

Physical Education's Contribution to Daily Physical Activity Among Middle School Youth

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Little is known about the exact contribution of physical education (PE) to total daily physical activity (PA) among children and adolescents. Therefore, the purpose of this study was to describe the PA of middle school students during PE and non-PE days and determine if children would compensate for a lack of PE by increasing their PA later in the day. Two hundred seventy nine students (159 boys, 120 girls) wore pedometers (Walk4Life LS252, Plainfield, IL) during 5 school days, with at least two of the days including scheduled PE. The least (~1,575; 31% increase), moderately (~2,650; 20% increase), and most highly active students (~5,950; 34% increase) accumulated significantly more daily step counts on days when they participated in PE. Nearly three times the percent of boys (37%) and more than two times the percent of girls (61%) met the recommended steps/day guidelines on days when PE was offered. Rather than a compensatory effect, the most highly active students were more active on school days with PE, even after accounting for the steps they accrued in PE. The evidence is consistent with other studies that have found that PE contributes meaningfully to daily PA, that youth do not compensate when they are not provided opportunities to be physically active in school-based programs, and some youth are stimulated to be more active when they participate in school-based PA programs.

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Regular physical activity (PA) participation is associated with numerous physical and mental health benefits for youth (36). In addition, the growing obesity epidemic and prevalence of inactivity-related chronic diseases such as Type II diabetes has brought attention to the importance of interventions to increase PA and reduce sedentary behaviors (35). Despite the benefits associated with an active lifestyle, a substantial proportion of school-age youth do not meet the current recommended guidelines of 60 min of PA per day (26,36,40). To address this public health challenge, experts and governmental agencies have called for schools to take a leadership role in delivering comprehensive health and physical education (PE) programs that include the promotion of PA (5,27). Schools have also been called to invest in comprehensive PA programs that provide students with PA opportunities beyond those provided in PE (25,45).

Previous studies have revealed that children can accumulate meaningful amounts of PA during school hours (2,17,24,29). In some elementary students, PA accrued during the school day accounts for nearly 30–50% of their total daily activity (8,15,39). Although PE offers numerous health and psychosocial benefits and is a part of a well-rounded education, its contribution to children's overall daily PA levels has not been fully established. Using pedometers, Tudor-Locke et al. (38) and Brusseau et al. (4) found that PE, recess, and lunchtime were important sources of PA during the school day. Upper elementary students in their studies spent a relatively small amount of time in structured PE (30–35 min); yet, PE accounted for a moderate amount of the total daily PA (8–14%). Dauenhauer & Keating (10) reported a concomitant increase in daily PA when time spent in elementary PE increased from 30 to 60 min per day (11–16%).

Total daily PA is generally higher on days that boys and girls have PE (9,24). Although PE can contribute meaningfully to elementary students' total daily PA, this impact may be limited to only those school days when students participate in PE (24). It has been posited that children may have an intrinsic biological drive to be active, such that periods of restricted PA may be followed by periods of increased activity to meet basic biologic drives, such as a need for central nervous system stimulation or balanced energy homeostasis (9,30). Based on this premise, children should compensate for inactivity by increasing their PA on school days when it is restricted (e.g., no PE, no recess, etc.) and/or after school when PA is less restricted (9,24). Dale and colleagues (9) assessed PA through accelerometry in 76 third and fourth grade children during active versus restricted activity school days. During the active days, children received PE as well as outdoor recess while on the restricted days they were not afforded PE and spent their recess time indoors at a computer. A compensatory effect was not seen in the children's after school PA. In fact, they accumulated a significantly greater amount of PA during after school hours on active days than on restricted school days. Similarly, Morgan et al. (24) did not find compensatory increases in daily PA levels on school days without PE. In their study, the most active children accumulated significantly more steps (850) on school days with PE than on those days without PE, even after adjusting for steps taken during PE. While these findings fail to support the intrinsic biological drive hypothesis, they suggest that PE and school-based opportunities for PA may have a stimulatory effect on total daily PA, at least among the most active children. Further study of the possible stimulatory effect of PE on total daily PA is warranted.

