Regular Article

Exercise time positively correlates with physical fitness, regardless of overweight, obesity and underweight among primary and secondary students: A Japanese nationwide cross-sectional study

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Brief running title: Exercise time is associated with physical fitness regardless of body size

Abstract

More research is needed to understand how exercise time and physical fitness relate to body size. In particular, there are no studies that have examined the relationship between physical activity and physical fitness, taking into account both overweight/obesity and thinness, using national samples. This study aimed to analyze exercise time by body size and physical fitness using a Japanese national sample of Japanese children and adolescents. The survey included 19,471 primary and 10,596 secondary schools in Japan. After excluding participants with missing data, the analysis included 878,348 Year 5 primary school students and 757,358 Year 8 secondary school students. Body mass index (BMI) was calculated based on participants' height and weight, and they were subsequently categorized into four BMI groups: underweight, normal weight, overweight, and obese. Physical fitness was classified as high or low based on the total score from eight physical fitness tests. Exercise time was assessed via a questionnaire and compared between the high- and low-fitness groups within each BMI category. Among the boys and girls in primary and secondary schools, exercise time was greater in the high-fitness group compared with the low-fitness group across all four BMI categories (Underweight, normal-weight, overweight and obesity). In conclusions, this study suggested that exercise time is positively associated with higher physical fitness regardless of whether

an individual is obese, underweight, or normal weight. These results may indicate the importance of promoting exercise time among all children, and further longitudinal studies are needed.

Keywords: Physical activity; Fitness; Obesity; Thin; Children; Adolescents

運動時間は過体重，肥満，低体重に関わらず小学生および中学生の体力と正の相関関係にある：日本人を対象とした全国横断研究

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概要

運動時間と体力が体格とどのように関連するかを理解するためには，さらなる研究が必要である。特に，過体重/肥満と低体重を考慮して，日本の全国サンプルを用いて運動時間と体力との関連を検討した研究はない。そこで本研究では，日本の全国サンプルを用いて小学生および中学生を対象に，体格及び体力別の運動時間について検討することを目的とした。調査は日本の小学校 19,471 校と

中学校 10,596 校を対象とした。欠損データのある対象者を除き，小学校 5 年生 878,348 名と中学校 2 年生 757,358 名を分析対象者とした。Body Mass Index（BMI）は対象者の身長と体重に基づき算出され，対象者は低体重，標準体重，過体重，肥満の 4 つの BMI グループに分類された。体力は，体力テスト 8 項目の合計点に基づいて評価され，対象者は高体力群と低体力群に分類された。運動時間は質問票で評価され，4 つの BMI グループ内の高体力群と低体力群における運動時間を比較した。小学生と中学生の男女において，4 つの BMI グループ（低体重，標準体重，過体重，肥満）すべてにおいて，高体力群は低体力群よりも運動時間が長かった。結論として本研究の結果から，運動時間は過体重/肥満，低体重，または標準体重であるかに関わらず，高い体力と正の関連性のあることが示唆された。これらの結果は，すべての子供に対して運動時間を促進することの重要性を示している可能性があり，今後縦断的な検討が必要とされる。

Introduction

Obesity during childhood and adolescence is associated with cardiovascular disease risk factors, including systolic and diastolic blood pressure, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol, triglycerides, and fasting blood glucose, similar to the associations observed in adults[1]. Additionally, it is linked to increased morbidity and mortality from cardiovascular and metabolic diseases in adulthood[2,3]. However, obesity prevalence is higher than it was before in many countries[4].

Moreover, physical fitness has been shown to influence cardiovascular disease risk factors independently of body weight[5,6]. Notably, research indicates that "fat but fit" children exhibit lower cardiovascular risk factors than their "fat but unfit" peers[7-10]. These findings suggest that maintaining a normal body weight is not the only determinant of good health, and that physical fitness is also crucial[6].

Few studies have examined the relationship between the physical activity of individuals with different body sizes and their physical fitness in the context of the "fat but fit" concept[8]. Pozuelo-Carrascosa et al.[8] compared physical activity across four groups of 312 children aged 9–11 years based on their body size and fitness level: "Fat but Fit," "Fat Unfit," "Unfat Fit," and "Unfat Unfit." Their findings showed no

19 differences in light or moderate physical activity between the groups. However, vigorous
20 physical activity was found to be higher in the “Unfat Fit” group compared with the other
21 three groups. Notably, no differences in physical activity at any intensity were observed
22 between the “fat but fit” and “fat unfit” groups[8)].

