



## Relationships among fitness, obesity, screen time and academic achievement in Japanese adolescents



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### HIGHLIGHTS

- Poor fitness interfered with satisfactory academic performance in Japanese boys.
- Obesity interfered with satisfactory academic performance in Japanese girls.
- The influences of fitness and obesity were independent of time spent on video games.
- The influences of fitness and obesity were independent of attending cram school.

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### ABSTRACT

**Purpose:** Students who study intensively in one of Japan's 'cram schools' and/or spend excess time on electronic devices such as video games are in a sedentary state much of the time, and this may affect their physical fitness. We investigated whether there are relationships among obesity, physical fitness and academic achievement in Japanese students after controlling for socioeconomic and behavioral confounding factors.

**Methods:** The data of 315 students (152 females [48%], 163 males [52%]; 12–13 yrs old) were analyzed. Academic achievement was assessed by the total grade points on eight school subjects (GP8). Students with a body mass index at or above the 85th percentile of each gender were classified as the overweight/obese group. Physical fitness was evaluated by the total score on eight fitness tests. Socioeconomic and behavioral confounders including the mother's educational background, household income, cram school utilization and time spent on video games/mobile phones were used as covariates.

**Results:** The GP8 of the overweight/obese students was significantly lower than that of the normal weight students (27.2 vs. 29.0 points, respectively). After adjusting for the confounders, the physical fitness score was found to be a significant factor for determinants of GP8 in boys ( $\beta = 0.324$ ), but not in girls. The obesity status was a factor for GP8 in the girls ( $\beta = -0.160$ ) but not in the boys.

**Conclusion:** These results suggest that physical fitness in boys and obesity status in girls could be important factors not only for health status but also for academic achievement, independent of socioeconomic and behavioral backgrounds.

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### 1. Introduction

Obesity and poor physical fitness among children are critical public health problems in developed countries including Japan, because they lead to an increased risk of cardiovascular disease and premature mortality in adulthood [1–5]. It has been demonstrated that aerobic capacity, an indicator of physical fitness, is related to reading and arithmetic

ability in children [6–21] and that acute exercise temporarily enhances cognitive function [22,23]. In addition, childhood obesity, which is associated with poor fitness, has been reported to have a negative influence on cognitive function and academic achievement [24–31].

Many children in Japan and other East Asian countries attend cram schools (test preparation centers) or have private teachers [32] with the goal of enhancing their academic achievement, but the cram school/private tutoring time may limit the children's available time for physical activity and sports participation. Compared with previous findings in European countries and the United States [6–23], there may be different relationships among physical fitness, obesity, and academic

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achievement in children in these East Asian countries. In Japan, children spent a lot of time watching television (whether on a TV or on the Internet), playing video games and/or using mobile phones; it was reported that 43% of Japanese children engaged in over 2 h of daily screen time [5]. During these electronic device-based activities, the children are sedentary, and this may negatively affect both their physical fitness and academic achievement. As a matter of public health, it is necessary to clarify the relationships among physical fitness, obesity, and academic achievement after adjusting for social and lifestyle confounders in children.

The purpose of the present study was to determine whether there are relationships among physical fitness, obesity and academic achievement in Japanese first-year junior high school students. To better understand the relationships among obesity, low physical fitness and academic achievement, we adjusted for potential confounders such as household income, mother's educational background, attendance at a cram school or use of a private teacher, and time spent on electronic devices.

## 2. Methods

### 2.1. Participants

During the autumn of 2012, 315 first-year junior high school students (equal to seventh graders in the United States; male,  $n = 163$ ; female,  $n = 152$ ; age range, 12–13 yrs and born during the same year) from three public schools in Hokkaido Prefecture participated in this study. To recruit participants, all students of these schools were given a pack containing a leaflet and questionnaires for themselves, a letter of explanation and request for cooperation with this study to their parents/guardians, and questionnaires for their parents/guardians ( $n = 493$ ). In the explanation letter, they were informed that all data collected from the students and their parents/guardians would be anonymous; thus, personal information such as students' names and birth dates was not obtained. Only those students whose parents/guardians consented to their participation based on the provided explanation completed and returned the questionnaires ( $n = 344$ ; male/female = 180/164), thereby consenting to participate. A total of 29 students were excluded due to missing data or because they did not complete the questionnaires or fitness tests (incomplete questionnaires,  $n = 4$ ; missing grade points,  $n = 1$ ; incomplete physical fitness tests,  $n = 20$ ; and missing body weight/height data,  $n = 4$ ). The data of a total of 315 students were thus analyzed in the present study. This study was approved by the institutional review board of Hokkaido University of Education.

