not shown).

We next used the χ² test to investigate the relationships of month and season of birth with obesity. For both sexes, there were no statistically significant differences in the prevalence of obesity among months and seasons of birth when all age groups were analysed together (data not shown). Separate analyses for each stratum of age revealed that the highest prevalence of obese boys have born during spring (among 6-year-old boys) and summer (among 7-year-old boys), whereas the highest prevalence of obese girls have born during spring (among 6-year-old girls) and winter (among 10-year-old girls) (Table 2).

Table 2. Comparison of obesity prevalence among season of birth by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Season of birth</th>
<th>Boys</th>
<th></th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Obese</td>
<td>Non-obese</td>
<td>Obese</td>
</tr>
<tr>
<td>6</td>
<td>Spring</td>
<td>94(11.5%)*</td>
<td>722(88.5%)</td>
<td>75(10.2%)*</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>93(9.8%)</td>
<td>855(90.2%)</td>
<td>77(8.0%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>61(6.5%)</td>
<td>880(93.5%)</td>
<td>70(7.8%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>66(7.7%)</td>
<td>796(92.3%)</td>
<td>51(5.8%)*</td>
</tr>
<tr>
<td>7</td>
<td>Spring</td>
<td>108(11.2%)</td>
<td>856(88.8%)</td>
<td>112(11.9%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>134(13.0%)*</td>
<td>900(87.0%)</td>
<td>109(11.6%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>74(8.2%)</td>
<td>827(81.8%)</td>
<td>76(9.1%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>91(9.9%)</td>
<td>825(80.1%)</td>
<td>84(9.7%)</td>
</tr>
<tr>
<td>8</td>
<td>Spring</td>
<td>140(15.0%)</td>
<td>795(85.0%)</td>
<td>120(13.3%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>152(15.1%)</td>
<td>858(84.9%)</td>
<td>124(12.6%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>140(14.2%)</td>
<td>846(85.8%)</td>
<td>116(12.8%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>124(13.2%)</td>
<td>816(86.8%)</td>
<td>101(11.7%)</td>
</tr>
<tr>
<td>9</td>
<td>Spring</td>
<td>184(18.3%)</td>
<td>822(81.7%)</td>
<td>127(13.6%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>173(17.8%)</td>
<td>800(82.2%)</td>
<td>145(15.3%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>153(16.5%)</td>
<td>773(83.4%)</td>
<td>114(13.7%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>152(16.4%)</td>
<td>775(83.6%)</td>
<td>112(13.0%)</td>
</tr>
<tr>
<td>10</td>
<td>Spring</td>
<td>190(19.0%)</td>
<td>810(81.0%)</td>
<td>144(15.6%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>204(18.8%)</td>
<td>880(81.2%)</td>
<td>121(12.3%)*</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>163(17.5%)</td>
<td>768(82.5%)</td>
<td>122(13.7%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>180(18.6%)</td>
<td>788(81.4%)</td>
<td>142(16.6%)*</td>
</tr>
<tr>
<td>11</td>
<td>Spring</td>
<td>175(17.2%)</td>
<td>840(82.8%)</td>
<td>133(14.2%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>185(16.8%)</td>
<td>914(83.2%)</td>
<td>143(14.9%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>205(20.6%)</td>
<td>792(79.4%)</td>
<td>161(15.5%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>179(20.1%)</td>
<td>713(79.9%)</td>
<td>141(16.2%)</td>
</tr>
<tr>
<td>12</td>
<td>Spring</td>
<td>171(17.6%)</td>
<td>800(82.4%)</td>
<td>150(15.6%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>173(17.0%)*</td>
<td>846(83.0%)</td>
<td>169(16.0%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>210(20.7%)</td>
<td>804(79.3%)</td>
<td>151(15.8%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>203(21.2%)</td>
<td>753(78.8%)</td>
<td>131(15.4%)</td>
</tr>
<tr>
<td>13</td>
<td>Spring</td>
<td>187(17.7%)</td>
<td>872(82.3%)</td>
<td>155(15.6%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>196(18.0%)</td>
<td>896(82.0%)</td>
<td>160(16.1%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>180(17.7%)</td>
<td>836(82.3%)</td>
<td>152(15.8%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>187(17.8%)</td>
<td>862(82.2%)</td>
<td>119(12.3%)</td>
</tr>
<tr>
<td>14</td>
<td>Spring</td>
<td>180(15.7%)</td>
<td>970(84.3%)</td>
<td>151(14.8%)</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>197(16.5%)</td>
<td>994(83.5%)</td>
<td>166(15.0%)</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>177(16.0%)</td>
<td>929(84.0%)</td>
<td>140(13.3%)</td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>165(16.6%)</td>
<td>828(83.4%)</td>
<td>143(14.9%)</td>
</tr>
<tr>
<td>15</td>
<td>Spring</td>
<td>30(15.2%)</td>
<td>167(84.8%)</td>
<td>15(8.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>567(15.8%)</td>
<td>3020(84.2%)</td>
<td>4522(13.4%)</td>
<td>29287(86.6%)</td>
</tr>
</tbody>
</table>

