Original Article

Relationship between Moderate-to-Vigorous Physical Activity and Sedentary Behavior on School and Non-School Days in Japanese Children

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Background: Ensuring moderate-to-vigorous intensity physical activity (MVPA) and reducing sedentary behavior (SB) are beneficial to children's health. Although previous studies have pointed out that MVPA was associated with SB, little is known about the relationship between these two outcomes when objectively measured separately on both school and non-school days. Determining whether MVPA can replace SB for children can help in identifying targets and opportunities for intervention.

Objective: This study aimed to examine the relationship between objectively measured MVPA and SB among boys and girls on school and non-school days.

Methods: In this cross-sectional study, data were collected annually from 2015 through 2017, in February and March. A total of 278 children (grades 4–6) participated in the study and wore a triaxial accelerometer to monitor their activities. Children were asked to wear the accelerometer on their waist, for at least 7 consecutive days during all the waking hours, removing it during water-based activities such as showering, bathing, or swimming. A partial Spearman's rank correlation analysis was performed, and the correlation coefficient was calculated to assess the relationship between MVPA and SB controlled grade and wearing time for both sexes on school and non-school days. The correlation coefficients were compared using the Fisher's z-transformation.

Results: Total 225 (108boys, 117girls) and 227 (105boys, 122girls) children met the criteria for wearing the accelerometer on school days and non-school days, respectively. Objectively measured MVPA and SB showed sex-based differences. Boys engaged in daily MVPA time longer than girls on both school and non-school days. In addition, daily SB time of boys was less than those of girls on school day. Significant inverse relationships were observed between MVPA and SB in both boys (−0.63 and −0.67) and girls (−0.64 and −0.72) on school and non-school days. The correlation coefficients were no significant sex differences in the z-scores. Additionally, the correlation coefficients for school days were comparable with those for non-school days regardless of sex.

Conclusions: This study has shown that there is dependent relationship between MVPA and SB in children regardless of the day. Namely, these findings suggest that targeted health education program that increases MVPA and reduces SB can promote a physically active lifestyle among children.

Keywords: triaxial accelerometer, physical activity, school day, non-school day

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I. Introduction

A physically active lifestyle is beneficial for children. For optimal health benefits, more than 3 metabolic equivalents (METs) of intense physical activity (PA) have been recommended and accepted worldwide[1–4]. As per the PA guidelines, children are required to accumulate at least 60 minutes of more than 3 METs of moderate-to-

vigorous intensity physical activity (MVPA), preferably every day. In addition to the MVPA recommendation, there is growing research on sedentary behavior (SB), which is also considered a health indicator or outcome in children[5], and is defined as any activity requiring 1.5 METs or less in a sitting, reclining, or lying posture (e.g., TV viewing, video game playing, computer use)[6]. The general consensus is that SB is a potential risk factor for adiposity and cardiovascular disease, and for poor fitness, self-esteem, and academic achievement in school-aged children and youth[5][7]. There has been considerable interest in both decreasing SB and increasing MVPA for improving the overall health of children.

Although some researchers have examined the hypothesis that MVPA and SB are not mutually exclusive[8][9], recent cross-sectional studies have reported an inverse relationship between objectively measured MVPA and SB[10–14]. We explored the relationships between MVPA and SB on both school and non-school days separately in this study. A meta-analysis has revealed a difference in MVPA in relation to days of the week (school and non-school days)[15][16]. Similarly, the between-day difference in SB is also seen[17-19]. Information regarding these differences and the activities associated with them may be useful for developing appropriate interventions. One study which reported a decrease in MVPA and an increase in SB among children regardless days of the week suggested that they may benefit most from weekday interventions due to the possibility of participating in physical education classes at school[20]. However, little is known about the relationship between MVPA and SB when objectively measured separately on both school and non-school days. Determining whether MVPA can replace SB for children on school and non-school days could help in identifying targets and opportunities for intervention.

