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Longitudinal changes and tracking of in-school physical activity in primary school children: four-year longitudinal study

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Abstract

Background There is little evidence on the tracking of physical activity during school hours. In addition, tracking physical activity in schools provides important evidence for understanding children's physical activity and conducting intervention studies. Therefore, this study examined longitudinal changes and tracking of in-school physical activity in primary school children.

Methods In this study, physical activity was investigated longitudinally in primary school children for 4 years. The baseline participants consisted of 103 second-grade students (7–8 years old) who participated. Step counts and moderate-to-vigorous physical activity (MVPA) in school and during first recess and lunch/second recess were examined using an accelerometer (Kenz Lifecorder GS 4-second version; Suzuken Co. Ltd, Nagoya, Japan).

Results After excluding missing data (moving school; $n=8$, physical activity; $n=8$), 87 (43 boys and 44 girls) of whom were included in the final analysis. Step counts and MVPA during school and physical education in boys did not decrease across the school years. By contrast, in girls, step counts during school did not decrease across the school years, however MVPA did decrease. In addition, for both sexes, step counts and MVPA during first recess decrease across the school years. During lunch/second recess, only step counts decrease across the school years in both sexes. In addition, the tracking coefficients for step counts and MVPA for boys in school and during first recess and lunch/second recess were found across many school years. Contrarily, girls had fewer significant tracking coefficients between school years than boys. There were also few significant tracking coefficients between grades for physical education step counts and MVPA for both boys and girls.

Conclusions Our results suggested that in-school step counts for both boys and girls does not decrease across the school years. However, given that girls demonstrated reduced levels of in-school MVPA across the school years, it is important to promote strategies to increase MVPA in this group.

Keywords Physical activity, Step counts, Moderate-to-vigorous physical activity, Youth, Recess, Physical education, Longitudinal study, Tracking

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Introduction

A number of reviews have revealed the multifaceted positive effects of physical activity on mental and physical aspects in children [1–4]. Therefore, World Health Organization indicates the importance of engaging in an average of 60 min of moderate-to-vigorous physical activity (MVPA) daily, as one of the physical activity guidelines [5]. However, physical activity guidelines for children are insufficient in many countries [5, 6]. Guthold et al. [6] reported that 81.0% of adolescents aged 11 to 17 years internationally do not meet physical activity guidelines. Reilly et al. [7] also reported on the compliance rate of physical activity guidelines for children from 2014 to 2022, and the compliance rate of physical activity guidelines for children internationally did not reach 40%. In addition, declines in physical activity over time also represent a concern [8]. Conger et al. [8] reported that physical activity levels had decreased overall between 1995 and 2017, based on research conducted in eight developed countries including children, adolescents and adults.

Children's physical activity tends to decrease over time from approximately 6 years old [9–11]. Wolff-Hughes et al. [11] assessed physical activity in Americans aged 6–19 years ($N = 3698$) with accelerometers and reported that physical activity was highest at age 6 and gradually decreased thereafter. Cooper et al. [9] also assessed physical activity in 27,637 children aged 2.8–18.4 years in 10 countries using accelerometers and reported that physical activity peaked at 5–6 years old and then decreased by 4.2% per year. In addition, in a systematic review and meta-analysis examining longitudinal changes in moderate-to-vigorous physical activity (MVPA) among 22,091 individuals aged 3–18 years, Farooq et al. [10] reported that MVPA decreased from 8 years old in boys and 6 years old in girls. Based on these previous studies, it is important to maintain physical activity levels and prevent a decline in physical activity levels during childhood. This will help prevent obesity and weight gain, and lead to desirable bone health, cardiometabolic health, cognitive outcomes, mental health and physical fitness [5].

Children's physical activity settings can be generally categorized as in-school and out-of-school activities. The contribution of out-of-school activities (e.g., after-school sports activities and before/after-school active travel activities) to physical activity has been reported to be important [12–14]. Cox et al. [13] measured step counts among New Zealand children (school years 1–6) in and out of school using pedometers and found that out-of-school steps accounted for 52.4% of the daily steps. Moreover, Gidlow et al. [14] examined the in-school contribution to daily physical activity using accelerometers in UK children (3–16 years) and reported that the in-school contribution was 29.4% ± 9.8%; however, when after-school activities were included, the contribution increased markedly to 49.1% ± 11.2%. In addition, a systematic review and meta-analysis by Campos-Garzón et al. [12] found that commuting to school contributed 48% of the physical activity in youth.