Data are presented as number (% within month).
* Adjusted residual < -2; ** Adjusted residual > 2.
DISCUSSION

In the present study, we found that the height and weight of schoolchildren were influenced by variation in month and season of birth, with a tendency to increase from Apr, reach a peak in May or Jun and then gradually decrease until Mar (from spring to winter); this trend was pronounced during eight consecutive years of repeated observation.

The influences of month and season of birth on growth in height and weight have been well documented (12-15). In agreement with our findings, Weber, et al. (12) indicated that in Australia (southern hemisphere), males born between Feb to Jul were taller than those born in the remaining months, and Kihlbom, et al. (13) reported that in Sweden (northern hemisphere) males born between Mar and May were significantly taller than those born in Nov or Dec. Because the effect seems to be similar in both the hemispheres, some common factor across the world was suggested. However, the studies of Shephard, et al. (14) and Kosciński, et al. (15), both in the northern hemisphere, revealed contradicting findings that children born between Jul and Mar and those between Oct and Mar were significantly taller and heavier, respectively, than those born in the remaining months. Consequently, the above-mentioned literature do not support the hypothesis that global factors, including the total amount of energy reaching the earth and hemisphere-related climatic conditions, act through the UV-dependent production of vitamin D, enzymes or hormones influencing growth of body size. These inconsistent results may surface from differences in geographical location, season, climate, month of anthropometric measurement, genetic, environmental and socioeconomic factors.

In addition, high birth weight and early exposure to cold conditions have been reported to be associated with obesity during adulthood because of the increase in the number of adipose tissues during cold conditions (20). In view of this, the highest prevalence of obese 6-year-old children born during spring and obese 10-year-old girls born during winter can be explained partly by the temperature rhythm in Tokushima Prefecture (Fig. 4). However, early exposure to cold condition alone cannot account for the greater prevalence of obese 7-year-old boys born during summer, but rather the interaction between high birth weight and early exposure to cold or other factors. Unfortunately, such interaction cannot be used to explain our findings because of the lack of birth weight data in Tokushima schoolchildren. Since no significant difference in DOB among the four seasons was found in both boys and girls, we infer that there is no influence of season of birth on DOB.

Until date, there have been no definitive explanations of why body height and weight depend on the month of birth. Nevertheless, there are several possible explanations of the observed dependence of height, weight and DOB on month and season of birth.

First, we agree with the postulation of Weber, et al. (12) that the periodicity of height and weight may be due to influences extending from the time of late pregnancy to the first postnatal year, and infer a phylogenetic remnant in humans because seasonal photic input is known to regulate various body functions and growth in mammals. Human growth appears to be the fastest during the three months before birth and during infancy. Weight doubles and infants grow taller by about 10 cm during the first three months of birth (21), and body fat percentage increases rapidly from 12% at birth to 25% in about 6 months (22). Meanwhile, growth deficits that arise before the fourth year cannot be compensated fully even if good or excellent environmental conditions follow (23).