The aim of this study was to examine the relationship between objectively measured MVPA and SB on school and non-school days among boys and among girls, in separate groups. It has been suggested that objectively measured MVPA and SB are linked to differences in sex[21–23].

II. Methods

1. Enrollment Procedure

We conducted a cross-sectional study at a private elementary school in Tokyo, Japan and collected data from February to March each year from 2015 through 2017. The school principal and homeroom teachers were made aware of the purpose and methods of the study, and gave their approval for the study to be performed. The parents received complete information about the purpose and methods of the study through their homeroom teachers, and parental consents were returned to the teachers by the children. A total of 278 children (51% girls) from fourth to sixth grades (aged 9-12 years) and their parents agreed to participate in the study. The children were required to wear a triaxial accelerometer for the study. The study was approved by the Ethics Committee of the Graduate School of Human Informatics, Tohoku Gakuin University (Reference number 2017R001).

2. Demographics and Anthropometrics

The children's grade, sex, body weight, and body height were reported in a self-administered questionnaire. Weight status, referred to as "the percentage of overweight (%)," was assessed using the Japanese cut-offs that were established based on the national reference data for Japanese children[24]. Details of the percentage of overweight parameter have been described elsewhere[25]. Briefly, the percentage of overweight (%) was calculated by using data on children's weight (kg), height (cm), and standard weight (kg). Physical assessment based on the percentage of overweight can be classified as "normal or less (less than +20%)" and "obese (+20% or more)".

3. Objective Measurement of Physical Activity and Sedentary Behavior

Habitual MVPA and SB were assessed using a triaxial accelerometer (HJA-750C Active style Pro, Omron Healthcare, Kyoto, Japan), measuring 40 × 52 × 12 mm and weighing 23 g including batteries. The most commonly used accelerometer, ActiGraph[26], and more recently-introduced accelerometers such as the one used in this study have previously been used to evaluate the intensity of physical activities, from sedentary to vigorous, in both ambulatory and non-ambulatory activities in children[27]. Accelerometers can gather information on the time spent on ambulatory and non-ambulatory activities of varying intensities. The Omron HJA-750C Active style Pro was recently used successfully in a study to estimate the habitual PA of Japanese children[28]. Based on the default predictive equations for the accelerometer established for adults, and the results of a previous study in children[27], the following

conversion equations were used: the ambulatory activities are 0.6237 × MET value of Active style Pro + 0.2411, the non-ambulatory activities are 0.6145 × MET value of Active style Pro + 0.5573. The time spent on activities requiring more than 3 METs and 1.5 METs or less were treated as MVPA and SB, respectively. The number of children who met the recommended average of ≥ 60 minutes of MVPA per day[1–4] was also estimated.

Children were asked to wear the accelerometer on their waist, for at least 7 consecutive days during all the waking hours, removing it during water-based activities such as showering, bathing, or swimming. The accelerometers were set to record data at 10-second sampling intervals (epochs) throughout the wearing period. The non-wear time within a day was defined as periods with over 10 minutes of consecutive zero counts. There were 600 valid wearing minutes per day for both school and non-school days. A minimum of 3 school days and 1 non-school day with 600 minutes of wearing time per day were included in the analyses. These accelerometry methods including the epoch length, non-wear time, and valid wearing minutes and days were employed in accordance with a previous study[29].

4. Statistical Analysis

Sufficient sample size was calculated using the *t*-test for a point biserial model based on 0.9 power to detect a significant difference (medium effect size = 0.3, two-sided $P = 0.05$)[30]. Based on the calculation, a total of 109 participants were required.

