Research Quarterly for Exercise and Sport
©2008 by the American Alliance for Health, Physical Education, Recreation and Dance
Vol. 79, No. 2, pp. 256–260

Seasonality in Children's Pedometer-Measured Physical Activity Levels

Aaron Beighle, Brandon Alderman, Charles F. Morgan, and Guy Le Masurier

Key words: exercise, measurement, motion sensor, school

Despite the well documented benefits of regular physical activity for children and efforts to promote physical activity for youth, a better understanding of the determinants of regular physical activity for youth is needed (Sallis, Prochaska, & Taylor, 2000). Specifically, Sallis and colleagues suggested that environmental variables are the least studied of those associated with physical activity and children. One environmental component reported to have an impact on physical activity is season (Fisher et al., 2005; Pivarnik, Reeves, & Rafferty, 2003; Rowlands & Hughes, 2006; Uitenbroek, 1993), which has important implications for intervention development and evaluation. Seasons characterized as "low activity" may be identified as important times during the year for physical activity intervention implementation. Furthermore, to assess the effectiveness of any physical activity intervention, it is important to know if that measurement should take place during more than one season or if one bout of data collection during one season provides representative data.

Submitted: November 14, 2006
Accepted: June 12, 2007

Aaron Beighle is with the Department of Kinesiology and Health Promotion at the University of Kentucky. Brandon Alderman is with the Department of Kinesiology and Health at the University of Wyoming. Charles F. Morgan is with the Department of Kinesiology at the University of Hawaii. Guy Le Masurier is with the Department of Physical Education at Malaspina University-College.

Few studies have examined the impact of seasonality on physical activity levels in children. Using accelerometry, Tremblay and colleagues (2005) reported that children engaged in less moderate to vigorous physical activity in fall than in summer. However, the data were collected during fall when children were in school and summer when they were not in school. Given the sedentary nature of a structured school day, it is possible that being in school led to the lower physical activity levels more so than the season (Morgan, Pangrazi, & Beighle, 2003; Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006). Goran and colleagues (1998) used doubly labeled water to assess total energy expenditure during spring and fall and concluded that season has an impact on children's physical activity levels. Conversely, using uniaxial accelerometry, Fisher and colleagues (2005) suggested that for younger children seasonality only played a limited role on physical activity behaviors. However, the authors of this study pointed to the cross-sectional nature of data collection as a limitation. Previously researchers measured children's physical activity using direct observation four times throughout the year (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993). The results of this study indicated that activity levels differed significantly by time of year. To our knowledge, only two studies examined seasonality using pedometers. The first study used pedometers to measure Greek children's physical activity levels during winter and summer (Loucaides, Chedzoy, & Bennett, 2003). Findings from this study suggested boys and girls were significantly more active in summer. Similarly, Rowlands and Hughes (2006) examined 36 8–10-year-old boys and found they were significantly more active during summer than winter.

Seasonality appears to have an impact on children's physical activity levels, but equivocal findings demand more study in this area. With the increased use of pedometers in both research and practice, collecting descriptive data in various seasons to examine the impact of seasonality on pedometer-measured physical activity among children is warranted. Therefore, the purpose of this study was to compare the pedometer-determined children's weekday physical activity levels during winter and spring.

Method

Participants

Participants were first- through fifth-grade students attending two elementary schools in the southern United States. The first author's niversity Institutional Review Board provided approval prior to data collection. All participants signed assent forms and returned informed consent forms signed by a parent or guardian. Students were not compensated for participation in the study.

Instruments

Participants' physical activity was measured using the MLS 2505 pedometer (Walk4Life, Inc., Plainfield, IL). Previous studies have validated this pedometer for assessing accumulated physical activity in steps (Beets, Patton, & Edwards, 2003; Schneider, Crouter, Lukajic, & Bassett, 2003).

Weather Data

Data were collected in February 2005 and May 2005. For each day of data collection, high and low temperature, and hours of daylight were recorded. Seasonal variations in weather were assessed using procedures described below. The climate in the region is typically highly variable with large fluctuations in temperature during any given season. During winter data collection, the mean temperature was 38° F (3.3° C) with an average of 644 min (10.7 hr) of daylight. Also during the winter data collection, the average amount of precipitation (snow) was 0.33 inches [17.8 cm]. The mean temperature during the spring was 55° F (12.8° C) with an average of 842 min (14 hr) of daylight and no precipitation.

