Journal of Science and Medicine in Sport 19 (2016) 733–737

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Contextual factors related to physical activity during daily middle school physical education

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ARTICLE INFO

Article history:
Received 27 June 2015
Received in revised form
18 September 2015
Accepted 7 October 2015
Available online 22 October 2015

Keywords:
Child behavior
Exercise
Pediatrics
Physical fitness
Schools

ABSTRACT

Objectives: Given the importance of optimizing physical activity in adolescents, the purpose of this study was to examine the effect of activity mode, environment, and semester on step counts/minute and MVPA during daily middle-school physical education (PE).
Design: A prospective and observational research design.
Methods: Participants included 232 students (Mean age = 13.3 ± 0.4 years) recruited from the seventh and eighth grades from one public middle-school in the U.S. Activity modes were employed across the school year including motor skills, games, and fitness activities located in indoor and outdoor environments. Step counts/minute and MVPA were monitored across 132 PE lessons during Fall and Spring semesters using NL-1000 piezoelectric pedometers. A three-way Multivariate Analysis of Covariance (MANCOVA) was employed to examine the effect of activity mode (skill games vs. fitness), environment (indoors vs. outdoors), and semester (Fall vs. Spring) on student step counts/minute and MVPA. MANCOVA was followed by separate ANCOVA tests.
Results: MANCOVA yielded a statistically significant three-way interaction (Wilks' $\Lambda = 0.98$ $F(2, 1153) = 8.9$, $P < 0.001$). Follow-up tests supported that physical activity was higher during outdoor fitness activities in the Fall compared to indoor motor skills in the Spring for step counts/minute (Mean difference = 27.0 steps/minute, $P < 0.001$, Cohen's $d = 1.6$) and MVPA (Mean difference = 7.8 min, $P < 0.001$, Cohen's $d = 2.0$).
Conclusions: Daily middle-school physical activity was the highest during outdoor fitness activities in the Fall and the lowest during indoor motor skill games in the Spring.

1. Introduction

Optimal levels of moderate-to-vigorous physical activity (MVPA) have numerous health and physical performance benefits in the pediatric population, however fewer than 12% of boys and 4% of girls of adolescent age achieve the recommended 60 min of MVPA per day.[1,2] There is evidence that declines in MVPA may commence in children as young as 5–6 years old and adolescents transitioning from primary to secondary school may display significant declines in MVPA and increases in sedentary behaviors.[3,4] Indeed, adolescents spend a significant portion of weekday time in school settings and the majority of this time is sedentary,[5] however, physical education (PE) provides opportunities for adolescents to engage in MVPA to improve their physical and cognitive health.[6] Approximately 80% of states in the U.S mandate PE in middle school,[7] and students with opportunities for daily PE have a particular advantage to achieve the daily 60-min MVPA guideline set by the U.S. Department of Health and Human Services. Despite this potential benefit of daily PE for increasing MVPA,[8,9] it is not mandated in most states in the U.S. Indeed, less than 8% of public middle schools in the U.S. offer daily PE.[10]

Past research has shown that the amount of gym space, access to play equipment, and activity mode can significantly predict the amount of PE time spent in MVPA.[11,12] Environmental correlates of MVPA during PE have also shown to be significant predictors and include the setting of PE lessons (indoors vs. outdoors), climate, and season.[13–15] Research has shown that outdoor PE lessons tend to yield higher levels of MVPA compared to indoor PE lessons.[13] Also, students enrolled in schools located in warm and dry climates tend to have higher levels of MVPA compared to students enrolled in schools located in cooler and wetter climates.[15] Interestingly, season has also shown to be a determinant of MVPA. It has

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http://dx.doi.org/10.1016/j.jsams.2015.10.001
1440-2440/

been shown that children and adolescents' MVPA is highest in the Fall months compared to Spring, Summer, and Winter months.[14] Although these correlates have been established in free-living conditions, no research has examined these factors within a daily PE context.

In order to determine if daily PE curricula are taken full advantage of to achieve optimal levels of physical activity, understanding of the aforementioned contextual factors that may contribute to MVPA behavior is of critical importance. Therefore, the purpose of this study was to examine the effect of activity mode (motor skills/games, fitness), PE environment (indoors, outdoors), and semester (Fall semester, Spring semester) on pedometer step counts/minute and estimates of time in MVPA during daily middle school PE. It was hypothesized that physical activity would be higher during fitness activities, during outdoor activities, and during activities performed in the Fall semester.

2. Methods

Data were collected on a convenience sample of 232 seventh and eighth grade students recruited from one public middle school located in a large metropolitan area in the Southwestern U.S. Daily PE was not mandated in the state where the data collection took place. There were 88 girls and 144 boys who participated and the mean age of the sample was 13.3 ± 0.4 years. All except three students participated in this study because of transferring to a different school in the middle of the year (99% response rate). Written assent was obtained from the students and written consent was obtained from the parents prior to data collection. The University Institutional Review Board approved the protocols used in this study. The funding organization had no role in data collection, analysis or interpretation of the data, or approval of the final version of the manuscript.