23 To date, this remains the only study examining physical activity in relation to
24 body size and physical fitness, highlighting the need for further research. Moreover, no
25 studies have simultaneously considered factors such as obesity and being underweight in
26 this context. While being underweight is less common than being obese, it is often
27 overlooked as a health concern. However, being underweight can lead to several health
28 issues such as impaired growth, poor bone health, and fertility problems[11-13)]. To my
29 knowledge, there are no reports on the exercise time of underweight children with high
30 physical fitness.

31 Examining exercise habits in relation to body size and physical fitness could
32 highlight the positive relationship between physical fitness and exercise habits across all
33 body sizes, thereby reinforcing the importance of regular physical activity. These findings
34 could help emphasize the benefits of staying active, regardless of body size, to children,
35 parents, and school staff. Therefore, this study aimed to examine exercise time in relation
36 to body size and physical fitness using a national sample of Japanese children and

adolescents.

Methods

Study design, setting, and participants

This study included participants from the National Survey on Physical Fitness, Athletic Performance, and Exercise Habits, conducted annually in Japan[14]. This survey included all Year 5 primary school students and all Year 8 secondary school students in Japan and assessed their physical fitness through tests and questionnaire-based surveys on anthropometry, exercise habits, and lifestyle factors.

All anthropometric measurements, fitness assessments, and exercise time surveys were conducted and compiled at each school between April and July 2023. In Japan, Year 5 primary school students are typically 10 or 11 years old, while Year 8 secondary school students are usually 13 or 14 years old. However, individual ages (birthday month) at the time of the survey were not available for this study. Therefore, for consistency, all participants were categorized as 10.0 years old (primary school) and 13.0 years old (secondary school), based on how old they would turn between April and July 2023.

The survey covered all 19,471 primary schools and all 10,596 secondary schools

in Japan, with 18,918 primary schools and 10,021 secondary schools participating in the survey (participation rate: 97.2% for primary schools, 94.6% for secondary schools) [14]. A total of 1,003,155 primary school students and 962,917 secondary school students were eligible, with 990,165 primary school students (504,439 boys and 485,726 girls) and 923,980 secondary school students (473,858 boys and 450,122 girls) participating, resulting in a participation rate of 98.7% for primary school students and 96.0% for secondary school students. After excluding participants due to missing data (anthropometry, physical fitness and exercise time), the final analysis included 878,348 primary school students (443,865 boys and 434,483 girls) and 757,358 secondary school students (390,274 boys and 367,084 girls) (Fig. 1).

This study obtained anonymized data from the Japan Sports Agency under the individual data provision system of the National Survey on Physical Fitness, Athletic Performance, and Exercise Habits[15]. Additionally, this study received ethical approval from the Institutional Review Board of Mie University (approval No. 2024-24).

Figure. 1

Anthropometry

Height and weight were measured according to a standardized manual[16] used nationwide in all schools. Height was recorded to the nearest 0.1 cm, and body weight was measured to the nearest 0.1 kg while participants wore light clothing and no shoes. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Additionally, BMI categories—underweight, normal weight, overweight, and obese—were determined using the cut-off values established by Cole et al.[17] (Table 1).

Table 1

Physical fitness

Physical fitness was assessed using the norms established by the National Statistical Survey on Physical Fitness and Motor Ability of the Ministry of Education, Culture, Sports, Science, and Technology in Japan[18]. For primary school students, the assessment included handgrip, sit-ups, sit-and-reach, side-to-side jumps, 20-m shuttle run, 50-m dash, standing broad jump, and softball throw. For secondary school students, the tests included handgrip, sit-ups, sit-and-reach, side-to-side jumps, 20-m shuttle run or an endurance run (1500 m for boys, 1000 m for girls), 50-m dash, standing broad jump, and handball throw.

Each test result was graded on a scale of 1 to 10, with the total fitness score (out

of 80) used to assess overall physical fitness[18]. These physical fitness test items and total fitness score have been reported to be associated with blood lipid levels in primary and secondary school students[19]. Participants were classified into two groups (high- and low-fitness) based on the national mean total fitness score for their age group (Year 5: Boys 52.60, Girls 54.29; Year 8: Boys 41.18, Girls 47.08), as reported by the Japan Sports Agency[14].

Exercise time

The exercise time was assessed using a questionnaire by the National Survey on Physical Fitness, Athletic Performance, and Exercise Habits[14]. Primary school students were asked the following question: "During a typical week, how much time do you spend exercising (including play that involves physical movement) and participating in sports each day, excluding physical education lessons at school? Please fill in the boxes for each day of the week." They recorded their daily exercise time from Monday to Sunday in minutes.