Much of the PA research on young adolescents (grades 5 and 6) has been limited to the elementary school setting. Less is known about PA in the middle

school environment where there may be fewer opportunities for higher intensity activity (e.g., recess and/or lunchtime activity) but more opportunities for lower intensity activity (e.g., traveling from classroom to classroom). McKenzie (22) suggests that social-ecological theory may be a viable approach to understanding the middle school context and the opportunities it provides for students to be physically active. From this perspective (3,12), the school environment consists of several interrelated systems that interact with the individual to influence behavior. School structure, everyday routines, and classroom level practices are just a few of those factors that may collectively impact the degree to which children are physically active during the school day. Given the sociocultural complexity of today's school environment with individual teachers dictating the climate of the classroom, education policies and laws driving the school accountability system, and our society rewarding outcomes that do not always involve or promote good health, it remains to be determined how much of the middle school day is available for PA.

Schools are being called to provide a Comprehensive School Physical Activity Program (CSPAP) to promote PA for all students (25,27). The foundation of a CSPAP is quality PE designed to maximize PA during PE lessons and to foster lifelong PA outside the gymnasium. Thus, a better understanding of the relationship between the PA levels during PE and outside of PE is warranted. Specifically, limited research has examined this relationship with middle school students. Therefore, the purpose of this study was twofold: 1) to describe the PA of middle school students during PE and non-PE days, and 2) to determine any compensatory or stimulatory effects PE has on their total daily PA. Gender and activity level differences in middle school students' PA were also examined.

Methods

All students ($N = 403$) from a middle school (comprised of fifth and sixth grades only) in a medium size community (~14,000) in the Rocky Mountain region of the U.S. were recruited to participate in this study. Students were informed of the study during a school-wide assembly and asked to complete an assent form if they were willing to participate. The school's web-based portal was used to inform parents about the study. Assent to participate was received from 375 of the students (201 boys, 174 girls). One parent or guardian declined permission for his children ($n = 2$) to participate.

Participants

Mean age of the students was $11.8 \pm .66$ years and they had an average BMI (kg/m^2) of 19.31 ± 3.8 and 18.67 ± 4.0 for boys and girls, respectively. The prevalence of overweight and obesity in this sample was 24% and 9.3%, respectively, based on the International Obesity Task Force thresholds. The sample reflected the ethnic distribution of the school: 82% Caucasian students, 13% Hispanic, 2% American Indian or Alaskan Native and 2% two or more races. The Institutional Review Board at the University of Wyoming and the middle school principal approved all procedures.

Characteristics of the School and Physical Education Program

Students in the study attended school for 7 hr and 40 min, from 7:55 a.m. to 2:45 p.m.. They received PE a minimum of two days per week for 35 min each period. Due to a rotational schedule that accommodated for missed days due to parent-teacher conferences and field trips, some students received three days of PE and some students received only two days of PE during the period when data were collected. Class sizes ranged from 19 to 21 students. A certified teacher with a master's degree in physical education taught the lessons. The sport education curriculum model was used (see (34) for full description of model) and the focus of the lessons was on floor hockey and striking with long handled implements. Students also participated in 15 min of recess in the morning and afternoon. Their lunch period was 35 min in duration. Generally, students were given 20 min to eat and 15 min of recess during this period.

Procedures

A multifunction pedometer (Walk4Life LS252, Plainfield, IL) was used to assess PA since it provides an objective and valid measure of steps taken in children (1,17,32) and because it offers an economical means for describing PA in a large sample like the one in this study. All pedometers were subjected to a walking and shake test (42) before being used each day. Instrumental error did not exceed 5% in any of the pedometers.