A partial Spearman's correlation analysis was performed to assess the relationship between MVPA and SB controlling for grade and wearing time. Weight status was excluded as a control variable because there were few obese children. In addition, there was not a J-curve relationship between physical activity and weight status. As the Shapiro-Wilk test indicated a non-normal distribution of MVPA and SB, the partial Spearman's rank correlation coefficient ($_{partial}\rho$) was used[31][32]. The rule of thumb for interpreting the size of a correlation coefficient was set per previous reports[32]: 0-0.3: negligible; 0.3-0.5: low; 0.5-0.7: moderate; 0.7-0.9: high; and 0.9-1.00: very high. For estimation of differences between correlation coefficients for the two sexes and different days, we used the z-value (z) that was calculated by Fisher's z-transformation of $_{partial}\rho$[33]. The correlation analysis was applied for boys and girls separately on both school and non-school days, after verifying the differences in the mean values of the accelerometry variables (valid day of wearing, wearing minutes, time spent on MVPA and SB) and the rates of guideline conformance based on MVPA, using the Mann–Whitney U test and Fisher's exact test, respectively. Effect r for the Mann–Whitney U test and Phi (φ) for Fisher's exact test were calculated to evaluate the effect size[33][34] for differences in the accelerometry variables and the rates of guideline conformance between the two sexes.

The G*power program 3.1.9.2[35][36] and SPSS 25.0 (IBM SPSS Statistics, IBM Corp., Armonk, NY, USA) were used for statistical analyses. Significance was set at $P < 0.05$.

III. Results

1. Sample Characteristics and Sex Difference

All 278 children included in the study wore a triaxial accelerometer. However, five children had to stop wearing the device due to personal reasons (e.g., feeling sick). Of the remaining 273 children, 225 (82%) and 227 (83%) met the criteria for wearing the accelerometer on school days (≥3) and non-school days (≥1), respectively (**Table 1**). These subsamples were included in the present analyses. The mean days of meeting criteria for wearing on both school and non-school days were 4.1±0.8 and 1.7±0.5, respectively. The objectively measured MVPA and SB minutes per day were evaluated based on the sex of the child. MVPA in boys was significantly higher than in girls on both school days ($U = 3646.5$, $P < 0.001$, effect $r = 0.37$) and non-school days ($U = 5050.0$, $P < 0.001$, effect $r = 0.18$), while SB was significantly lower on school days ($U = 5082.0$, $P < 0.001$, effect $r = 0.17$). No significant difference in SB was found on non-school days ($U = 6275.0$, $P = 0.79$). Regarding differences in conformance to MVPA guidelines, there was a significant difference between boys and girls on different days of the week (school days, $P < 0.001$, $\varphi = 0.27$; non-school days, $P = 0.02$, $\varphi = 0.14$). Given that objectively measured MVPA and SB showed sex-based differences, the correlation analysis was applied for boys and girls separately.

2. The Correlation Coefficient between MVPA and SB

Significant inverse relationships were observed between objectively measured daily MVPA and SB for both boys and girls on school (**Figure 1**) and non-school days (**Figure 2**). For boys, moderate inverse correlations

Table 1 Descriptive characteristics and physical activity levels of children

	School day (*N*=225)				Non-school day (*N*=227)			
	Boys (*n* = 108)		Girls (*n* = 117)		Boys (*n* = 105)		Girls (*n* = 122)	
Descriptive characteristics								
Grades, *n* (%)								
4th	35	(32)	39	(33)	41	(39)	44	(36)
5th	40	(37)	43	(37)	37	(35)	39	(32)
6th	33	(31)	35	(30)	27	(26)	39	(32)
Weight status, *n* (%)								
Normal or less	92	(85)	107	(91)	92	(88)	114	(93)
Obese	6	(6)	6	(5)	4	(4)	5	(4)
Missing	10	(9)	4	(3)	9	(9)	3	(2)
Physical activity levels								
Accelerometer data, median (first and third quartile)								
Valid days of wearing, day	4.0	(4.0, 5.0)	4.0	(4.0, 5.0)	2.0	(1.0, 2.0)	2.0	(1.0, 2.0)
Wearing minutes, min	826.0	(775.8, 890.1)	842.6	(807.4, 892.9)	795.4	(719.8, 882.0)	804.3	(733.7, 866.6)
MVPA, min	77.0	(59.4, 109.6)	58.9	(45.3, 76.4) [b]	57.2	(34.4, 82.8)	42.9	(27.3, 65.3) [b]
SB, min	437.1	(384.0, 481.5)	462.5	(403.5, 517.0) [b]	447.4	(385.1, 533.8)	453.4	(379.8, 573.3)
Guideline meeting[a], *n* (%)	81	(75)	57	(49) [c]	48	(46)	39	(32) [c]