Secondary school students were asked, "How many minutes do you spend engaging in each of the following activities: school sports club, local sports club, and other sports or exercise?" Please indicate the time spent on each activity for each day of

the week (excluding physical education classes at school).” They recorded their exercise time separately for each day from Monday to Sunday. In this study, total weekly exercise time (minutes/week) was calculated as the sum of daily exercise time for primary and secondary school students.

Statistical analysis

The participants’ anthropometric data, exercise time, and physical fitness variables are presented as mean ± standard deviation, stratified by age and gender. Height, weight, and total fitness scores across the four body size groups (underweight, normal weight, overweight and obese) were compared using a one-way analysis of variance with Bonferroni multiple comparisons. Relationship between exercise time and total fitness score by BMI categories was analyzed using Spearman correlation coefficient (rho). Exercise time between the two fitness groups (low and high-fitness) was analyzed using the unpaired t-test, with the effect size (d) calculated. All statistical analyses were conducted using IBM SPSS Statistics version 30.0 (IBM Japan, Ltd., Tokyo, Japan). In this study, analyses were conducted by grade, gender, and physical fitness, and since α errors may increase, the statistical significance was set at $p < 0.01$. Additionally, children's anthropometry in Japan is generally evaluated based on degree of obesity[16]. Therefore,

the results evaluated based on degree of obesity are shown in the supplementary material.

Results

Participants' characteristics

Table 2 presents the participants' anthropometric measurements, total fitness scores, and exercise time variables. Among the boys and girls in primary and secondary schools, height, weight, and BMI were highest in the following: Obese, overweight, normal weight, and underweight. The total fitness scores and exercise time were lowest in the obese group and highest in the normal-weight group for boys and girls in primary and secondary schools. Additionally, participants' characteristics classified by degree of obesity is provided in Supplementary Material 1.

Table 2

Relationship between exercise time and total fitness score by BMI categories

Table 3 presents the relationship between exercise time and total fitness score by BMI categories. A significant correlation (rho = 0.33 to 0.53, $p < 0.001$) was found between exercise time and physical fitness in both boys and girls primary and secondary school

students. Additionally, the relationship between exercise time and total fitness score by degree of obesity categories are provided in Supplementary Material 2.

Table 3

Exercise time classified by BMI and fitness

Table 4 presents exercise time classified by BMI and fitness. Among the boys and girls in primary and secondary schools, exercise time was greater in the high-fitness group compared with the low-fitness group across all four BMI categories. The effect size (d) of these differences were moderate to large (0.59–1.05). Additionally, exercise time classified by degree of obesity and fitness are provided in Supplementary Material 3.

Table 4

Discussion

In this study, boys and girls in primary and secondary schools belonging to the normal-weight group exhibited greater physical fitness than those in the other groups, followed by the overweight, underweight, and obese groups (Table 2). Previous studies have

163 reported that grip strength is higher in individuals with a high BMI compared with those
164 with a normal or underweight BMI[20,21]. Additionally, underweight children have been
165 found to be more agile than those with a normal weight[22]. However, when multiple
166 physical fitness factors were evaluated collectively, the results of this study were
167 consistent with those of a previous study[20], which found that children with a normal
168 weight exhibited the highest physical fitness, while children who were underweight or
169 obese exhibited the lowest. Therefore, when considering various physical fitness factors
170 comprehensively, it is suggested that individuals who maintain a normal weight tend to
171 exhibit higher physical fitness compared with those who are obese or underweight.

172 Regarding exercise time in relation to BMI, the normal-weight group exhibited
173 the highest values for boys and girls in primary and secondary schools, while the obese
174 group exhibited the lowest (Table 2). Previous studies[23,24] have reported that children
175 with obesity engage in lower moderate-to-vigorous physical activity (MVPA), as assessed
176 by accelerometers, compared with children who are not obese. Additionally, Cooper et
177 al.[25], who evaluated physical activity using an accelerometer in children aged 2.8 to 18.4
178 years from 10 countries, reported that participants who were overweight/obese exhibited
179 lower physical activity levels compared with those with a normal weight after the age of
180 7. These results are consistent with previous studies[23-26].