Second, the dependence of height, weight and obesity on nutritional factors and diseases has been known for a long time. In Japan, eating habits and the composition of food have been influenced by changes in climate and temperature over the four seasons (24). Of 30 nutritional components of the diet, most intakes (87%), including energy, proteins, lipids, vitamins and minerals (except for carbohydrate, phosphorus, vitamin D, oleic acid, alpha-linolenic acid and cholesterol) varied significantly with seasons. The average daily intake of these nu-
trients reduced in the order, autumn, winter, spring
and summer (25, 26). In addition, there was signifi-
cant seasonal variation in the amount of unabsorbed
dietary carbohydrate from breakfast, which was the
largest during winter and the smallest during autumn
among young female Japanese subjects (27). On the
other hand, children are more prone to infectious
diseases in the cold season than in others and birth
month affects the probability of falling ill (9-12).
Thus, we infer that the effect of month of birth on
height and weight may be due to seasonal variation
in food intake, eating habits and early exposure to
diseases.

Third, the socioeconomic status of the family may
be important in determining height and weight.
Kihlbom, et al. (13) and Koscinski, et al. (15) re-
ported strong and significant effect of month of
birth in a group of people with high socioeconomic
status. Fathers in this group more often had their
children during spring. We cannot draw any conclu-
sion on such a relationship in this study owing to
lack of socioeconomic data.

Finally, these growth characteristics (height,
weight and obesity) are influenced by genetic fac-
tors as well as environmental and socioeconomic con-
ditions. Studies on candidate-gene associations and
geno-wide scans for human obesity have implied
many loci and genes on autosomal chromosomes in the development of human height and obe-
sity (28, 29).

All the hypotheses discussed above need to be
tested by prospective studies taking into account the
effects and interactions among environmental and
socioeconomic conditions, as well as genetic factors
during the process of growth in children. Accord-
ingly, in the context of a cross-sectional study con-
ducted on a large sample with data standardization
and separate analyses with regard to gender and age,
our findings suggest that the month and season of
birth influence height and weight but not the de-
gree of obesity in Tokushima schoolchildren.

ACKNOWLEDGEMENTS

The survey was conducted by the Committee for
Prevention Strategy against Lifestyle-related Disease.
We wish to thank Dr. Nguyen Van Tuan for advices
regarding the statistical analysis. We thank all mem-
bers of the committee and all teachers, parents and
children in Tokushima Prefecture.

REFERENCES

1. Matsushima Y, Yoshiike N, Kaneda F, Yoshida
K, Takimoto H : Trends in childhood obesity
in Japan over the last 25 years from the national
between obesity and seasonal variation in body
weight among elementary school children in
Tokyo. Econ Hum Biol 4 : 253-261, 2006
3. Togashi K, Masuda H, Rankinen T, Tanaka S,
Bouchard C, Kamiya H : A 12-year follow-up
study of treated obese children in Japan. Int J
Obes 26 : 770-777, 2002
4. Sei M, Nakatsu T, Yuasa K, Tanaka H, Indriani,
Munakata H, Nakahori Y : The prevalence of
metabolic complications in children with severe
obesity. Pediatrics International 49, 2007 (in
printing)
5. Lam DA, Miron JA, Riley A : Modeling sea-
sonality in fecundability, conceptions and births.
Demography 31 : 321-346, 1994
6. Miura T, Nonaka K, Shimura M, Nakamura I :
A study of the sex ratio of first-born according
to the mother’s month of birth. Arch Gynecol
233 : 263-266, 1983
7. Miura T, Nakamura I, Nonaka K, Shimura M :
Correlation between month of menarche and
8. Dobhammer G, Vaupel JW : Lifespan depends
on month of birth. Proc Natl Acad Sci 98 : 2934-
2939, 2001
9. Severson RK, Davis S : Breast cancer incidence
and month of birth : evidence against an etio-
logic association. Eur J Cancer Clin Oncol 23 :
1067-1070, 1987
10. Hu YH, Kuroishi T, Matsushita Y, Nagata C,
Shimizu H : Birth season and breast cancer risk
in Japan. Breast Cancer Res Treat 39 : 315-319,
1996
11. Nonaka K, Imaizumi Y : Deaths from cere-
brovascular diseases correlated to month of
birth : elevated risk of death from subarachnoid
hemorrhage among summer-born. Int J Biome-
teorol 44 : 182-185, 2000
12. Weber GW, Prossinger H, Seidlter H : Height
depends on month of birth. Nature 391 : 754-
755, 1998
13. Kihlbom M, Johansson SE : Month of birth, so-
cioeconomic background and development in
14. Shephard RJ, Lavallee H, Jequier JC, LaBarre