Abbreviations: MVPA, moderate-to-vigorous physical activity; SB, sedentary behavior.

[a] Guideline meeting indicates at least 60 minutes of MVPA preferably every day.

[b] Mann–Whitney U test indicates significant differences between boys and girls.

[c] Fisher's exact test indicates significant differences between boys and girls.

Significance was set at $p < 0.05$.

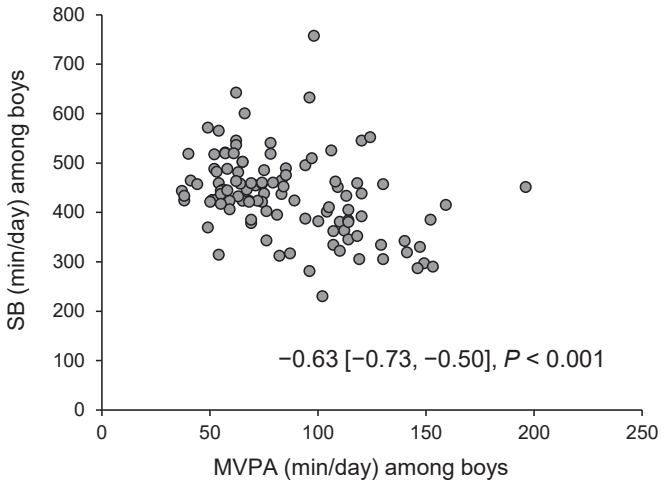
were observed between the objectively measured MVPA and SB on both school days ($n = 108$, $_{partial}\rho = -0.63$, $P < 0.001$) and non-school days ($n = 105$, $_{partial}\rho = -0.64$, $P < 0.001$). There was no significant difference in coefficient between school days and non-school days based on the Fisher's test ($z = 0.13$, $P = 0.89$). Similarly, among girls, the objectively measured daily MVPA showed an inverse and moderate or high correlation with SB on both school days ($n = 117$, $_{partial}\rho = -0.67$, $P < 0.001$) and non-school days ($n = 122$, $_{partial}\rho = -0.72$, $P < 0.001$). Consequently, among girls, there was no significant difference in coefficient between school days and non-school days ($z = 0.74$, $P = 0.46$). Furthermore, we did not find a significant difference in coefficients between boys and girls on both school days ($z = 0.46$, $P = 0.64$) and non-school days ($z = 1.04$, $P = 0.30$).

IV. Discussion

This study found that objectively measured MVPA and SB were inversely correlated, both on school and non-school days, among boys and girls. Additionally, there was no significant difference in the coefficients based on the Fisher's z. The findings of this study can help promote good health among children from fourth to sixth grades.

Our correlational findings are in agreement with those of recent studies that used accelerometry methods to evaluate PA among Japanese children[13)14)], whereas some data collected with European children[10–12)] reported slightly lower correlations than our findings. Two studies with Japanese children observed moderate and inverse partial correlations of −0.61[13)] and −0.58[14)]. One cross-sectional study in Portugal reported an inverse correlation coefficient of −0.45 between objectively measured MVPA and SB among children aged 9-12 years[11)]. Another prospective analysis indicated that objectively measured MVPA was inversely correlated with SB (Pearson's r = −0.44 and −0.47) among overweight Portuguese children aged 10.1±0.8[10)]. Another repeated measures study also showed an inverse partial correlation of −0.49 among Danish children aged 8-11 years[12)].