There are fewer studies examining physical activity in underweight children compared with those who are obese. Chung et al.[26] used an accelerometer to assess physical activity levels in a nationally representative sample of U.S. children aged 6–17 years and examined the relationship between physical activity and BMI. Overall, girls who were underweight were more active than girls who were overweight or obese but less active than girls who maintained a normal weight. Additionally, results for boys indicated that they tend to become more active as their weight decreases. Furthermore, a study that assessed MVPA using an accelerometer in adolescents aged 12.5 to 17.5 years across 10 European cities reported no significant difference in activity levels between adolescents who were underweight or normal weight[27]. In contrast to previous studies[26,27], this study found that boys and girls in primary and secondary schools who were underweight had shorter exercise times than those who maintained a normal weight. This finding suggests that students who are underweight exercise for a shorter duration than normal-weight students, although differences in the methods used to assess physical activity and racial characteristics may have influenced the results.

In this study, physical fitness and exercise time were correlated across all body types (Table 3). Furthermore, moderate to large differences (effect size d = 0.59–1.05) in exercise time were observed between the high-fitness and low-fitness groups in all body

type groups (Table 4). Although previous study[8] found no significant differences in physical activity levels between obese and non-obese groups when comparing low-fitness and high-fitness groups using accelerometer, the present study found a correlation between exercise time and in physical fitness both obese and underweight groups (Table 4). These results suggest that, regardless of body size, there may be a certain degree of correlation between physical fitness and time spent exercising. Blair[28] suggested that physical activity benefits health regardless of body weight, as aerobic fitness is more strongly related to cardiovascular risk than BMI. The results of this study support this opinion. Although this study cannot determine causality, these findings suggest that regular exercise may lead to enhanced physical fitness levels across all body types.

This study possesses the strength of evaluating physical fitness from various aspects and being conducted on a large scale. However, it also has several limitations. First, this study is a cross-sectional study and therefore has significant limitations in terms of estimating causal relationships. Also, this study did not assess health outcomes beyond physical fitness. While children's physical fitness is a significant marker of health and is associated with cardiovascular risk factors, bone health, and mental health[29], this study could not clarify the actual health benefits for students exhibiting high levels of physical fitness. Additionally, due to the large scale of this study, body composition was not

evaluated and exercise time was based on self-reported data. Notably, previous research has shown discrepancies between exercise time assessed via the questionnaire used in this study and MVPA measured with an accelerometer[30,31]. Consequently, there is a possibility that exercise time was not accurately assessed, making it unsuitable for establishing BMI-based exercise time standards. In future studies, evaluating physical activity using accelerometers or pedometers may enable the development of more precise physical activity criteria based on BMI[32]. Furthermore, while it is unlikely to have significantly impacted the results, this study did not consider the birth month of the participants. Instead, age was defined as 10.0 years for Year 5 primary school students and 13.0 years for Year 8 secondary school students, potentially introducing some error in the BMI-based body size evaluations. However, even when analysis was performed using degree of obesity (Supplementary Material 2 and 3), the results were similar to those obtained using BMI. Additionally, this study has limitations in that it did not adjust for related factors such as dietary habits and other lifestyle habits (e.g., sleep), socioeconomic factors, and participation in sports clubs or extracurricular activities. Furthermore, although this study assessed physical fitness using a total fitness score, future research should examine the relationship between each fitness tests and exercise time, as well as the relationship between standardized total fitness scores and exercise

time. Finally, factors such as genetics[33] and biological maturity[34] may influence the relationship between physical fitness and exercise time. This study was unable to adjust for these factors, representing another limitation.

Conclusions

This study revealed that among primary and secondary school students, regular exercise was associated with higher levels of physical fitness, regardless of whether an individual was obese or underweight, in addition to being normal-weight. These findings may indicate the importance of promoting exercise time among all children. In the future, it will be necessary to conduct objective physical activity assessments and longitudinally examine the relationship between physical activity and anthropometry and physical fitness, taking into account related factors such as maturity.

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Contributions

KS conceptualized the study design and protocol, carried out the analysis, wrote the main manuscript text, prepared the tables and figure, and reviewed the manuscript.

Conflicts of Interest

The author declares no competing interests.

