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ORIGINAL ARTICLE

Outdoor playing during preschool was associated with a reduced risk of school-age obesity in Japan

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Abstract

Aim: This study investigated the association between outdoor play habits during preschool and school-age obesity.

Methods: We conducted a longitudinal cohort study of all children born in Japan during 2 weeks in January and July 2001. We defined outdoor play habits at age 2.5 years (third survey) as exposure, while parent-reported height and weight at age 7 years (seventh survey) were defined as overweight and obesity status using the WHO reference. Logistic regression models were used to estimate odds ratios (ORs) for associations between preschool outdoor play habits and school-age obesity, adjusting for parental and child factors.

Results: Of 53 575 children born, 42 812 had data on outdoor play habits at age 2.5 years, with 91% (38 970) having such habits. At age 7 years, 31 743/42 812 (74%) children had height and weight data, with 3249/31 743 (10%) classified as overweight or obesity (BMI SD score ≥1.0). Outdoor play habits were negatively associated with obesity (adjusted OR 0.85, 95% confidence interval (CI): 0.74–0.97).

Conclusion: Outdoor play habits in early preschool years are associated with a reduced risk of school-age obesity. Parents and caregivers may consider encouraging their children to outdoor play habits at an early age to help prevent obesity later in life.

KEYWORDS
outdoor play habits, physical activity, preschool, school-aged obesity, socioeconomic status

1 | INTRODUCTION

Obesity is a pressing global health issue that affects millions of people worldwide.[1,2] According to the World Health Organisation (WHO), the prevalence of obesity nearly tripled between 1975 and 2016.[3] Obesity and overweight reportedly increase the risk of mortality.[4] Preventing childhood obesity, then, is particularly important[5–8] because it can impact people even as adults.[9]

For childhood obesity, interventions such as diet modification and increased physical activity are the basis for children's weight management.[9] Indeed, the effectiveness of multicomponent interventions combining physical activity, diet and behavioural therapy in preventing obesity in children has been widely reported.[7] Children's physical activity has, moreover, been shown to have a positive relationship with exposure to nature through outdoor play.[10] Increasing children's outdoor play time reportedly decreases their risk of obesity[11] and negatively correlates with body mass index (BMI).[12] Thus, increased opportunities for outdoor play may improve children's physical activity and help prevent childhood obesity. However, some studies have found no association between children's outdoor

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; LMS, lambda-mu-sigma; OR, odds ratio; SD, standard deviation; WHO, World Health Organisation.

play and overweight,[13] which indicates a lack of consensus on this association. It is possible that such findings were those from studies involving only short-term follow-up cohorts[11,12,14] or those with cross-sectional designs.[15] The association between children's outdoor play habits and later obesity or overweight has not been investigated longitudinally.

The purpose of this study was to investigate the association between outdoor play habits during the preschool years and school-age overweight or obesity, using a large cohort representative of children born in Japan.

Key notes

- The role of outdoor play habits in the prevention of obesity has not been clearly demonstrated.
- This study showed that outdoor play habits during preschool years are associated with a reduced risk of obesity in school-age children.
- We suggest that parents and caregivers encourage outdoor play habits in their children at an early age, as this may help prevent obesity later in life.

2 | MATERIALS AND METHODS

2.1 | Study design and participants

This was a population-based cohort study that targeted all babies born in Japan during a specific period. The Ministry of Health, Labour and Welfare of Japan has been conducting the Longitudinal Survey of Newborns in the 21st Century since 2001 to establish strategies to counter the declining birth rate in Japan.[16] The primary goal of this survey is to study the growth of children and use this information to develop effective countermeasures to the declining fertility rate. The survey targeted all babies born in Japan between 10 January 2001 and 17 January 2001, or between 10 July 2001 and 17 July 2001. Baseline questionnaires were sent to a total of 53 575 families when eligible babies reached the age of 6 months; 47 015 families initially completed the baseline questionnaire (88% response rate), and follow-up questionnaires were sent annually. Birth records from Japanese vital statistics such as gestational weeks, singleton birth or not, and gender were also linked to the data from these surveys.[17]

Initially, only children for whom data were collected in the seventh survey were included in this study. The 4203 children for whom data on outdoor play habits were missing from the third survey (when they were 2.5 years old) were excluded, bringing the total number of eligible children to 42 812. By the seventh survey, 11 069 participants were lost to follow-up, leaving 31 743 children for inclusion in our analysis (see Figure 1).