On the contrary, schools are considered important settings for health promotion by WHO and UNESCO, as they enroll most children and they are equally capable of promoting children's health, well-being, and development [15, 16]. Indeed, in their systematic review and meta-analysis of physical activity in schools, Tassitano et al. [17] noted that the duration of MVPA in schools averaged 27.8 min and that structured environments make an important contribution to the accumulation of physical activity in youth. Focusing on the school as a domain is one important strategy for promoting physical activity. However, longitudinal changes physical activity in school as a whole and during physical education and recess have not been sufficiently investigated. Indeed, Tassitano et al. [17] noted that the representative study design was a cross-sectional study. Therefore, it is important to examine longitudinal changes in physical activity.

Longitudinal changes in physical activity provide important evidence for understanding physical activity in children, and examining the tracking of physical activity provides important evidence for conducting intervention studies in childhood. If it is confirmed that physical activity within the school is being tracked, this will be one of the reasons for the importance of increasing physical activity within the school. Tracking physical activity for the whole day has been reviewed [18, 19], and it has been reported that tracking coefficients for physical activity are reportedly low to moderate in the short term, with tracking coefficients decreasing over the long term. However, it is possible that tracking physical activity across the whole day could provide different outcomes than tracking physical activity during school. In addition, the extent to which the physical activity in each domain in schools carries over is an area for further investigation. Therefore, the purpose of this study was to examine longitudinal changes and track in-school physical activity in primary school children.

Methods

Study design, setting, and participants

In this study, physical activity and anthropometry were investigated longitudinally in primary school children. This study was conducted on children enrolled in one primary school who had no symptoms affecting their walking or exercise ability. In addition, children who had moved schools and children for whom there was no data on physical activity were excluded. All children had no impairments that affected ambulation or other conditions that affected their ability to exercise. The baseline survey was conducted in November 2019

among second-graders, who were followed-up each year in November until 2023 (Fig. 1). A primary school located in Okayama City, Okayama Prefecture, Japan was included in this study. The baseline participants consisted of 52 boys and 51 girls aged 7–8 years from three second-grade classes. After excluding missing data, 87 participants (aged 11–12, 43 boys and 44 girls) were included in the final analysis (Fig. 1).

In addition, the teachers were asked to complete a questionnaire (Supplementary Material 1) about the timetable for each day of the week with accelerometers, and the start and end of the school day, first recess, lunch/recess, and physical education were investigated. In this study, in-school physical activity was assessed over the entire school day, and physical activity during first recess, lunch/second recess, and physical education was also measured.

This study was approved by the Institutional Review Board of the Okayama University (approval No. H3001) and was conducted according to the principles of the Declaration of Helsinki. Written informed consent was obtained from all the participants and all parents of the participating children before their involvement in the study.

Physical activity

The physical activities evaluated by accelerometers are generally measured using indicators such as the step counts, sedentary time, low intensity physical activity, and MVPA, however in this study, we used the step counts and MVPA, which have been reported to be valid indicators of physical activity using the accelerometer [Kenz Lifecorder GS 4-second version (LC); Suzuken Co. Ltd, Nagoya, Japan], as indicators of physical activity. Kumahara et al. [20] reported that this accelerometer samples acceleration at a rate of 32 samples/s and assesses values ranging from 0.06 to 1.94 g. The acceleration signal was filtered using an analog bandpass filter