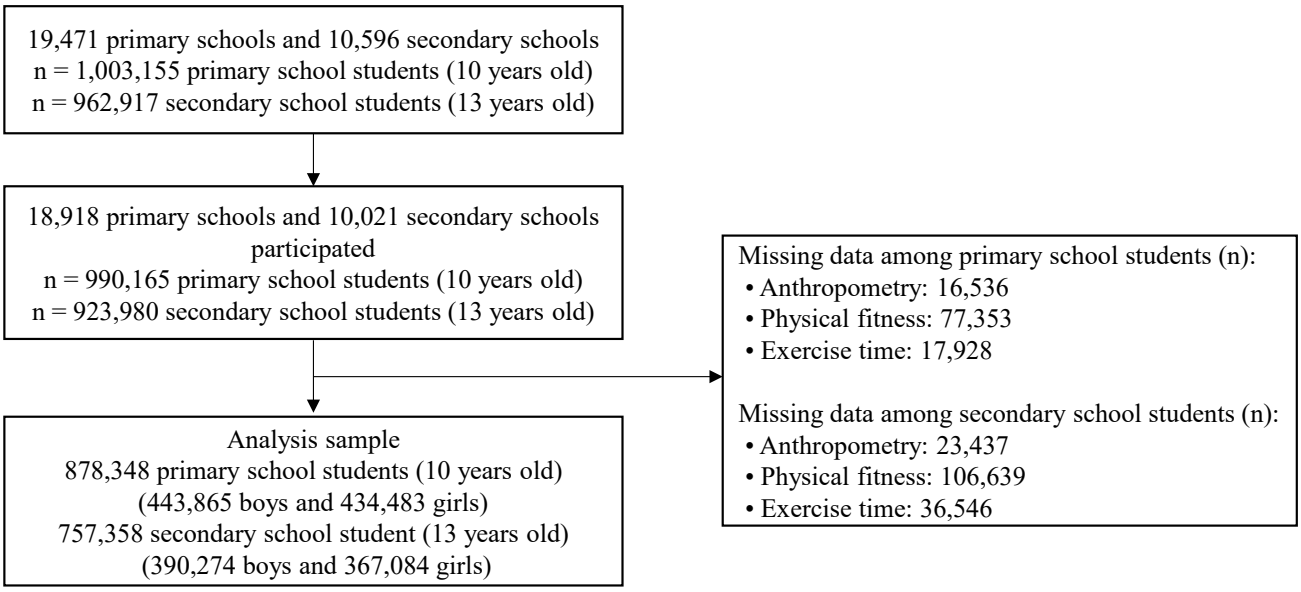

Fig. 1 Flowchart of the participants.

Table 1. The cut-off values for assessing underweight, normal-weight, overweight and obesity based on BMI

	Boys				Girls			
	Underweight	Normal-weight	Overweight	Obesity	Underweight	Normal-weight	Overweight	Obesity
Year 5	≤14.63	14.64–19.79	19.80–23.95	≥23.96	≤14.58	14.59–19.77	19.78–23.96	≥23.97
Year 8	≤15.84	15.85–21.88	21.89–26.86	≥26.87	≤16.23	16.24–22.48	22.49–27.56	≥27.57

BMI; Body mass index.

Table 2. Participants' characteristics classified by BMI

	Total	(A) Underweight	(B) Normal-weight	(C) Overweight	(D) Obesity	*Bonferroni test
Year 5						
Boys	n = 443865	n = 31241	n = 314749	n = 74597	n = 23278	
Height (cm)	139.6 ± 6.3	136.7 ± 5.8	138.9 ± 6.0	142.2 ± 6.1	144.8 ± 6.3	A<B<C<D
Weight (kg)	35.3 ± 7.8	26.3 ± 2.4	32.7 ± 4.2	43.5 ± 4.6	55.2 ± 6.9	A<B<C<D
BMI (kg/m^2)	18.0 ± 3.0	14.1 ± 0.5	16.9 ± 1.3	21.5 ± 1.2	26.3 ± 2.1	A<B<C<D
Total fitness score	52.6 ± 9.5	51.0 ± 9.3	54.0 ± 9.2	49.7 ± 9.3	45.5 ± 9.3	D<C<A<B
Exercise time (min/week)	548.4 ± 472.7	486.2 ± 449.0	579.6 ± 480.7	485.6 ± 447.2	410.0 ± 416.9	D<A,C<B
Girls	n = 434483	n = 38463	n = 322946	n = 61353	n = 11721	
Height (cm)	141.3 ± 6.9	137.3 ± 6.2	141.0 ± 6.8	144.5 ± 6.5	145.9 ± 6.3	A<B<C<D
Weight (kg)	35.2 ± 7.3	26.4 ± 2.6	33.7 ± 4.7	44.5 ± 4.7	55.3 ± 6.2	A<B<C<D
BMI (kg/m^2)	17.5 ± 2.6	14.0 ± 0.5	16.9 ± 1.4	21.3 ± 1.1	25.9 ± 1.8	A<B<C<D
Total fitness score	54.3 ± 9.0	52.1 ± 8.7	55.1 ± 8.8	53.0 ± 9.1	48.9 ± 9.1	D<A<C<B
Exercise time (min/week)	322.6 ± 338.2	294.9 ± 315.9	335.3 ± 345.5	287.2 ± 316.3	248.9 ± 287.6	D<C<A<B
Year 8						
Boys	n = 390274	n = 28476	n = 305851	n = 45432	n = 10515	
Height (cm)	161.3 ± 7.4	157.1 ± 7.9	161.3 ± 7.2	163.2 ± 7.1	164.3 ± 7.2	A<B<C<D
Weight (kg)	50.0 ± 9.9	37.4 ± 4.2	48.2 ± 6.3	63.3 ± 6.7	79.6 ± 9.1	A<B<C<D
BMI (kg/m^2)	19.1 ± 3.0	15.1 ± 0.7	18.5 ± 1.5	23.7 ± 1.4	29.4 ± 2.3	A<B<C<D
Total fitness score	41.4 ± 10.7	35.3 ± 9.4	42.7 ± 10.3	38.9 ± 11.6	32.6 ± 10.3	D<A<C<B
Exercise time (min/week)	724.4 ± 462.8	609.1 ± 442.8	744.4 ± 456.8	694.4 ± 493.6	581.7 ± 474.4	D<A<C<B
Girls	n = 367084	n = 26786	n = 300227	n = 35797	n = 4274	
Height (cm)	155.0 ± 5.3	154.2 ± 5.7	155.0 ± 5.2	155.2 ± 5.4	155.7 ± 5.6	A<B<C<D
Weight (kg)	46.7 ± 7.1	36.9 ± 3.2	45.9 ± 4.9	58.0 ± 5.2	72.1 ± 6.6	A<B<C<D
BMI (kg/m^2)	19.4 ± 2.6	15.5 ± 0.7	19.1 ± 1.6	24.1 ± 1.3	29.7 ± 1.9	A<B<C<D
Total fitness score	47.4 ± 11.6	44.8 ± 11.2	48.1 ± 11.5	44.5 ± 11.6	38.3 ± 10.7	D<A<C<B
Exercise time (min/week)	501.8 ± 434.0	451.0 ± 426.4	515.4 ± 434.9	446.1 ± 425.8	336.7 ± 386.0	D<A,C<B