Procedures

Data were collected Monday through Thursday for 1 week during winter and 1 week during spring. The same students participated in the winter and spring data collections. Four consecutive days of data were sufficient for assessing the weekday physical activity levels of children (Vincent & Pangrazi, 2000). To familiarize participants with the pedometer and minimize behavior that could interfere with the data collection protocol, pedometers were used during physical education for at least 1 month. During these classes students were taught to fasten the pedometer to their belt or waistband directly above their right knee.

On Monday morning at 9:30 a.m., students began wearing their sealed pedometers. Pedometers were sealed by tightening a 7-inch [17.8 cm] Catamount® multipurpose cable tie (Thomas & Betts, Memphis, TN) around the pedometer. Excess material was removed using electrical snips. Participants wore the pedometer throughout the day and took it off at night prior to going to bed. The following morning they attached the pedometer and wore it to school. On arriving at the classroom, they placed the pedometers in a collection box. During the first hour of school, step data were recorded and pedometers were resealed and returned to the students. During this hour, students were engaged in sedentary activities in their classroom. This process took place Tuesday through Friday during the week of data collection. Each day students were reminded to wear the pedometer all day, excluding water activities (e.g., bathing or swimming) and sleeping.

Height and weight data were collected during the week of data collection in both winter and spring. A stadiometer (Invicta, Leicester, England) was used to measure each participant's height without shoes. A mechanical balance beam scale (HealthoMeter, Inc., Bejing, China) was used to assess their weight. Prior to each use, the scale was calibrated according to manufacturer's recommended protocol. Student birth dates were obtained from informed consent and verified with school records.

Data Treatment and Analysis

Daily physical activity was recorded as steps per day. To determine seasonal differences in physical activity by gender, a one-way analysis of variance was conducted using steps/day. A paired sample t test was conducted to determine if mean steps/day differed by season. Multiple regression analysis was used to determine whether BMI, gender, and age were significantly related to physical activity in this population. A critical alpha level of $p < .05$ was adopted for all tests. Further, effect sizes (ES) were calculated for any pairwise comparisons by using Hedges' g statistic (Hedges, 1981), which involves subtracting the means of the two groups and dividing the mean difference by the pooled standard deviation across the two groups (e.g., boys vs. girls).

Results

Participants were 401 elementary school children (209 girls) living in the southern United States. Table 1 provides descriptive statistics by gender and season for steps/day. Due to insufficient data as a result of absenteeism and forgotten or lost pedometers, 80 students (42 girls) were removed from the winter analysis and 150 (75 girls) from the spring analysis. Only students with at least 3 days of data remained in the final analysis.

Seasonality Effects

During the winter, girls accumulated 7,910 steps/day (SD = 2,496) and boys 8,991 steps/day (SD = 2,933). During the spring, girls accumulated 9,727 steps/day (SD = 3,640) while boys accumulated 11,112 (SD = 5,003). Boys accumulated significantly more steps/day than girls both in winter, $F(1,318) = 12.67$, $p < .001$, ES = 0.40, and spring, $F(1,250) = 6.59$, $p = .011$, ES = 0.32. Although there were significant gender differences in physical activity during both winter and spring ($p < .01$), the variability in physical activity was greater during the spring assessment. Paired sample t tests revealed significant differences in total physical activity by season. Specifically, significantly more steps/day, $t(216) = 7.17$, $p < .001$, occurred in spring relative to winter. Multiple regression analysis including gender, age, and BMI indicated that both BMI and gender significantly predicted steps/day in spring and winter; however, age was not a significant predictor of steps/day ($p > .05$).