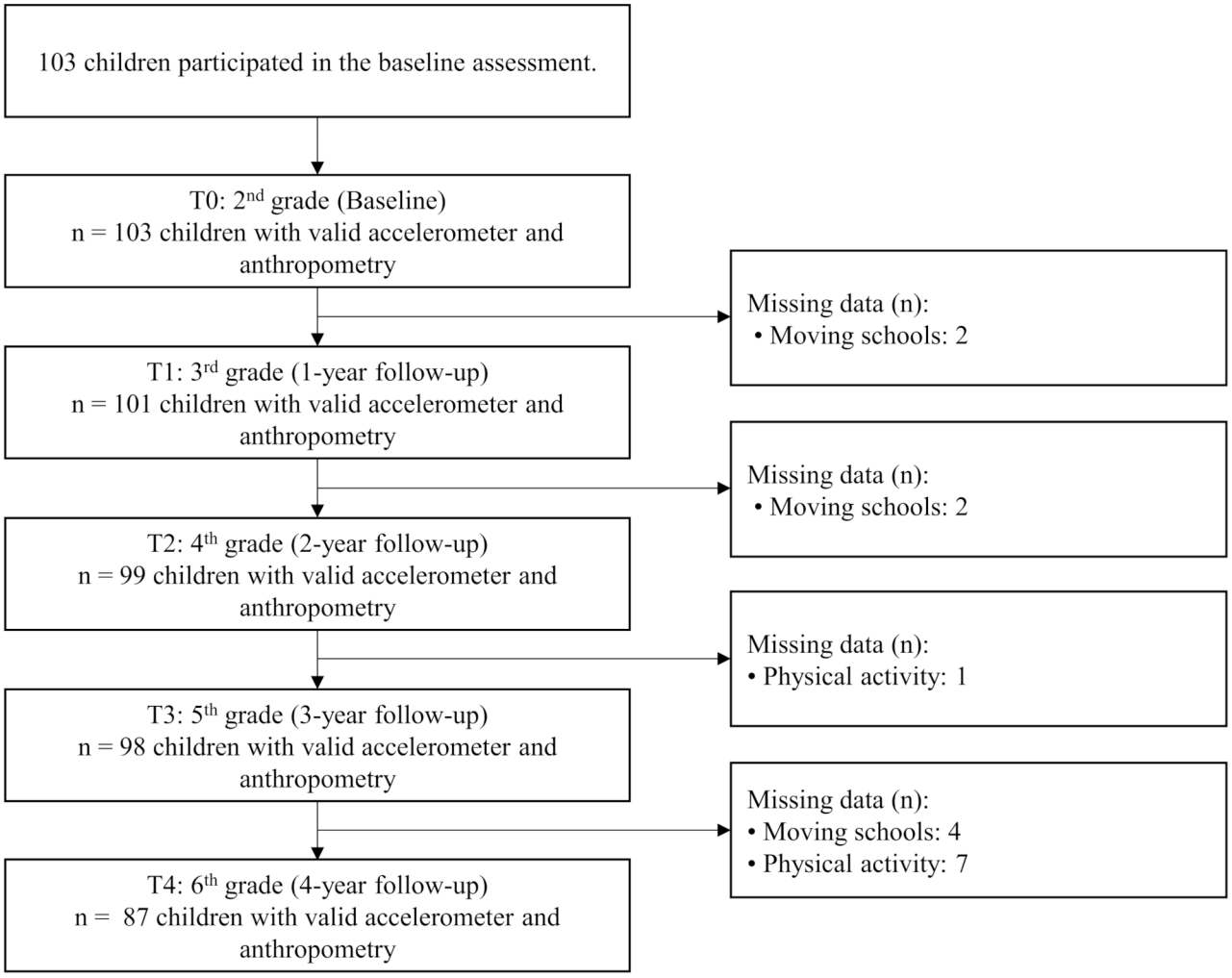

Fig. 1 Flowchart of participant enrollment

and subsequently digitized. The maximum pulse over 4 s was measured as the acceleration value and classified into 11 activity levels (0, 0.5, and 1–9). The epoch length of the LC device was 4 s. Adachi et al. [21] reported that the total energy expenditure assessed using the doubly labeled water method was significantly correlated with total steps and activity level (LC1–6 and 7–9) detected using the LC device in Japanese children (total steps, $r = 0.79$, $p < 0.05$; LC1–6, $r = 0.71$, $p < 0.05$; LC7–9, $r = 0.83$, $p < 0.05$). In addition, Sasayama and Adachi [22] found that the activity level for MVPA is equivalent to a value of ≥ 5 as detected using the LC device. Therefore, the MVPA cutoff was calculated as previously described [22]. Participants wore the LC device on their waists for 5 consecutive weekdays during school time. The accelerometers were given to the children by the teachers every morning and collected and kept at the end of the school day. The school teachers told the children to wear the accelerometers on their waists every morning, and also told them to wear them during physical education lessons. The data from the accelerometer was downloaded using the Lifecorder EX 4-second version Ver.2.11 software. Accelerometer data was used in the analysis from days when the accelerometers were worn at all times from the start of the school day to the end of the school day. Step counts and MVPA during in-school physical activity, first recess, and lunch/second recess were obtained for each day of the week and averaged to obtain individual representative values. Accelerometer data were collected for at least three weekdays. In Japan, physical education classes are generally held twice or three times a week. Physical activity during physical education was analyzed using data from at least 1 day. In the investigation conducted in 2020, physical education classes were analyzed using participants from only two classes ($n = 58$), as physical education were not held once a week in one of the three classes. Physical education classes were taught by teachers specializing in physical education, and ball games and mat activities (2019), ball games (2020), dance and relay races (2021), handball (2022) and basketball (2023) were conducted.