BMI; Body mass index. Values are means ± satandard deviations. *p<0.01

Table 3. Relationship between exercise time and total fitness score by BMI categories

		rho	p-value
Year 5			
Boys			
Underweight	n = 31241	0.53	< 0.001
Normal-weight	n = 314749	0.52	< 0.001
Overweight	n = 74597	0.49	< 0.001
Obesity	n = 23278	0.48	< 0.001
Girls			
Underweight	n = 38463	0.42	< 0.001
Normal-weight	n = 322946	0.42	< 0.001
Overweight	n = 61353	0.37	< 0.001
Obesity	n = 11721	0.33	< 0.001
Year 8			
Boys			
Underweight	n = 28476	0.42	< 0.001
Normal-weight	n = 305851	0.40	< 0.001
Overweight	n = 45432	0.47	< 0.001
Obesity	n = 10515	0.45	< 0.001
Girls			
Underweight	n = 26786	0.52	< 0.001
Normal-weight	n = 300227	0.53	< 0.001
Overweight	n = 35797	0.52	< 0.001
Obesity	n = 4274	0.46	< 0.001

BMI; Body mass index. rho; Spearman correlation coefficient.

Table 4. Exercise time classified by BMI and fitness

	Low fit	High fit	p-value	effect size d
Year 5				
Boys				
Underweight	n = 16908	n = 14333		
	318.6 ± 344.8	683.8 ± 476.4	< 0.001	0.89
Normal-weight	n = 130846	n = 183903		
	355.7 ± 363.4	739.0 ± 490.4	< 0.001	0.87
Overweight	n = 45374	n = 29223		
	348.8 ± 358.6	698.2 ± 486.4	< 0.001	0.85
Obesity	n = 17979	n = 5299		
	327.3 ± 353.5	690.5 ± 487.3	< 0.001	0.94
Girls				
Underweight	n = 23012	n = 15451		
	211.0 ± 240.2	419.8 ± 369.2	< 0.001	0.70
Normal-weight	n = 150037	n = 172909		
	220.7 ± 254.5	434.7 ± 381.3	< 0.001	0.65
Overweight	n = 34354	n = 26999		
	207.6 ±245.8	388.5 ± 363.6	< 0.001	0.60
Obesity	n = 8523	n = 3198		
	204.4 ± 247.8	367.3 ± 346.9	< 0.001	0.59
Year 8				
Boys				
Underweight	n = 21233	n = 7243		
	531.7 ± 418.8	835.9 ± 433.2	< 0.001	0.72
Normal-weight	n = 137861	n = 167990		
	577.9 ± 426.8	881.1 ± 434.7	< 0.001	0.70
Overweight	n = 27244	n = 18188		
	538.3 ± 433.8	928.3 ± 485.4	< 0.001	0.86
Obesity	n = 8438	n = 2077		
	500.6 ± 434.1	911.1 ± 488.4	< 0.001	0.92
Girls				
Underweight	n = 15837	n = 10949		
	298.4 ± 357.0	671.8 ± 422.0	< 0.001	0.96
Normal-weight	n = 141948	n = 158279		
	312.1 ± 361.6	697.7 ± 413.8	< 0.001	0.99
Overweight	n = 21633	n = 14164		
	293.6 ± 355.0	679.1 ± 419.5	< 0.001	1.01
Obesity	n = 3447	n = 827		
	367.4 ± 345.3	625.7 ± 411.8	< 0.001	1.05