Students wore unsealed pedometers for one week (i.e., five consecutive weekdays) in late April and early May 2010. Before the beginning of the study, a research assistant reviewed with participants how the pedometer functions including pedometer placement (e.g., wear the pedometer on waist band directly above knee, removal during water activities, and restriction on shaking it). Students were instructed to wear the device each day until bedtime and not to alter their normal activity. Step counts were recorded at designated time points during the school day (e.g., at commencement of the first class period, at the end of the last class period, and at bedtime). On days that students attended PE, step counts were also recorded at the beginning and end of the PE class. Teachers and research assistants monitored the data each day to ensure completeness and fidelity. Due to the number of times step counts were recorded throughout the day and the students' familiarity with the pedometers, we chose to use unsealed pedometers. Pedometers were already being used in the school's PE curriculum to monitor and assess PA, so students were familiar with how to wear them and how they functioned.

Before school on Day 1, classroom teachers were provided a box of pedometers that were coded for each of the students in their class and a form they would use to record each student's step count at the beginning and again at the end of the school day. Teachers were also provided a written set of instructions that outlined proper placement of the pedometers and an overview of the recording schedule. In the event that the students' school day ended with a special class (e.g., music, art, PE), the specialist recorded end of day step counts on the form that was provided to the classroom teacher.

At the beginning of school on Day 1, the classroom teacher gave each student a pedometer to wear for the week. At the end of the first school day, students received a form that they would use to record their step count at bedtime. Parents were asked to verify bedtime step count by providing their signature beside each daily measure. The next morning, students placed the pedometer on their waistband and continued their morning routine. When they arrived at school, their classroom teachers recorded the beginning of school day step count. Students continued to wear the pedometers for the remainder of the school week. Recording and verification of step counts at the start of school, end of school, and bedtime were replicated for each of the following four school days. At least one research assistant was present at the school during all of the days that step counts were recorded so that questions teachers or students had about the pedometer could be addressed. At the end of school on the last day, the classroom and/or specialist teachers recorded the final step count and collected the pedometers.

On the first day of data collection, an additional instructional station was added in their PE class to allow researchers to obtain height and weight measures on the students. This process required the student to be out of PE for less than one minute. Height and weight were measured without shoes to the nearest 0.5 cm and 0.1 kg, respectively, using a digital stadiometer and scale. Otherwise, no modifications were made to the curriculum or instruction during the study. The physical educator and/or research assistant recorded the students' step counts as they entered the gymnasium (before the beginning of class) and just before them exiting the gymnasium at the conclusion of the class.

Data Analysis

A minimum of four days of data collection with pedometers has been shown to be adequate time to reliably assess children's PA patterns through pedometry (37). Before conducting data analyses, daily step counts were examined to determine if students met the inclusion criteria of four days of data. Because PE was offered on either 2 or 3 of the data collection days, steps per day attributable to PE or non-PE days as well as steps/lesson represent the average across those days. Of the 279 students who met the inclusion criteria, 106 (38%) had 3 days, 132 (47%) had 2 days, and 41 (15%) had one day of PE, respectively, across the five days of data collection. The major reason for the loss of data from the original sample included the failure to secure a bedtime step count measure on two or more of the data collection days ($n = 74$ students; ~20% of the original sample).

Descriptive statistics were computed for all variables and are presented as means \pm *SD*, and independent *t* tests were used to examine gender differences. Mean total steps/day were computed as well as mean step counts attributed to the school day and after school on PE days and non-PE days. Similar to a previous study (24), participants were split into the three activity groups based on mean steps/day by sex to ensure an equal number of boys and girls in each of the groups. This tertile split resulted in groups that were similar in steps/day to those reported in the Morgan et al. (24) study. Assumptions for univariate and multivariate analyses (normality, linearity, and homoscedasticity) were checked before performing inferential analyses. A one-way ANOVA was conducted to determine if BMI differed between the least, moderate, or most active students. A two way (sex \times activity

level) ANOVA was conducted to determine differences in steps taken during PE. Two separate two-way repeated-measures ANOVAs were performed to determine the contribution of PE to overall daily PA and whether students compensate to attain more PA on days without PE. Sex and activity level were used as between subjects factors in both ANOVA procedures. In the first analysis, mean steps/day on days with and without PE were used as repeated measures factors and in the second analysis, mean steps accumulated in PE were subtracted from mean steps/day on PE days to account for or partial out steps accumulated during PE. To determine the contribution of PE to daily PA, a two-way (sex \times activity level) ANOVA was conducted using the ratio of steps accumulated in PE to total daily steps as the dependent measure. All statistical analyses were conducted using a significance level of $p = .05$, and Bonferroni-corrected t tests were used for post hoc comparisons. Effect size estimates (ES) were calculated for ANOVAs and pairwise comparisons by using partial η^2 and Hedges' g statistic (18), respectively. Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) version 18.0 software (SPSS Inc., Chicago, IL) for Windows.