Anthropometry

Height and weight were measured once a year. Height and weight were measured in April only in grade 3, whereas it was measured in September in all other grades. Height was measured to the nearest 0.1 cm, and body weight was measured to the nearest 0.1 kg in light clothing without shoes. Body mass index (BMI) was calculated as the ratio of weight (kg) to height squared (m^2).

Statistical analysis

The characteristics of participants and physical activity variables are presented as the mean ± SD. Longitudinal changes in physical activity and anthropometry were examined using paired one-way analysis of variance and Bonferroni's post-hoc multiple-comparisons test. The relationships with temporal changes in physical activity were tested using the Jonckheere–Terpstra test. In addition, tracking of physical activity was examined by sex using Spearman's correlation coefficient. All analyses were performed using the SPSS Statistics software version 29.0 (IBM Japan, Tokyo, Japan), and the results were considered statistically significant at $p < 0.05$.

Results

Characteristics of the participants

Table 1 presents the participants' characteristics, age, height, weight, and BMI. The height and weight of the participants in this study (measured in April for third grade and in September for the other grades) did not substantially differ from the Japanese national averages [23] [measured from April to June; height (in cm): second, 122.9 ± 5.27 (boys) and 122.0 ± 5.24 (girls); third, 128.5 ± 5.42 (boys) and 128.1 ± 5.68 (girls); fourth, 133.9 ± 5.77 (boys) and 134.5 ± 6.44 (girls); fifth, 139.7 ± 6.37 (boys) and 141.4 ± 6.86 (girls); sixth, 146.1 ± 7.37 (boys) and 147.9 ± 6.41 (girls); weight (in kg): second, 24.6 ± 4.39 (boys) and 24.0 ± 4.19 (girls); third, 28.0 ± 5.60 (boys) and 27.3 ± 5.18 (girls); fourth, 31.5 ± 6.85 (boys) and 31.1 ± 6.32 (girls); fifth, 35.7 ± 8.12 (boys) and 35.5 ± 7.41 (girls); and sixth, 40.0 ± 9.22 (boys) and 40.5 ± 8.06 (girls)].

Table 1 Participant characteristics

	Boys (n = 44)				Girls (n = 43)			
	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Second grade	7.7 ± 0.5	125.3 ± 4.2	24.1 ± 2.9	15.7 ± 1.9	7.8 ± 0.4	124.4 ± 5.2	24.4 ± 3.7	15.3 ± 1.4
Third grade	8.7 ± 0.5	128.6 ± 4.4	26.2 ± 3.1	16.2 ± 1.8	8.8 ± 0.4	127.5 ± 5.3	26.4 ± 3.7	15.8 ± 1.4
Fourth grade	9.7 ± 0.5	136.6 ± 4.8	31.8 ± 5.3	16.7 ± 2.4	9.8 ± 0.4	137.0 ± 6.3	31.5 ± 5.5	17.0 ± 2.2
Fifth grade	10.7 ± 0.5	143.0 ± 5.5	36.2 ± 6.7	17.1 ± 2.5	10.7 ± 0.4	144.3 ± 6.6	35.7 ± 6.4	17.6 ± 2.4
Sixth grade	11.7 ± 0.5	150.4 ± 6.9	40.3 ± 7.3	17.8 ± 2.2	11.7 ± 0.4	150.4 ± 6.2	40.3 ± 6.3	17.7 ± 2.3