BMI; Body mass index. Values are means ± satandard deviations. Exercise time; minutes/week.

Supplementary Material 1. Participants' characteristics classified by degree of obesity

	Total	(A) Underweight	(B) Normal-weight	(C) Overweight	(D) Obesity	*Bonferroni test
Year 5						
Boys	n = 443865	n = 12238	n = 372668	n = 28927	n = 30032	
Height (cm)	139.6 ± 6.3	142.5 ± 5.4	139.2 ± 6.1	140.9 ± 6.7	141.9 ± 7.0	B<C<D<A
Weight (kg)	35.3 ± 7.8	28.2 ± 3.1	33.5 ± 5.6	44.2 ± 6.4	51.6 ± 8.6	A<B<C<D
Degree of obesity (%)	2.0 ± 16.2	−23.0 ± 3.0	−2.2 ± 9.7	24.5 ± 2.9	42.3 ± 11.5	A<B<C<D
Total fitness score	52.6 ± 9.5	52.4 ± 9.5	53.6 ± 9.2	48.3 ± 9.0	45.3 ± 9.2	D<C<A<B
Exercise time (min/week)	548.4 ± 472.7	501.9 ± 458.7	568.0 ± 477.2	460.7 ± 438.2	407.7 ± 416.1	D<C<A<B
Girls	n = 434483	n = 12607	n = 381055	n = 22473	n = 18348	
Height (cm)	141.3 ± 6.9	143.3 ± 5.7	141.1 ± 6.9	142.0 ± 7.4	142.4 ± 7.3	B<C<D<A
Weight (kg)	35.2 ± 7.3	28.1 ± 3.2	34.1 ± 5.9	44.3 ± 6.8	50.6 ± 8.3	A<B<C<D
Degree of obesity (%)	0.4 ± 14.3	−23.0 ± 2.9	−2.2 ± 9.5	24.3 ± 2.9	41.1 ± 10.4	A<B<C<D
Total fitness score	54.3 ± 9.0	53.2 ± 8.8	54.8 ± 8.8	51.2 ± 8.8	48.4 ± 8.9	D<C<A<B
Exercise time (min/week)	322.6 ± 338.2	287.1 ± 312.2	329.7 ± 342.1	278.8 ± 310.4	252.9 ± 290.9	D<A,C<B
Year 8						
Boys	n = 390274	n = 12592	n = 339438	n = 18559	n = 19685	
Height (cm)	161.3 ± 7.4	161.9 ± 7.0	161.2 ± 7.3	161.5 ± 7.8	162.0 ± 8.2	B<C<A<D
Weight (kg)	50.0 ± 9.9	38.7 ± 4.6	48.5 ± 7.4	62.5 ± 8.1	73.0 ± 11.3	A<B<C<D
Degree of obesity (%)	0.1 ± 15.3	−23.4 ± 3.6	−3.1 ± 9.1	24.3 ± 2.9	44.1 ± 13.4	A<B<C<D
Total fitness score	41.4 ± 10.7	35.7 ± 9.7	42.3 ± 10.5	37.4 ± 11.2	33.2 ± 10.4	D<A<C<B
Exercise time (min/week)	724.4 ± 462.8	567.7 ± 441.7	739.8 ± 458.8	676.4 ± 494.0	603.9 ± 475.2	A<D<C<B
Girls	n = 367084	n = 14526	n = 328801	n = 13932	n = 9825	
Height (cm)	155.0 ± 5.3	154.5 ± 5.6	155.0 ± 5.3	154.8 ± 5.5	155.2 ± 5.8	A<C<B,D
Weight (kg)	46.7 ± 7.1	36.0 ± 3.2	46.1 ± 5.5	58.6 ± 4.7	67.2 ± 7.3	A<B<C<D
Degree of obesity (%)	−1.2 ± 13.3	−23.3 ± 3.1	−2.6 ± 9.3	24.1 ± 2.8	41.7 ± 10.8	A<B<C<D
Total fitness score	47.4 ± 11.6	44.1 ± 11.1	47.9 ± 11.5	43.8 ± 11.5	40.0 ± 11.0	D<A,C<B
Exercise time (min/week)	501.8 ± 434.0	438.6 ± 424.1	511.7 ± 434.9	431.3 ± 420.0	364.4 ± 396.6	D<A,C<B