Results

These analyses are based on 279 students (159 boys, 120 girls) who met data collection criteria (i.e., wore pedometers for a minimum of 4 days). Table 1 provides mean \pm *SD* descriptive statistics by gender. Overall, students took $12,002 \pm 5,083$ steps/day, with boys ($12,092 \pm 5,524$) averaging slightly albeit not significantly more steps/day than girls ($11,903 \pm 4,589$). No significant gender differences were found for BMI or steps taken during or after school on PE and non-PE days; however, boys accumulated significantly more steps during PE than girls did, $1,428 \pm 460$ versus $1,176 \pm 513$, $p < .01$, $ES = .52$. Results from the one-way ANOVA revealed a significant difference in BMI between the three different activity levels, $F(2, 277) = 8.78$, $p < .05$. The least, moderate, and most active groups had BMI values of 19.8, 18.6, and 18.3 kg/m², respectively. Follow up tests revealed significant differences between the least active and other two activity level groups ($p < .05$), which did not significantly differ from one another.

Results from the two-way (sex \times activity level) ANOVA assessing steps accumulated during PE revealed a significant main effect of sex, $F(1, 277) = 29.75$, $p < .001$, and activity level main effect that approached significance, $F(2, 277) = 3.02$, $p = .052$. No significant sex \times activity level interaction was found, $p > .05$. Follow

Table 1 Descriptive Statistics by Gender

	Boys	Girls	Total
<i>N</i>	159	120	279
Age	11.8 \pm .68	11.79 \pm .64	11.8 \pm .66
Height (cm)	149.82 \pm 8.9	151.13 \pm 9.0	150.43 \pm 8.9
Weight (kg)	43.70 \pm 11.2	43.0 \pm 10.8	43.4 \pm 11.0
BMI	19.31 \pm 3.8	18.67 \pm 4.0	19.02 \pm 3.9

up comparisons revealed that boys accumulated more steps during PE than girls did and significantly fewer steps were accumulated by the least active group of students than the moderately or highly active students, who did not significantly differ in their accumulated steps during PE (see Figure 1).

The initial two-way repeated-measures ANOVA of PA on PE versus non-PE days revealed that the PE main effect was significant, $F(1, 277) = 32.90, p < .001$, partial $\eta^2 = .18$. A significant PE day x activity level interaction was also found, $F(2, 277) = 5.09, p < .01$, partial $\eta^2 = .07$. No significant differences were found for the PE day x sex interaction or the three-way interaction (PE day x sex x activity level), $p > .05$. Follow-up simple main effects using a Bonferroni correction were conducted to evaluate the significant two-way interaction between school days with and without PE for each of the three activity levels. Significant differences were found among school days with and without PE for students in the lowest activity level group, $F(1, 277) = 5.42, p < .05$, $ES = .76$, moderately active, $F(1, 277) = 7.05, p < .01$, $ES = 1.01$, and most highly active students, $F(1, 277) = 34.78, p < .01$, $ES = .84$, (see Figure 2). Students across all activity levels accumulated significantly more steps/day on school days with PE. Step counts on school days with and without PE by activity level are presented in Table 2. PE contributed approximately 15%, 10.9%, and 6.4% of the total daily PA among least, moderate, and most highly active students, respectively. Results from the two-way (sex x activity level) PE contribution analysis revealed a significant activity level main effect, $F(2, 277) = 11.22, p < .001$, partial $\eta^2 = .13$, with the least and moderately active students receiving a greater contribution of daily PA from PE than the most active students, $p < .01$.