### 2.2. Academic achievement

Academic achievement was assessed by the total grade point (GP) of school subjects evaluated by school teachers; individual grades were reported for 8 school subjects (Japanese, Mathematics, Social Studies, Sciences, English, Music, Arts, and Home Economics/Vocational Technology). Students earn 1 to 5 credit points for each subject; thus, a student can receive a maximum of 40 grade points for the 8 subjects in question. The total GPs of all 8 school subjects (GP8) and of a subset of 5 subjects (GP5; Japanese, Mathematics, Social Studies, Sciences, and English) were used as continuous variables. The 5 subjects included in GP5 are commonly used for the entrance examination to high school in Japan.

### 2.3. Physical fitness

Physical fitness was assessed based on the 8 tests shown in the Supplemental Fig. 1 in the online version at <http://dx.doi.org/10.1016/j.physbeh.2016.04.055>. (50-m sprint, standing broad jump, repeated side-steps, sit and reach, sit-ups, hand grip strength, handball throw,

and 20-m shuttle run). These fitness tests were adopted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan and are conducted nationwide. Students perform the fitness tests during physical education classes wearing light clothes and rubber-soled shoes. Prior to the measurements, the students stretched and did some warm-up exercises. The rest interval between tests is at least 3 min. The physical education teachers of each school must follow strictly the measurement protocol stipulated in the test manual [33]. Performance-to-score conversion tables made by the MEXT are used to standardize the results into 10 grades of score for each gender (see Supplemental Tables 1 and 2 in the online version at <http://dx.doi.org/10.1016/j.physbeh.2016.04.055>). The score classifications of each fitness test in Supplemental Tables 1 and 2 in the online version at <http://dx.doi.org/10.1016/j.physbeh.2016.04.055> are based on the mean and standard deviation values of Japanese children [33]. Levels of comprehensive physical fitness were evaluated based on total physical fitness test scores (PFS; the PFS points ranged from 8 to 80). Detail measurement procedures for the physical tests were in Supplemental method because of words number limit.

### 2.4. Body mass index (BMI)

Height and body mass were measured by using stadiometers and scales. BMI was calculated as body mass (kg) / height (m)<sup>2</sup>. In order to maintain anonymity, we did not obtain the birth dates of the students, and were therefore unable to calculate BMI z-score based on the reference values for Japanese children. Each student was classified into either the normal weight group, defined as a BMI below the 85th percentile, or the overweight/obese group, which was defined as a BMI at or above the 85th percentile according to the definition of the U.S. Centers for Disease Control and Prevention [34].

### 2.5. Socioeconomic and lifestyle confounders

The students and their parents completed a questionnaire concerning their socioeconomic background. The household income, mother's education, use of a cram school or private teacher and time spent on video games/mobile phones were determined. The household income and mother's education were reported by the parents, and the use of a cram school or private teacher and the time spent using electronic devices were reported by the students. Household income was assessed with one questionnaire item ("How much does your family earn annually?") on a 5-point scale (i: < ¥ 2,000,000; ii: ¥ 2,000,000–¥ 3,999,999; iii: ¥ 4,000,000–5,999,999; iv: ¥ 6,000,000–¥ 7,999,999; v: ¥ 8,000,000 or more).

The highest level of the mother's education was assessed with one item ("What is the highest level of education attempted by the mother?") on a 6-point scale (i: completed junior high school; ii: completed or dropped out of high school; iii: completed or dropped out of a vocational school; iv: completed or dropped out of a junior college; v: completed or dropped out of undergraduate studies; vi: completed or dropped out of graduate studies). A dichotomous item ("Do you use a cram school/private teacher?" with 0: No; 1: Yes) was used to assess the use of a cram school/private teacher. Time spent using electronic devices was assessed with one item ("How much time do you spend daily playing video games or using a mobile phone on school days?") on a 5-point scale (i: ≥ 2 h; ii: 1–2 h; iii: 30–60 min; iv: 15–30 min; v: almost not use).

The following were used as dichotomous items because these variables were used as covariates in the multiple regression analysis: integrated scales of household income (0: < ¥ 6,000,000; 1: ≥ ¥ 6,000,000), mother's education (0: high school graduate or less; 1: completed or dropped out from a vocational school, a junior college, or undergraduate or graduate studies) and excess time spent on electronic devices (0: < 2 h/day; 1: ≥ 2 h/day).

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