A moderate or high inverse correlation was observed between MVPA and SB among boys and girls regardless of days of the week. These results suggest that increasing MVPA as well as reducing SB should be considered for promoting a physically active lifestyle among children. Boys in this study were already spending over



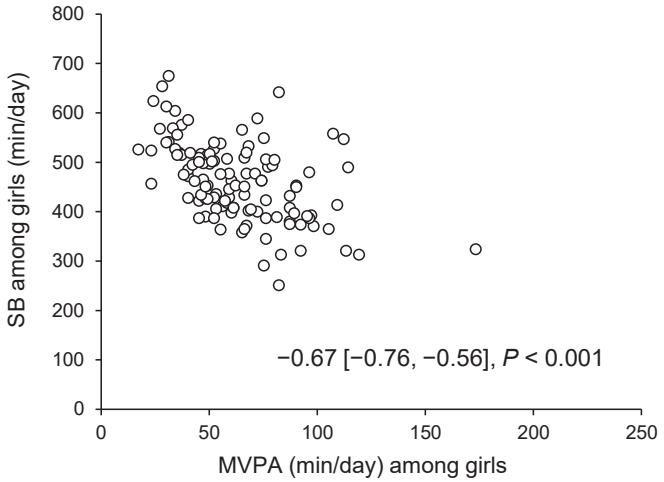
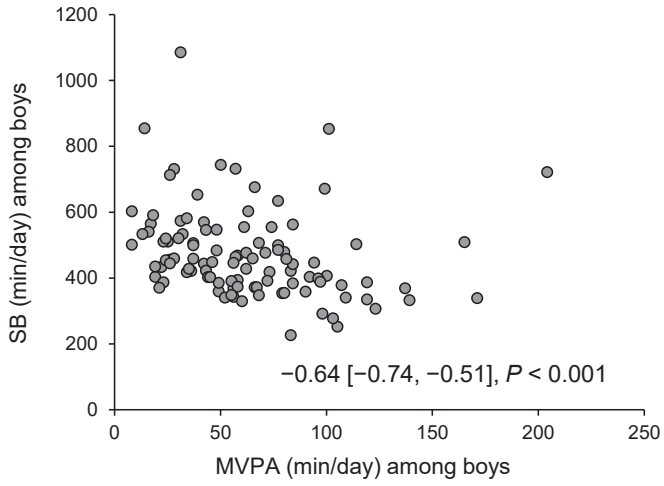


Figure 1 Relationship between moderate-to-vigorous physical activity (MVPA) and sedentary behavior (SB) in boys (n = 108) and girls (n = 117) on school days
Statistics indicate partial Spearman's rank correlation coefficients ($_{partial}$ ρ) controlled for grade and wearing time [upper and lower limit of 95% confidence interval] and P-values.



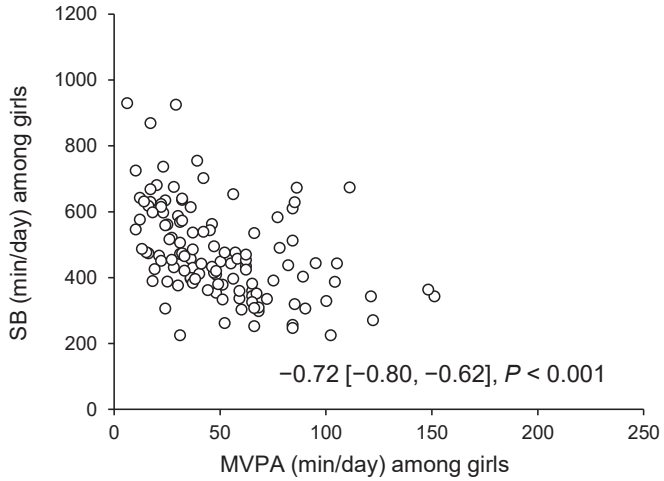


Figure 2 Relationship between moderate-to-vigorous physical activity (MVPA) and sedentary behavior (SB) in boys (n = 105) and girls (n = 122) on non-school days
Statistics indicate partial Spearman's rank correlation coefficients ($_{partial}$ ρ) controlled for grade and wearing time [upper and lower limit of 95% confidence interval] and P-values.