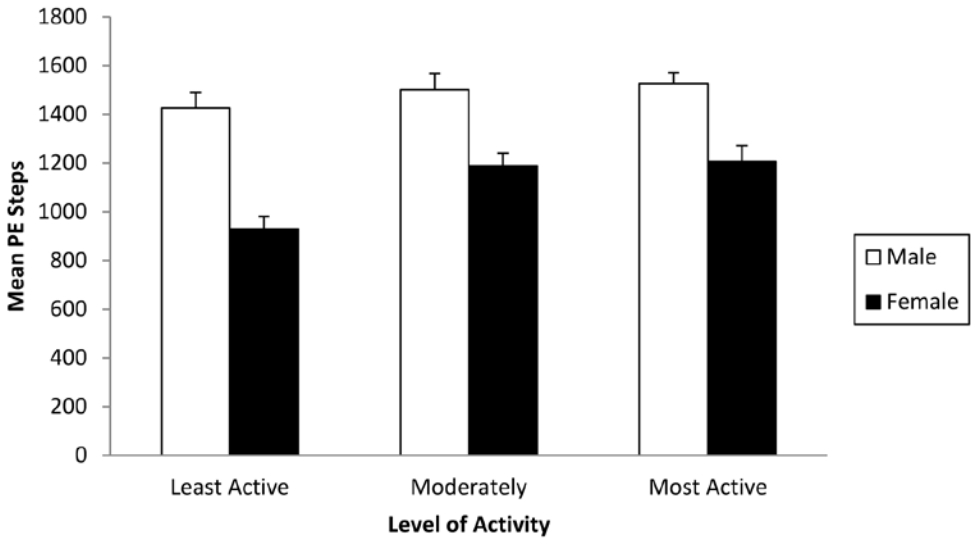


Figure 1 — Mean Steps per Physical Education Lesson (*SE*) by Activity Level and Sex

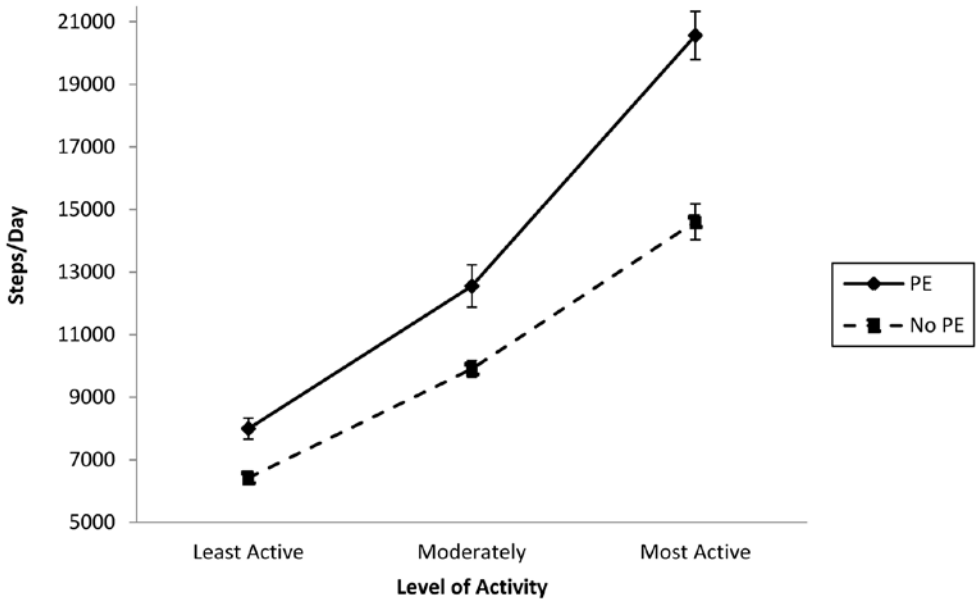


Figure 2 — Significant Steps per School Day (with and without Physical Education) by Activity Level