The values are presented as the mean ± standard deviation. BMI, body mass index

Longitudinal change of in-school physical activity

For boys, the step counts for in-school physical activity were 7754.8 ± 1457.5, 6782.8 ± 1328.7, 6811.8 ± 1741.3, 8586.7 ± 2587.5, and 7352.0 ± 2799.5 steps/day in grades 2, 3, 4, 5, and 6, respectively, whereas the durations of MVPA in these grades were 24.1 ± 6.9, 19.9 ± 5.6, 20.2 ± 7.4, 27.2 ± 11.5, and 21.0 ± 11.9 min/day, respectively. During the first recess, the step counts in grades 2–6 were 1396.1 ± 444.9, 1057.2 ± 329.0, 1181.1 ± 386.0, 1223.0 ± 506.2, and 677.1 ± 209.9 steps/day, respectively, whereas the durations of MVPA were 5.5 ± 2.6, 4.1 ± 1.8, 4.8 ± 2.1, 5.0 ± 2.8, and 2.2 ± 1.1 min/day, respectively. During lunch/second recess, the step counts in grades 2–6 averaged 1818.7 ± 654.8, 743.2 ± 251.4, 1222.1 ± 512.7, 1936.5 ± 641.1, and 1663.1 ± 527.8 steps/day, respectively, whereas the durations of MVPA were 6.3 ± 3.0, 2.4 ± 1.3, 3.6 ± 1.9, 6.7 ± 3.1, and 4.6 ± 2.3, respectively. In physical education, the step counts in grades 2–6 were 1969.6 ± 245.7, 1473.8 ± 390.7, 2076.5 ± 494.2, 2073.5 ± 424.3, and 1837.9 ± 616.0 steps/day, respectively, and the durations of MVPA were 7.0 ± 2.0, 5.0 ± 1.9, 5.1 ± 3.0, 6.5 ± 2.1, and 7.4 ± 2.9 min/day respectively (Supplementary Material 2).

For girls, the step counts during in-school physical activity in grades 2–6 averaged 6433.1 ± 1169.3, 5693.9 ± 1072.0, 5766.7 ± 1766.6, 6510.3 ± 1415.2, and 5622.1 ± 1563.8 steps/day, respectively, whereas the durations of MVPA were 18.0 ± 4.8, 16.7 ± 4.5, 15.4 ± 5.9, 18.5 ± 5.9, and 13.6 ± 5.9 min/day, respectively. During first recess, the step counts in grades 2–6 were 976.2 ± 312.3, 791.2 ± 246.5, 945.4 ± 347.8, 839.3 ± 342.1, and 552.9 ± 202.7 steps/day, respectively, whereas the durations of MVPA were 3.3 ± 1.7, 2.8 ± 1.3, 3.4 ± 1.7, 2.9 ± 1.7, and 1.4 ± 0.9 min/day, respectively. During lunch/second recess, the step counts in grades 2–6 were 1459.9 ± 472.0, 583.1 ± 251.0, 1058.0 ± 510.2, 1457.5 ± 488.4, and 1333.7 ± 403.2 steps/day respectively, whereas the durations of MVPA were 4.3 ± 2.3, 1.9 ± 1.1, 3.0 ± 1.8, 4.3 ± 2.0, and 3.1 ± 1.5 min/day, respectively. In physical education, the step counts in grades 2–6 were 1783.7 ± 281.9, 1393.2 ± 249.0, 1814.5 ± 391.8, 1843.8 ± 394.4, and 1475.0 ± 411.1 steps/day respectively, whereas the durations of MVPA were 6.4 ± 1.8, 4.8 ± 1.5, 5.9 ± 2.8, 5.4 ± 1.7, and 5.0 ± 1.8 min/day, respectively (Supplementary Material 2).

Tracking of in-school physical activity

Table 2 presents the tracking coefficients for in-school physical activity between grades.