2.2 | Exposure (outdoor play habits)

We defined outdoor play habits in the preschool years based on the results of the Longitudinal Survey of Newborns in the 21st Century third (2.5 years old) survey. In that survey, in response to the question, 'Where do your children usually play (excluding home residences and daycare centres attended)', respondents were asked to select all applicable answers from the following options: 'in my garden or on the grounds of my apartment complex', 'in parks', 'in natural areas such as fields, forests, and beaches', 'on the street', 'in shrines and temples', 'in playgrounds in department stores and supermarkets', 'other' and 'don't play anywhere but inside my home'. If one or more of the first five items were chosen, the respondent was considered to have exposure to outdoor play.

2.3 | Outcome (children's obesity status)

We determined overweight and obesity for school-aged children (7 years old) based on the results of the Longitudinal Survey of Newborns in the 21st Century seventh survey. We recorded children's height and weight at 7 years of age, as reported by parents, in centimetres and kilograms, respectively, to 1 decimal point. We calculated BMI for each participant, using their reported height and weight. Each participant's BMI was converted to a BMI Z-score using smoothed L, M and S values for BMI standards from a representative population of Japanese children.[18] The lambda-mu-sigma (LMS) method was used to monitor changes in skewness in the distribution during childhood as a way to construct normalised growth standards. This method was proposed by Cole.[19] Participants were classified into four BMI categories according to WHO criteria[20]: underweight (BMI standard deviation [SD] score of −5 or more and less than −2), normal weight (BMI SD score of −2 or more less than 1), overweight (BMI SD score of 1 or more less than 2) and obesity (BMI SD score of 2 or more less than 5). Children with overweight or obesity were defined as those having a BMI SD score of 1.0 or greater.

2.4 | Covariates

We selected covariates in accordance with previous studies and domain knowledge. To adjust for potential confounding variables from socioeconomic status or children's lifestyle, we adjusted for confounding by parental and child factors. Parental factors included both spouses' education level (university or higher, junior college, high school, junior high school or other; categorical), household income status (very low; <400 yen, low; 400–505 yen, middle; 506–699 yen, and high; ≥700 yen (quartiles); categorical), smoking status (dichotomous) and maternal age at delivery (≤19, 20–34, and ≥35 years; categorical).[21–27] Child factors included gender (dichotomous), term or preterm birth (<37 weeks of gestation; dichotomous),