Each student's physical activity was monitored using NL-1000 piezoelectric pedometers (New Lifestyles Inc., Lee's Summit, MO, USA). The NL-1000 model recorded total number of steps and time (in minutes) of MVPA for the entirety of each PE lesson. Total steps were converted to steps per minute by dividing total steps by class time. McMinn et al.[16] found statistically significant correlations between the GT1M accelerometer and the NL-1000 model across several different activity modes with intra-class correlations (ICCs) ranging from ICC = 0.72 to 1.00. A further detailed description of this model and physical activity intensity categorization were previously reported in the literature.[17,18] Each pedometer was labeled with an identification number and matched to a student with the respective identifier prior to each PE class.

All data collection took place over an entire school year and involved a total of 132 PE lessons across approximately 28 weeks (excluding holiday and academic testing weeks). Fall semester was defined as lessons from late August through December and involved a total of 70 PE lessons. Spring semester was defined as lessons from January through May and involved a total of 62 PE lessons. Each PE lesson was approximately 40 min in duration and was held 5 days a week (Monday through Friday). Some weeks PE was held 4 days per week because of special school events (i.e. assemblies, field trips, etc.). The curriculum involved a combination of motor skill games and health-related fitness activities. Units were 2–3 weeks long and were taught in both indoor (gymnasium) and outdoor (open grass field) environments. The teaching style included a traditional sport and physical activity model (direct instruction) with warm-ups, skill practice, and game opportunities. Activity spaces included a gymnasium the size of a small basketball court, a small fitness room, a small dance room, and a large grass field that was large enough for two full sized soccer fields. Mondays, Tuesdays, Thursdays, and Fridays were skill days and every Wednesday was a fitness day. Skill lessons included skill development, small-sided skill games, and team tournaments within a specific sport context. Fitness activities included circuit training, aerobic exercise activities, and flexibility training. The PE teacher provided the researchers information on what the specific lesson was for a respective day and whether the lesson was administered indoors or outdoors.

Anthropometric measures were collected during PE using a portable stadiometer (Seca 214; Chino, CA, USA) and medical scale (Seca 882 Digital BMI Scale; Chino, CA, USA). Students' height (to the nearest 0.5 cm) and weight (to the nearest 0.1 kg) were measured with shoes off and body mass index (BMI) was calculated using standard procedures. Students put on the NL-1000 pedometer immediately after changing for PE class. The pedometers were worn on the right side of the body at waist level on the superior boarder of the iliac crest above the right knee. Before each PE lesson, pedometers were checked to ensure a reading of zero and randomly calibrated using the "shake test" to ensure accurate measurement of step counts according to the recommended procedures given by Vincent and Sidman.[19] The researchers recorded all data once per week and excluded data due to student absence, tardiness to PE class, or injury.

Derived variables for pedometer steps per minute and MVPA were obtained by calculating the mean values per PE activity. Data were classified as being administered into either Fall and Spring semesters, being indoors or outdoors, and either being motor skills/games or fitness. Although descriptive data for each individual PE activity was reported, they were not analyzed using inferential statistics in order to specifically examine the aforementioned contextual factors. Less than 10% of the data was missing and no student was completely absent for an entire unit, therefore it was determined that the missing data did not significantly bias the results. Descriptive analysis consisted of examining anthropometric, step counts, and MVPA mean differences between sexes using independent *t*-tests. A three factor $2 \times 2 \times 2$ Multivariate Analysis of Covariance (MANCOVA) was employed to examine the effect of activity mode (motor skills and games, fitness), environment (indoors, outdoors), and semester (Fall, Spring) on pedometer step counts per minute and estimated time in MVPA, controlling for the clustering of daily physical activity measurements within each student and the clustering of students within classrooms. Sex was originally entered into the model as an additional factor but was subsequently excluded from the primary analysis because of a lack of a modifying effect. Wilks' lambda was used to determine the statistical significance of the multivariate model. Follow-up analyses included separate ANCOVA tests with Bonferroni alpha level adjustment. A priori alpha level was set at $P \leq 0.05$ to determine statistical significance and Cohen's delta ($d = x_1 - x_{2/s_{pooled}}$) was used to determine the effect size and practical significance of each pair-wise comparison. Effect sizes were classified as small if $d \leq 0.2$, medium if $d \cong 0.5$, and large if $d \geq 0.8$.[20] All analyses were carried out using IBM SPSS v22.0 statistical software package (Armonk, NY, USA).

3. Results

The descriptive data for each individual motor skill and games lessons are presented in Table 1 and the descriptive data for fitness lessons are presented in Fig. 1. The descriptive statistics across all lessons for the total sample and within sex groups are reported in Table 2. On average, boys were taller and displayed a higher step count/minute and time in MVPA compared to girls ($P < 0.001$). Across the school year, 51.1% of the PE lessons were taught indoors and 53.0% of the PE lessons were taught during Fall semester. Fitness lessons presented in Fig. 1 were distributed similarly across both Fall and Spring semesters. MANCOVA yielded