Discussion

The results of this study suggested that the in-school physical activity is almost the same as the results of previous studies [17, 24–26]. The in-school step counts in this study were approximately 6800–8600 and 5600–6500 steps/day for boys and girls, respectively, whereas the durations of MVPA for boys and girls were approximately 20–27 and 14–18 min/day, respectively (Fig. 2). Brusseau and Hannon [24] reviewed the step counts in school and reported that in children aged 5–18 years in the USA ($n = 17$), the averages were 3800–6800 steps for boys and 2500–5500 steps for girls. A study of children outside the USA ($n = 12$) also reported averages of 3500–8100 steps for boys and 3000–7000 steps for girls [24]. Regarding MVPA, Tassitano et al. [17] reported an average duration of MVPA of 27.8 min at school. Concerning MVPA during physical education, Tanaka et al. [25], who assessed physical activity using accelerometers in Japanese children (mean age, 9.2 ± 1.5), reported a daily duration of 12.3 ± 6.1 min. Reilly et al. [26] reviewed MVPA during recess, observing that the weighted mean duration per day across 24 studies was 12 min. Although it is difficult to make direct comparisons because various pedometers and accelerometers were used in previous studies and the step counts and MVPA determined by the LC device in this study were reported to differ from those recorded by the frequently used international ActiGraph [27], the step counts and MVPA of the participants in this study were suggested to be comparable to those in previous studies.

It has been reported that overall daily physical activity decreases from around the age of 6 [9–11], however, with regard to in-school physical activity, in this study found that step counts and MVPA in school did not decline with grade progression, excluding MVPA in girls (Fig. 2). As a factor in this, in our study, in-school physical activity might have been influenced by the increase in time spent in school. Generally, in Japan, the time spent in school per day is shorter in lower grades but progressively longer in higher grades. Therefore, the maintenance of physical activity levels could be influenced by the time spent in school. However, this study found no evidence of a decrease in-school physical activity (excluding MVPA in girls). Therefore, while overall daily physical activity with age, it was suggested that in-school physical activity does not decrease. In particular, with regard to physical activity in physical education, there was no decrease in physical activity for either boys or girls, with the exception of MVPA for girls. These results may indicate the importance of physical education in maintaining physical activity.

However, the study results revealed a decreasing trend in physical activity during first recess and lunch/second recess, in contrast to the results for in-school physical activity and physical education. Therefore, an environment and interventions that encourage children to be active on their own might be necessary during recess. Furthermore, a decreasing trend was more likely to be observed for MVPA in girls during school. This suggests

Table 2 Tracking of in-school physical activity

	Boys (n = 44)				Girls (n = 43)			
	Third grade r	Fourth grade r	Fifth grade r	Sixth grade r	Third grade r	Fourth grade r	Fifth grade r	Sixth grade r
In-school physical activity								
Step counts (steps/day)								
Second grade	0.544*	0.588*	0.491 *	0.343*	0.396*	0.223	0.265	0.430*
Third grade		0.516*	0.539*	0.425*		0.465*	0.576*	0.473*
Fourth grade			0.622*	0.412*			0.265	0.264
Fifth grade				0.507*				0.397*
MVPA (min/day)								
Second grade	0.567*	0.556*	0.470*	0.398*	0.347*	0.168	0.259	0.326
Third grade		0.526*	0.520*	0.413*		0.444*	0.595*	0.460*
Fourth grade			0.541*	0.443*			0.183	0.169
Fifth grade				0.490*				0.368*
First recess								
Step counts (steps/day)								
Second grade	0.410*	0.290	0.262	0.214	0.208	0.154	0.035	0.363*
Third grade		0.562*	0.406*	0.560*		0.492*	0.434*	0.341*
Fourth grade			0.199	0.098			0.213	-0.041
Fifth grade				0.323*				0.226
MVPA (min/day)								
Second grade	0.480*	0.326*	0.283	0.231	0.239	0.264	0.095	0.263
Third grade		0.556*	0.380*	0.497*		0.446*	0.433*	0.340*
Fourh grade			0.181	0.124			0.171	-0.086
Fifth grade				0.345*				0.230
Lunch and second recess								
Step counts (steps/day)								
Second grade	0.459*	0.372*	0.392*	0.279	0.257	0.097	0.174	0.240
Third grade		0.370*	0.402*	0.175		0.274	0.402*	0.318*
Fourth grade			0.371*	0.251			-0.024	0.173
Fifth grade				0.372*				0.258
MVPA (min/day)								
Second grade	0.502*	0.380*	0.407*	0.329*	0.201	0.063	0.124	0.132
Third grade		0.354*	0.399*	0.118		0.240	0.438*	0.298
Fourth grade			0.331*	0.273			-0.014	0.101
Fifth grade				0.403*				0.285
Physical education[1]								
Step counts (steps/day)								
Second grade	0.159	0.223	0.138	-0.140	0.042	0.044	0.031	0.039
Third grade		0.269	0.106	0.274		0.149	0.346*	0.335*
Fourth grade			0.231	0.312			0.186	-0.114
Fifth grade				0.217				-0.040
MVPA (min/day)								
Second grade	0.135	0.135	0.028	-0.190	0.180	0.230	0.174	0.068
Third grade		0.295	0.129	0.304*		0.201	0.287	0.372*
Fourth grade			-0.427*	-0.194			0.026	-0.120
Fifth grade				0.243				-0.048