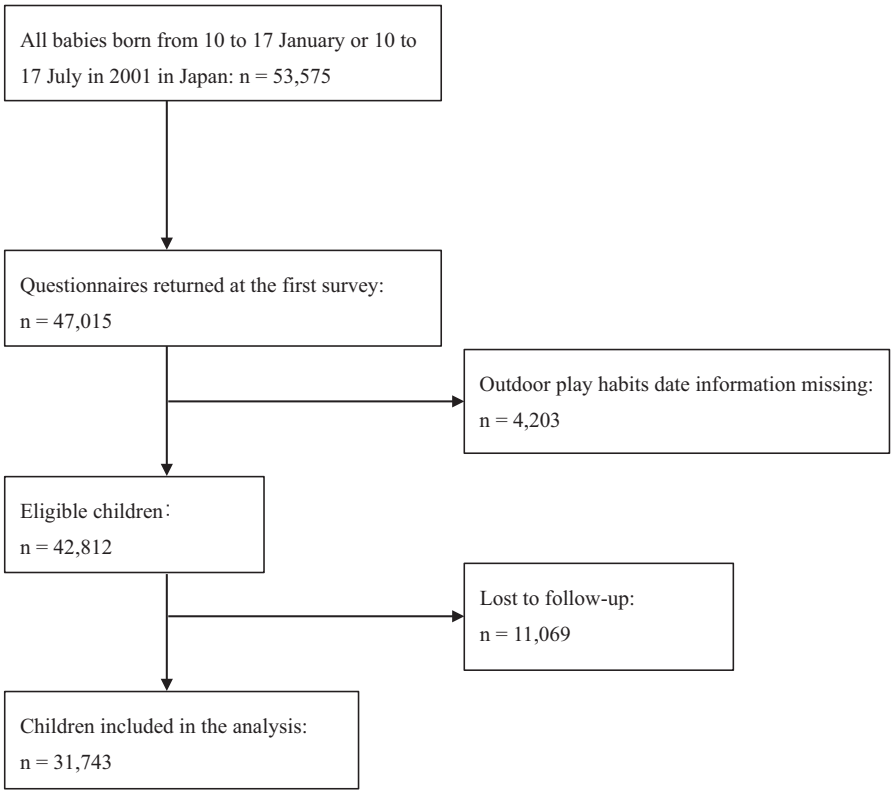

FIGURE 1 Participant selection process.

birth weight (<2500 and ≥2500 g; dichotomous), singleton or multiple birth (dichotomous), place of birth and residence (ward, city, town or village; categorical) and nursery school attendance at 3.5 years of age (dichotomous).[28–30]

2.5 | Statistical analysis

We first compared baseline characteristics between groups with and without outdoor play habits at age 2.5 years. Additionally, baseline characteristics were compared between groups of children with and without outdoor play habits who were lost to follow-up by age 7.

In logistic regression models, we estimated crude odds ratios (ORs) for the associations between outdoor play habits during preschool years and children's obesity status at 7 years of age, using 'without outdoor play habits' as a reference (model 1). Next, we adjusted for parental factors (i.e. education level, income status, smoking status and maternal age at delivery; model 2), then additionally adjusted for child factors (i.e. gender, term or preterm birth, birth weight, singleton or multiple birth, place of birth and residence, and nursery school attendance) in the final model (model 3).

In sensitivity analyses, we further adjusted for more lifestyle factors in addition to the adjustment variables in model 3: families' awareness of a healthy diet (i.e. whether families were careful to reduce their children's sugar intake; dichotomous), average television viewing time per day (≤2 h; dichotomous), and bedtime (after 9:00 PM; dichotomous).[31] All confidence intervals (CIs) were calculated at the 95% level. Stata statistical software (Stata SE version 17; StataCorp) was used for all the analyses.

2.6 | Ethics approval

This study was approved by the Institutional Review Board at Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences (No. 1506-073). Informed consent was obtained by the opt-out method on the university's website.

3 | RESULTS

Participants' demographic characteristics are shown in Table 1, categorised as with or without outdoor play habits at age 2.5 years old. Of 53 575 children born, data on outdoor play habits at age 2.5 years were available for 42 812 children. Of these, 38 970/42 812 (91%) had outdoor play habits. At the age of 7 years, 31 743/42 812 (74%) children had data on height and weight reported by parents, and 3249/31 743 (10%) were classified as overweight or obesity. Compared with the children who engaged in regular outdoor play habits, the children who did not engage such habits tended to have parents with lower education levels, higher rates of maternal smoking and lower income status. There were 7182 cases with missing information for education level (mother, 3340; father, 3832), 9256 cases with missing information for income status, 1301 cases with missing information for smoking status (mother, 278; father, 1023), 2570 cases with missing information for maternal age at delivery, and 4203 cases with missing information for nursery school attendance. Demographic characteristics of children lost to follow-up, by with and without outdoor play habits, are shown in Table 2. Compared to the children with outdoor play habits, the children without outdoor

TABLE 1 Demographic characteristics of children included in the analysis at age 7.0 years, by outdoor play habits at age 2.5 years ($N = 42\,812$).