Degree of obesity (Underweight; <−20%, Normal-weight; −19.9–19.9, Overweight; 20.0–29.9, Obesity; >30.0). Values are means ± satandard deviations. *p<0.01

Supplementary Material 2. Relationship between exercise time and total fitness score by degree of obesity categories

		rho	p-value
Year 5			
Boys			
Underweight	n = 12238	0.53	< 0.001
Normal-weight	n = 372668	0.52	< 0.001
Overweight	n = 28927	0.48	< 0.001
Obesity	n = 30032	0.48	< 0.001
Girls			
Underweight	n = 12607	0.42	< 0.001
Normal-weight	n = 381055	0.42	< 0.001
Overweight	n = 22473	0.35	< 0.001
Obesity	n = 18348	0.33	< 0.001
Year 8			
Boys			
Underweight	n = 12592	0.44	< 0.001
Normal-weight	n = 339438	0.41	< 0.001
Overweight	n = 18559	0.46	< 0.001
Obesity	n = 19685	0.45	< 0.001
Girls			
Underweight	n = 14526	0.51	< 0.001
Normal-weight	n = 328801	0.53	< 0.001
Overweight	n = 13932	0.51	< 0.001
Obesity	n = 9825	0.47	< 0.001

Degree of obesity (Underweight; <−20%, Normal-weight; −19.9–19.9, Overweight; 20.0–29.9, Obesity; >30.0). rho; Spearman correlation coefficient.

Supplementary Material 3. Exercise time classified by degree of obesity and fitness

	Low fit	High fit	p-value	effect size d
Year 5				
Boys				
Underweight	n = 6891	n = 5347		
	336.5 ± 361.1	715.0 ± 482.7	< 0.001	0.94
Normal-weight	n = 193834	n = 178834		
	384.6 ± 380.4	766.8 ± 491.6	< 0.001	0.88
Overweight	n = 21719	n = 7208		
	368.4 ± 372.9	738.5 ± 498.9	< 0.001	0.91
Obesity	n = 25344	n = 4688		
	346.2 ± 366.5	740.4 ± 501.5	< 0.001	1.04
Girls				
Underweight	n = 7441	n = 5166		
	202.9 ± 235.2	408.4 ± 365.0	< 0.001	0.73
Normal-weight	n = 197853	n = 183202		
	225.7 ± 258.0	442.1 ± 383.7	< 0.001	0.67
Overweight	n = 15309	n = 7164		
	219.5 ± 255.7	405.7 ± 372.6	< 0.001	0.63
Obesity	n = 14365	n = 3983		
	214.5 ± 254.7	391.2 ± 362.3	< 0.001	0.63
Year 8				
Boys				
Underweight	n = 10009	n = 2583		
	500.3 ± 414.9	829.0 ± 445.4	< 0.001	0.78
Normal-weight	n = 183436	n = 156002		
	601.4 ± 429.2	902.5 ± 438.6	< 0.001	0.70
Overweight	n = 13178	n = 5381		
	559.5 ± 444.2	962.8 ± 492.9	< 0.001	0.88
Obesity	n = 16407	n = 3278		
	534.3 ± 440.9	952.3 ± 487.4	< 0.001	0.93
Girls				
Underweight	n = 9882	n = 4644		
	319.5 ± 368.8	692.1 ± 422.6	< 0.001	0.96
Normal-weight	n = 178580	n = 150221		
	335.7 ± 371.5	721.0 ± 411.3	< 0.001	0.99
Overweight	n = 9560	n = 4372		
	310.7 ± 364.6	695.0 ± 412.6	< 0.001	1.01
Obesity	n = 7885	n = 1940		
	288.9 ± 356.0	671.6 ± 405.1	< 0.001	1.05

Degree of obesity (Underweight; <−20%, Normal-weight; −19.9–19.9, Overweight; 20.0–29.9, Obesity; >30.0). Values are means ± satandard deviations. Exercise time; minutes/week.