* $p < 0.05$. MVPA, moderate-to-vigorous physical activity. [1] Boys $n = 30$, Girls $n = 28$

that there are differences in the decrease in physical activity between boys and girls, and that interventions involving MVPA are necessary for girls. Indeed, in a review of physical activity during school recess by Ridgers et al. [28], it was reported that physical activity during school recess was higher in boys than in girls. Therefore, strategic in-school physical activity promotion focusing on recess, physical education and girls is needed.

This study found significant tracking coefficients across a relatively large number of grades for in-school physical

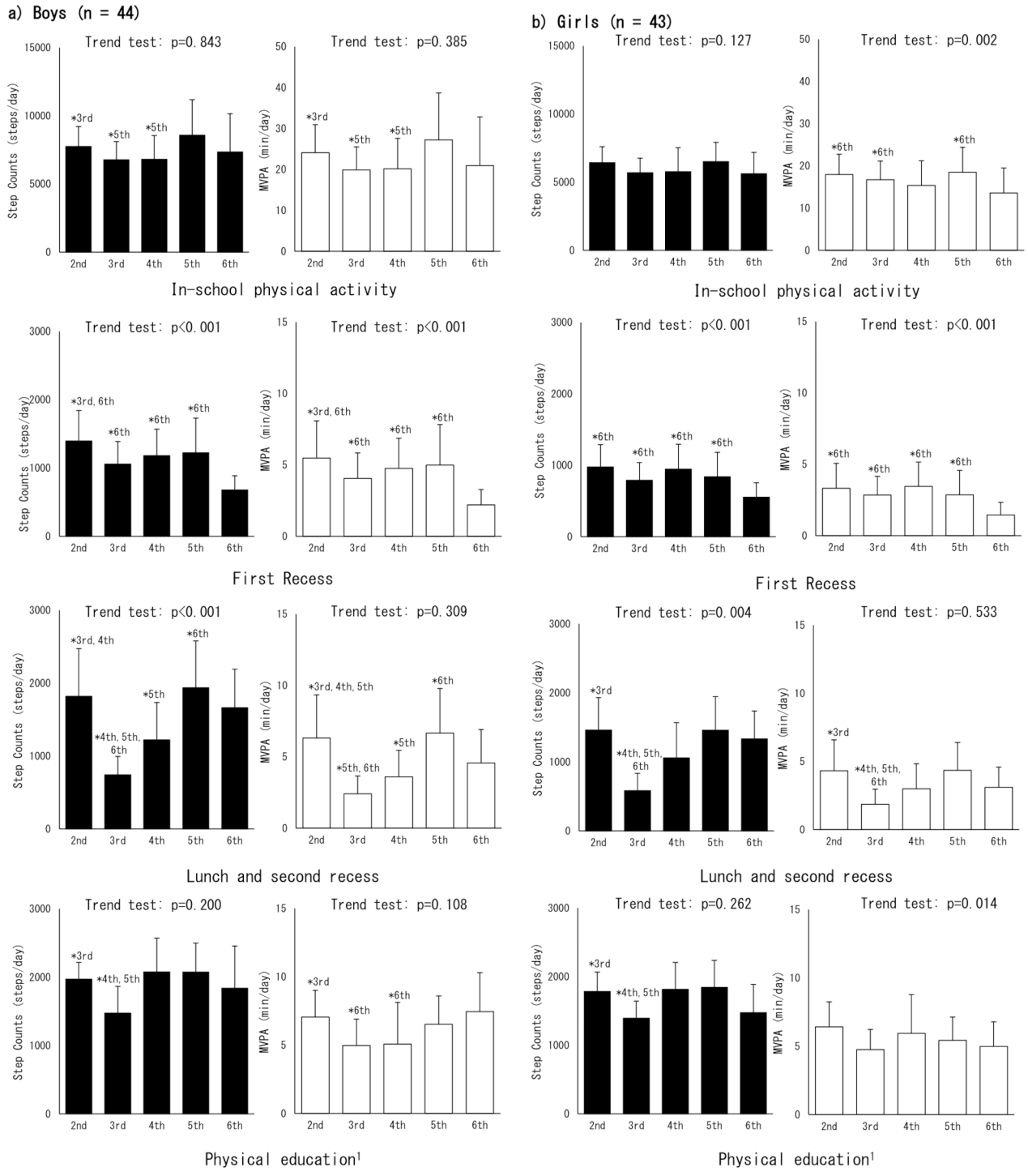

Fig. 2 Longitudinal changes in in-school physical activity. MVPA, moderate-to-vigorous physical activity. 1; Physical education (boys $n = 30$, girls $n = 28$). * $p < 0.05$, Bonferroni's test. The Jonckheere–Terpstra test was used to assess the decreasing trends among the values in the five groups

activity, first recess, and lunch/second recess (Table 1). Furthermore, the data indicated that the overall trends might be stronger for boys than for girls. This suggests the need for more interventions in girls than in boys. In physical education, a small tracking coefficient between grades was found for both boys and girls, but no significant correlations were found between most grades. The tracking coefficient between grades 4 and 5 for boys was −0.427 ($p < 0.05$), contradicting the correlations for other items. The reason why this correlation during physical

education differed from those for in-school physical activity, first recess, and lunch/second recess might be attributable to the fact that physical education classes have a low free-will activity component. This finding might also be attributable to the fact that physical education data were only available for two of three classes in grade 4, and the type of sports activities in the physical education classes differed in each grade group. Overall, this study confirmed that in-school physical activity tracks more strongly during periods of free-will activity, such as recess. It was also confirmed that this trend was relatively stronger for boys than for girls. These findings suggest that interventions focusing specifically on girls in the upper grades are needed to prevent a decrease in activity during recess.