	With outdoor play habits ($n = 38\,970$)	Without outdoor play habits ($n = 3842$)
	n (%)	*n* (%)
Obesity, *n* (%)	2932 (10.1)	317 (11.7)
Gender, *n* (%)		
Boys	20 368 (52.3)	1848 (48.1)
Girls	18 602 (47.7)	1994 (51.9)
Maternal smoking status, *n* (%)		
Yes	6019 (15.5)	692 (18.1)
Paternal smoking status, *n* (%)		
Yes	23 792 (62.2)	2396 (64.1)
Maternal educational attainment, *n* (%)		
University or higher	5374 (14.2)	475 (12.9)
Junior college	15 905 (42.1)	1400 (38.0)
High school	15 023 (39.8)	1645 (44.7)
Junior high school or other	1453 (3.8)	163 (4.4)
Paternal educational attainment, *n* (%)		
University or higher	13 927 (37.2)	1207 (33.4)
Junior college	5889 (15.7)	564 (15.6)
High school	15 180 (40.6)	1539 (42.6)
Junior high school or other	2413 (6.5)	303 (8.4)
Maternal age at delivery, *n* (%)		
≤19 years	159 (0.4)	28 (0.8)
21–34 years	31 316 (85.0)	3075 (84.8)
≥35 years	5357 (14.5)	522 (14.4)
Household income, *n* (%)		
Quantile 0–25 (<400 yen)	8226 (24.3)	914 (28.8)
Quantile 25–50 (400–505 yen)	8007 (23.7)	716 (22.5)
Quantile 50–75 (506–699 yen)	8817 (26.1)	777 (24.4)
Quantile 75–100 (≥700 yen)	8769 (25.9)	771 (24.3)
Preterm birth (<37 weeks)	1895 (4.9)	219 (5.7)
Birth weight, *n* (%)		
<2500 g	3207 (8.2)	394 (10.3)
Singleton or multiple birth, *n* (%)		
Singleton birth	38 195 (98.0)	3760 (97.9)
Multiple birth	775 (2.0)	82 (2.1)
Residential area, *n* (%)		
Wards	8382 (21.5)	792 (20.6)
Ordinance-designated city	203 (0.5)	11 (0.3)
Cities	22 872 (58.7)	2333 (60.7)
Towns or villages	7513 (19.3)	706 (18.4)
Nursery school attendance, *n* (%)		
Yes	10 179 (26.1)	1309 (34.1)
Families' awareness about a healthy diet, *n* (%)		
Yes	14 663 (37.6)	1255 (32.7)
Average television viewing time per day, *n* (%)		
≦2 h	19 829 (51.9)	2031 (56.7)
Bedtime, *n* (%)		
After 9:00 PM	32 472 (87.4)	3092 (90.0)

play habits tended to have mothers with lower education levels and lower income status.

At 7 years of age, 10.1% and 11.7% of children with and without outdoor play habits, respectively, were classified as overweight and obesity. The ORs and adjusted ORs (aORs) from the logistic regression models are shown in Table 3. Outdoor play habits were negatively associated with overweight or obesity in the crude model (model 1), with ORs of 0.85 (95% CI: 0.75–0.96). Even after adjusting for the covariates, the protective associations for overweight or obesity status remained significant, with aORs of 0.85 (95% CI: 0.74–0.97) in both adjusted models 2 and 3.

In our sensitivity analysis, even when we further adjusted for families' awareness about a healthy diet, average television viewing time per day, and average bedtime, in addition to the adjustment variables in model 3, the main findings did not change substantially, with ORs of 0.84 (95% CI: 0.72–0.97).