Table 2 Pedometer Step Counts by Activity Level

	Least Active	Moderately Active	Most Active	Total
Total Steps	7,210 ± 1,569	11,226 ± 937	17,585 ± 4,460	12,002 ± 5,083
With PE				
School day	3,791 ± 1,264	5,360 ± 1,893	6,564 ± 3,543	5,239 ± 2,666
After school	4,304 ± 2,893	5,787 ± 2,143	11,642 ± 8,138	7,097 ± 5,774
Without PE				
School day	2,892 ± 1,164	3,754 ± 1,300	4,832 ± 3,129	3,825 ± 2,199
After school	3,304 ± 2,876	5,529 ± 2,135	8,713 ± 5,614	5,787 ± 4,220

For the second repeated-measures ANOVA to test for the compensatory effect of PA on days without PE, a significant school day (minus PE steps) x activity level interaction was found, $F(2, 277) = 4.39, p < .05$, partial $\eta^2 = .06$, as well as a significant school day main effect, $F(1, 277) = 12.34, p < .01$, partial $\eta^2 = .08$. No significance was found for the school day x sex interaction, $F(1, 277) = 0.04, p = .94$ or the school day x sex x activity level interaction, $F(2, 277) = 0.17, p = .84$. Follow-up tests revealed that the most active group accumulated significantly more

steps on school days with PE (minus steps attributed to PE) than on school days without PE, $F(1, 277) = 19.49, p < .01$. No significant pairwise differences were found between the school days with and without PE for the low and moderately active groups.

Discussion

The purpose of this study was to describe the PA levels of middle school students during PE and non-PE days and to determine whether PE results in any compensatory or stimulatory effects on total daily PA. The fifth and sixth grade children in this study averaged approximately 12,000 steps per day. They were slightly less active than a comparable sample of sixth grade students attending an elementary school in Arizona (13,746 steps (39)), but slightly more active than sixth-graders attending middle schools in California and South Carolina (10,229 and 7,782 steps/day for boys and girls, respectively (28)). According to social-ecological theory, school structure and everyday routines influence student behavior (11,12). In the traditional elementary school, students may travel to classes taught by a specialist (e.g., PE, art, music) but typically remain in their classroom for all other content areas. In our study, middle school students attended a home room for the purpose of beginning and ending the school day and for organizing the cohort to attend special classes. For all other classes they traveled from classroom to classroom. Research into the effects of school design on children's PA has just begun to emerge in the literature. For instance, in the Trial of Activity for Adolescent Girls (TAAG), Cohen, Scott, Wang, McKenzie and Porter (6) found that the school footprint size accounts for 20% of adolescent girls' light and MET-weight MVPA during school hours as measured by accelerometers. More research is needed to determine the ecological effect of school structures and schedules on children's PA.

Recommendations for steps per day for children have been determined using both normative and criterion referenced approaches (20,41). For children aged 6–12 years, Vincent and Pangrazi (41) recommended 11,000 and 13,000 steps/day for girls and boys, respectively. Tudor-Locke and colleagues (38) used criterion referenced cut points associated with healthy body mass index in 6–12 year old children and recommended girls accumulate 12,000 steps/day and boys accumulate 15,000 steps/day. Although boys in this study ($12,092 \pm 5,524$) fell short of this recommended value, girls ($11,903 \pm 4,589$) approximately met the steps/day cut point. On days without PE, only 13% of boys and 27% of girls met the 15,000/12,000 step/day criterion standard set by Tudor-Locke et al. (38). Nearly three times the percent of boys (37%) and more than two times the percent of girls (61%) met the recommended steps on days when PE was offered. These findings underscore the importance of structured PE in contributing to children's total daily PA.