This study had several limitations. One strength of the study was its longitudinal design covering a 4-year period from grade 2 to grade 6. However, this study was limited by the fact that all participants were recruited from a single school. In addition, although the school in this study was not significantly limited by COVID-19, the surveys conducted after 2020 might have been influenced by COVID-19. Although it is not clear whether COVID-19 influenced the decline in physical activity in this study, the fact that some items of in-school physical activity (e.g. step counts) did not decline may emphasise the importance of school activities for maintaining physical activity. In addition, in-school physical activity might be significantly influenced by the cultural and social context of each country (e.g., physical education curriculum and recess length). Therefore, caution must be adopted in generalizing the results of the present study. Furthermore, Dyck et al. [29] reported that out-of-school activities are more strongly associated with BMI than in-school activities. Future studies should examine the association between in-school activities and various health outcomes. However, the present investigation is a valuable study of Asian children. In a review of 91 studies of in-school physical activity by Tassitano et al. [17], only five studies included Asian populations, whereas in the review of 52 studies examining whole-day MVPA in 128 regions by Farooq et al. [10], no study included an Asian population. Thus, further studies with Asian children are needed in the future. Furthermore, this study was unable to clearly identify the reasons for the decrease in MVPA during physical education classes and recess time among girls. It was suggested that further longitudinal and intervention research is needed to identify the reasons for this decrease and to increase physical activity among girls.

Conclusion

Our results suggested that in-school step counts for both boys and girls does not decrease across the school years. However, given that girls demonstrated reduced levels of in-school MVPA across the school years, it is important to promote strategies to increase MVPA in this group.

Abbreviations

BMI Body Mass Index
MVPA Moderate-to-Vigorous Physical Activity

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22256-8.

Supplementary Material 1

Supplementary Material 2

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Author contributions

Conceptualization and investigation: MA, KS and JY; Statistical analysis and writing - original draft preparation: KS, Writing - review and editing: MA and JY. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the Okayama University (approval No. H3001) and was conducted according to the principles of the Declaration of Helsinki. Written informed consent was obtained from all the participants and all parents of the participating children before their involvement in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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