4 | DISCUSSION

We used a nationwide Japanese birth cohort data set – The Longitudinal Survey of Newborns in the 21st Century – to investigate the association between outdoor play habits during preschool years (2.5 years old) and overweight and obesity among school-aged children (7 years old) in Japan, with adjustments for potential confounders. The results showed that school-aged children with regular outdoor play habits during their preschool years evidenced a lower prevalence of overweight and obesity than those without such habits.

Our findings suggest that outdoor play habits during preschool years lead to increased physical activity and may be a protective factor against obesity. Previous systematic reviews have reported significant health effects on physical activity of exposure to nature in outdoor play.[10] Furthermore, physical activity contributes to weight

TABLE 2 Demographic characteristics of children lost to follow-up, with and without outdoor play habits ($N = 11\,069$).

	With outdoor play habits ($n = 9944$)	Without outdoor play habits ($n = 1125$)
	n (%)	*n* (%)
Gender, *n* (%)		
Boys	5181 (52.1)	561 (49.9)
Girls	4763 (47.9)	564 (50.1)
Maternal smoking status, *n* (%)		
Yes	2202 (22.3)	276 (24.8)
Paternal smoking status, *n* (%)		
Yes	6677 (68.9)	750 (69.3)
Maternal educational attainment, *n* (%)		
University or higher	911 (9.9)	92 (8.9)
Junior college	3493 (37.8)	339 (32.8)
High school	4197 (45.4)	517 (50.0)
Junior high school or others	636 (6.9)	86 (8.3)
Paternal educational attainment, *n* (%)		
University or higher	2649 (29.1)	259 (25.8)
Junior college	1412 (15.5)	146 (14.5)
High school	4.125 (45.4)	481 (47.9)
Junior high school or others	909 (10.0)	118 (11.8)
Maternal age at delivery, *n* (%)		
≤19 years	94 (1.0)	16 (1.5)
21–34 years	8185 (86.8)	922 (86.5)
≥35 years	1154 (12.2)	128 (12.0)
Household income, *n* (%)		
Quantile 0–25 (<400 yen)	2224 (30.8)	286 (37.7)
Quantile 25–50 (400–505 yen)	1791 (24.8)	177 (23.4)
Quantile 50–75 (506–699 yen)	1673 (23.1)	154 (20.3)
Quantile 75–100 (≥700 yen)	1543 (21.3)	141 (18.6)
Preterm birth (<37 weeks)	547 (5.5)	66 (5.9)
Birth weight, *n* (%)		
<2500 g	871 (8.8)	128 (11.4)
Singleton or multiple birth, *n* (%)		
Singleton birth	9752 (98.1)	1106 (98.3)
Multiple birth	192 (1.9)	19 (1.7)
Residential area, *n* (%)		
Wards	2004 (20.2)	229 (20.4)
Ordinance-designated city	50 (0.5)	5 (0.4)
Cities	5839 (58.7)	671 (59.6)
Towns or villages	2051 (20.6)	220 (19.6)
Nursery school attendance, *n* (%)		
Yes	3062 (30.8)	439 (39.0)
Families' awareness about a healthy diet, *n* (%)		
Yes	3411 (34.3)	326 (29.0)
Average television viewing time per day, *n* (%)		
≦2 h	4964 (51.3)	576 (55.4)
Bedtime, *n* (%)		
After 9:00 PM	8282 (88.5)	884 (89.4)

loss and cardiopulmonary fitness,[34] and outdoor play may have positive effects on physical activity as well as on behavioural, cognitive and mental health, which leads to improved overall health.[10,35,36] Exposure to outdoor play habits during early preschool years, moreover, may lead to improved health behaviours and the prevention of obesity. However, many of these previous studies used a short-term follow-up or were cross-sectional in nature, and the findings were not consistent. Our study clarified these associations by using a longitudinal design.