60 minutes per day on MVPA on both school and non-school days, which is in accordance with the current PA guidelines[1–4]. In fact, most boys (75%) met the MVPA guidelines on school days, while less than half (46%) met the guidelines on non-school days. In addition, their SB minutes per day on non-school days increased by about 10 minutes. The focus, therefore, should be on reducing SB among boys. In contrast, less than half of the girls met the guidelines, and the percentage of meeting guideline on non-school days was only 32%. However, their SB minutes per day on non-school days did not increase. These results of lower levels of both MVPA and SB among girls were considered to reflect higher levels of light intensity activity (1.6-2.9 METs)[13)14)].

One of the strengths of this study was that data from school and non-school days were analyzed separately. Identifying correlations between school and non-school days separately is an important component in the sequence of research steps leading to the development of optimal intervention strategies for children[15)]. Such strategies could focus on either increasing MVPA or reducing SB in children. For example, reduction in the time spent viewing TV, playing video games, or using computers is expected to lead to an increase in the length of time spent playing outside to more than the recommended 3 METs. It is important for children to receive education on the importance of an active lifestyle regardless of days, because one of the aims of health

education is the acquisition of knowledge regarding the importance of active living for health[37]. Health education for children on the importance of PA on both school days and non-school days is necessary to develop a physically active lifestyle. School-based interventions to improve physical activity among children play an important role[38]. Recently, classroom-based physical activity interventions that integrate academic content have attracted attention[39]. For example, a cluster-randomized controlled trial of the "Virtual Traveller" intervention showed significant enhancement of MVPA among children[40]. The intent of this classroom-based intervention was to incorporate information regarding the importance of PA into math and English classes. Academic lessons regarding PA such as the "Virtual Traveller" have potential for physical activity promotion; however, further research is required to determine the extent to which such programs are beneficial in Japanese educational systems.

This study has limitations, which should be considered when interpreting the results. First, this study was conducted in a single geographic area in Tokyo, Japan. Second, although the findings were analyzed for boys and girls on school and non-school days separately, other confounders such as environmental, socioeconomic, and sociocultural factors[41–43] were not included in the analysis. Third, the PA data on weekends include those of children who only wore the accelerometer on either Saturday or Sunday, which could cause instability of results. Finally, children did not keep a record of the times they wore the accelerometer. Hence, there is a possibility that their activities were underestimated. However, the pediatric accelerometry methods, epoch length, non-wear time, and valid wearing minutes and days used in this study are widely used and acceptable[29].

Our findings indicate a moderate or high inverse relationship between objectively measured MVPA and SB among boys and girls on both school and non-school days. A targeted health education program that increases MVPA and reduces SB can promote a physically active lifestyle and the overall health of children regardless of the days.

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Main Works:
- Okazaki K, Suzuki K, Sakamoto Y and S Keiji. Usefulness of a self-reported physical activity questionnaire assessment for Japanese children. The Japanese Journal of Physical Fitness and Sports Medicine 66: 407-416, 2017
- Okazaki K, Suzuki K, Sakamoto Y and Sasaki K. Physical activity and sedentary behavior among children and adolescents living in an area affected by the 2011 Great East Japan earthquake and tsunami for 3 years. Preventive Medicine Reports 2: 720–724, 2015

Membership in Learned Societies:
- The Japanese Association of School Health
- Japan Society of Human Growth and Development
- Japanese Society of Physical Fitness and Sports Medicine
- Japan Society of Physical Education, Health and Sport Sciences