Much of the research on pedometer-based PA in PE has focused on children in elementary schools. In those studies that examined the pedometer-determined PA of fifth and/or sixth grade students, no differences were found between boys and girls in PE step counts (17,28,39). Sarkin and colleagues (31) found similar results when using accelerometers to examine boys' and girls' PA during PE. While boys and girls in our study took a similar number of steps as those reported in the literature, boys took significantly more steps during PE than girls did. It is unclear why this

gender-specific difference was seen in our study. The sport-education curriculum model was used in the PE classes and the focus of the lessons was on floor hockey and long-handled implements. One possible explanation is that the context of the lessons (e.g., team sports) was more attractive to the boys and subsequently resulted in greater PA than in girls (14,43). In a review of research on the PA levels in middle and high school PE, Fairclough and Stratton (13) reported that team sports were emphasized in curricula when boys were more active than girls. Further, Hill and Hannon (19) found that more middle school boys than girls prefer team sports like hockey. It is also possible that boys prefer the sport-education model that was used in the class, or at least the competition that it affords. Middle school boys have been shown to prefer playing competitive team sports more so than girls (7). Similarly, high school boys have reported an increase in enjoyment and perceived effort when participating in lessons using the sport-education model (44). Year 5 students in the U.K. perceived sport-education units to be more enjoyable than previous PE lessons due to opportunities for autonomy, affiliation and competition (21). However, no gender differences in perception were reported in this study. Lesson context has also been shown to have a differential effect on PA in middle school PE. Fitness activities often lead to the highest activity levels, followed by skill drills and game play (23,33). Future investigation into the sociocultural context PE affords students and the motives of middle school students toward PE is needed to better understand the contribution PE can make to children's PA and how it should be structured to have equal impact on boys' and girls' PA. In addition, the instructional practices of the teachers should be measured to determine their impact on PA outcomes of students during PE lessons.

In the current study, PE steps contributed approximately 11.8% of boys' and 9.9% of girls' total daily PA. Tudor-Locke et al. (39) reported similar contributions, but in their study PE steps accounted for a greater percentage of daily PA for girls (11.4%) than for boys (8.7%). Interestingly, while boys in our study accrued significantly more steps during PE, no significant gender differences in total steps were found at the end of the school day. Moreover, when school day PA was adjusted for PE steps (i.e., school day steps minus PE steps) no significant differences between boys and girls were found. These findings suggest that over the course of the active school day girls made up the difference in steps boys accumulated during PE. Although girls did not accrue as many steps as boys did during PE, they may have compensated for the lack of typical PA during PE by finding other opportunities to be active across the school day. As reported earlier, the school footprint can account for a certain amount of PA. Cohen et al. (6) reported as much as 20% of girls' PA could be explained by this factor. Only girls were included in their study so it is unclear if this environmental influence is similar or different for boys. Failure to dissect the school day into components beyond the time spent in PE, during school, and after school limits our ability to draw conclusions about these gender-related differences. Clearly more investigation is warranted to examine the specific contextual, environmental, and temporal aspects of the school day that influence PA among boys and girls. Studies in which the size of middle school buildings and grounds are calculated and those which employ a segmented approach similar to that used by Tudor-Locke et al. (39) may help to shed light on this issue, particularly if this approach is expanded to include the segments of the school day that are not typically designed to elicit PA.

We divided the students into three activity levels to better understand the impact PE has on their total daily PA levels. As to be expected, the least, moderately and highly active groups took more steps on days when they participated in PE (range 1,570–5,950). The least active group accumulated significantly fewer steps during PE (1,107) than the moderately (1,325) or highly active groups (1,434) did. However, participation in PE may have had considerable influence on the least active group's total PA. Nearly 15% of their total daily PA was accrued during PE compared with only 6% of the most active group's total daily PA. Morgan et al. (24) also found that PE resulted in a greater proportion of overall PA among the least active children (18%), although it still contributed 9% and 13% of the moderate and highly active children's PA. As a whole, these findings suggest that PE is a component of the school day that provides students with opportunities to be active, perhaps most importantly for those students who might not otherwise engage in MVPA.