In our study, preschoolers with outdoor play habits were less likely to be overweight or obese when they reached school age, even after adjusting for important confounding factors such as socioeconomic status. Generally, children with higher socioeconomic status tend to exhibit greater health-promoting behaviour patterns whereas children with lower socioeconomic status tend to display unhealthy behaviour patterns; these unhealthy behaviour patterns are also reportedly associated with the risk of obesity.[37,38] However, the present study showed that even after adjusting for these potential confounders, outdoor play habits may prevent obesity, which is consistent with several previous studies.[11,12] Thus, our results indicate that outdoor play habits during preschool years are an important factor in the prevention of obesity. Importantly, obesity in childhood affects obesity in adulthood,[39,40] and early prevention is essential.[5] While all types of physical activity play an important role in the prevention of obesity,[6] outdoor play habits during preschool years can improve physical activity and help prevent obesity among school-aged children, and may even have a positive impact on the prevention of obesity in adulthood. We obtained robust results of our sensitivity analyses that considered families' awareness about a healthy diet, average television viewing time, and bedtime, all of which reportedly influence obesity in children.[31–33] These results support the preventive effect of outdoor play habits in preschool years on obesity among school-aged children.

The main strength of this study is that participants were from a large, national, population-based study that involved regular long-term follow-ups. In the prevention of childhood obesity, previous reports have pointed out the importance of studies using such large, population-based, long-term follow-ups.[41] Additionally, we adjusted

TABLE 3 Associations between outdoor play habits at age 2.5 years and obesity at age 7 years.

		Odds ratio (95% CI)		
		Model 1 (Crude)	Model 2[a]	Model 3[b]
	N case/*N* (%)	(*n* = 31 743)	(*n* = 26 642)	(*n* = 26 632)
Without outdoor play habits	317/3842 (11.7)	1 [reference]	1 [reference]	1 [reference]
With outdoor play habits	2932/38970 (10.1)	0.85 (0.75–0.96)	0.85 (0.74–0.97)	0.85 (0.74–0.97)

Abbreviation: CI, confidence interval.

[a]Adjusted for parental factors (maternal and paternal educational attainment, household income, maternal and paternal smoking status, and maternal age at delivery).

[b]Adjusted for parental factors (maternal and paternal educational attainment, household income, maternal and paternal smoking status, and maternal age at delivery) and for child factors (gender, preterm birth (<37 weeks), singleton or multiple birth, residential area and nursery school attendance).

for a wide range of biological and socioeconomic confounders, which is important because obesity has been widely associated with socioeconomic confounders.

Some limitations in the present study should also be noted. First, this study was conducted among Japanese children, and the generalisability of its findings to other populations is unknown. Second, information on outdoor play habits was obtained from parental reports rather than from clinically confirmed methods. This may have resulted in misclassification. However, the information on outdoor play habits was obtained at age 2.5 years, when this age group is more likely to engage in outdoor play under parental supervision. Thus, the likelihood that parents would misclassify the information is low, and we therefore consider the risk of misclassification to be small. Third, children that were kept indoors may have other difficulties that affected their risk of obesity, such as autism spectrum disorder that limits their ability to play outside at age 2.5 years without tight supervision. Finally, the frequency and amount of the children's outdoor play was not measured. Therefore, future long-term studies are needed to objectively measure the frequency and amount of children's outdoor play and to investigate how these are related to future obesity.

5 | CONCLUSION

This study demonstrated that outdoor play habits in early preschool years are associated with a reduced risk of obesity in school-aged children. Parents and caregivers may consider encouraging their children to outdoor play habits at an early age to help prevent obesity later in life.

AUTHOR CONTRIBUTIONS

Takahiro Tsuge: Conceptualization; methodology; writing – original draft; writing – review and editing; formal analysis. **Naomi Matsumoto:** Conceptualization; methodology; supervision; writing – review and editing; formal analysis. **Soshi Takao:** Conceptualization; methodology; supervision; writing – review and editing. **Takashi Yorifuji:** Conceptualization; methodology; supervision; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

No competing financial interests exist.

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