Students in our study accumulated more total daily steps on days they had PE. We did not find that students in any of the activity level groups compensated for inactivity during school days and after school hours on non-PE days, even when subtracting the steps taken during PE. In fact, we found that some students were more active after school on days they had PE. Our findings are consistent with Dale et al. (9), who reported that third and fourth grade students were nearly three times more active in the afternoon/evening period following a school day that included opportunities to be active (e.g., PE day) than they were on days when PA was limited (e.g., no PE). In our study, the most active group took significantly more steps (~3,000) after school on days they had PE. The moderate (~1,900) and least active (~1,900) groups also took significantly more steps after school on PE days. Morgan et al. (24) found that among first through sixth graders only the most active children accumulated more PA on school days in which they participate in PE. Collectively, these findings suggest that not only does compensation not occur on less active days (i.e., no-PE), PE plus other opportunities to be active during the school day like recess and lunchtime activity may actually stimulate *more* activity over the course of the entire day, at least among the most active children. Future studies are warranted to investigate what specific psychobiological mechanisms are involved in this stimulatory effect and why the effect has only been found in the most active children.

The social-ecological model suggests that school environment (e.g., school schedule, physical make-up of the building and classrooms, PA opportunities, teacher modeling) influences student behavior (11,12). For the most part, school work done in the classroom does not require students to be physically active while PE provides students an opportunity for PA. In our study, the PA levels of all students increased on school days when they had PE. The lower activity group especially benefited from this opportunity to be active. Consistent with previous research (39), the majority of children's PA was accrued *after* school. In our study, students took between 1,758 and 1,962 more steps after school than they took during school. Hardman et al. (16) found similar differences between school time and leisure time PA; boys took 2,430 more steps after school while girls took 1,527 more steps. Although children spend a large majority of their waking hours at school, it remains to be determined how much PA is typically achieved during school and how much occurs before and after school hours.

Limitations

By its very nature, field research poses a number of limitations beyond the control of researchers. Our study was no different. Schedules were changed due to parent-teacher conferences and field trips, which caused some students to have PE three days during the data collection period and other students to have it only two days. Parents failed to verify and/or record bedtime step count, which resulted in some students' data being dropped from the analyses. Nonetheless, this type of research is valuable in that it provides insight into the daily PA of children in schools.

This study was a school-wide project that provides a representation of PA accrued by middle school students from a rural mountain-west community during school days when they did and did not have PE. Springtime in the Rocky Mountain west is often plagued by cold weather, windy conditions and snowstorms. Data for this study were collected in April and May; thus, this may limit the generalizability across seasons and to middle school students from different geographical regions.

Students in this study were familiar with pedometers, having previously used them in their PE program. Therefore we were confident that the data were not influenced by reactivity. A limitation of the pedometer used in this study is that it only recorded step counts and could not differentiate intensity or patterns of PA. During PE, students engaged in floor hockey and other activities involving long-handled implements. Often, these activities involved stationary positions where minimal locomotion was required, which could lead to an underestimation of their PA. We did not systematically observe and assess the specific types of PA that were performed during the PE lessons, nor did we formally observe the teacher's interaction with students. At least one researcher was present during the lessons and did not notice any overt teacher behaviors that could have led to gender differences in PA. However, formal observations could provide additional insight into possible factors that contributed to the gender differences seen in this study.

Using only step counts makes it impossible to draw conclusions about the type of non-PE activities girls engaged in during PE days that allowed them to catch up and match the boys PA by the end of the school day. Future research designs should use technology and/or procedures that can provide a segmental view of the school day. Focusing on the sociocultural context of the school and the periods of the school day that are not typically designed to elicit large amounts of PA (e.g., PA in the classroom, during passing periods, etc.) could help to further our understanding of gender differences and/or similarities in school time PA.

Summary

Our findings are similar to previous research and suggest boys and girls are more active on school days with PE versus school days without PE (9). We did not find that students compensate for the lost opportunity for PA during PE on days it was not offered. Rather, we found that on days that students had PE a carry-over effect may have resulted, at least for the most active students. This raises the question, "Does PE trigger increased PA during the school day and in the hours after it concludes?" If the answer is affirmative, more research is needed to examine the differential effect it has on students of all activity levels and how PE should be structured to increase their activity levels?

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