Discussion

The purpose of this study was to examine the impact of season on the pedometer-determined physical activity levels of elementary school students. Although researchers are becoming interested in seasonality, few studies to date have examined this issue by using pedometers. Understanding the seasonal variation in physical activity may help researchers and practitioners to better target interventions when physical activity levels are lowest. Further, it is vital to determine if more than one measurement period is needed during the year to accurately represent normal activity patterns. Boys in this study were more active than girls, regardless of season. This finding is consistent with other studies using pedometers and similarly aged children (Le Masurier, et al, 2005; Vincent & Pangrazi, 2000; Vincent, Pangrazi, Raustorp, Tomson, & Cuddihy, 2003). Although boys were significantly more active than girls during winter and spring, the difference was much less (mean difference = 1,080 steps) during winter. Furthermore, the variability of physical activity levels for boys and girls were lower in the winter. This decreased variability likely resulted from fewer opportunities to be active. Both boys and girls were significantly more active during spring than in winter. Two factors possibly contributed to this finding. The first was the temperature. During the spring data collection, the climate was much more conducive to outdoor physical activity. Although the mean temperatures suggest the weather was cool, in fact, during the afternoon hours when students were out of school, the temperature ranged from 70 to 74° F (21.1–23.3 ° C), which is comfortable for students in that area of the country. Also, during winter there was some light snow. Although the snow did not accumulate, it could have caused some students to avoid outdoor physical activity. Conversely, during spring no precipitation occurred. Further, during spring students had nearly 3.5 additional hr (210 min) of daylight to be active. Beighle and Pangrazi (2006) recently found that throughout the day students average approximately 90 steps per minute. Based on these figures, additional daylight in the winter would allow girls to accumulate the additional 1,600 steps and boys the additional 2,121 steps needed to bring their mean steps up to the spring average. When the issue of seasonality is examined, the temperature is often the focus; however, it is possible that children would be physically active if they had sufficient daylight hours, even if it were cold. Future research

Table 1. Descriptive statistics by gender and season

	Winter				Spring			
	Boys (n = 154)		Girls (n = 167)		Boys (n = 117)		Girls (n = 134)	
	M	SD	M	SD	M	SD	M	SD
Age	9.13	1.48	9.10	1.47	9.16	1.48	9.13	1.47
Body mass index	18.54	4.08	18.68	4.24	18.24	4.11	18.75	4.26
Steps	8,991	2,933[a]	7,910	2,496	11,112	5,003[a]	9,727	3,640

Note. In each row of means for winter and spring, values not sharing a common superscript differ by $p < .05$.

is warranted to examine whether the temperature or daylight hours contribute to lower physical activity levels during winter.

A finding of great importance in the present study was the low physical activity levels. The daily step counts for boys and girls were far below the findings of other studies with similar aged children (Beighle & Pangrazi, 2006; Le Masurier, et al, 2005; Vincent & Pangrazi, 2000). Data during these previous studies were collected during fall, when weather was conducive to physical activity outdoors. When these data are compared to the spring data from the current study, when weather was also conducive to physical activity outdoors, girls accumulated 1,300 and boys 2,000 fewer steps than their peers. When compared to recently published BMI-referenced standards of 12,000 and 15,000 steps/day for boys and girls (Tudor-Locke et al., 2004), during winter 8% of girls and 3% of boys achieved this standard and during spring 26% of girls and 17% of boys achieved this standard. Based on these percentages of BMI-referenced standards, one might argue that such a low level of compliance indicates the standard is too high; however, these recommendations were recently found to be reasonable estimates for children to meet current recommendations of moderate to vigorous physical activity (Rowlands & Eston, 2005). With the low physical activity levels during spring and winter, seasonality in physical activity intervention is of little importance, with interventions needed during both seasons. It is also important to assess the physical activity levels of populations prior to implementing interventions to determine the critical times in which physical activity is needed and to ward off more sedentary behaviors.

The results from the current study warrant future research. Specifically, studies examining the relationship between hours of daylight, temperature, and seasonality are necessary. Although this study suggests that physical activity levels drop during cold weather, it is not clear if this is entirely the case. Students may be less active simply because they have fewer hours to be outside. Also, studies conducted in different regions during various seasons are needed.

Several limitations to this study should be discussed. Data were only collected during the two seasons. For a more complete examination of seasonality, data should be collected during all four seasons and in different geographic regions. Data were collected during the weekday and, thus, provided a limited assessment of daily physical activity levels. As with all physical activity measurement tools, pedometers have limitations. Pedometers measure accumulated steps and do not provide data related to physical activity intensity. Last, only 4 consecutive days of physical activity during 1 week were used to determine seasonal physical activity. Future studies should consider using several bouts of data collection throughout the season to capture a more representative measure of seasonal physical activity when conditions such as precipitation and temperature fluctuate.

It is important that children are active throughout the year. However, the influence of daylight, temperature, weather, and other factors associated with seasons may have an impact on the physical activity levels of youth. Data from this study further support previous research and suggest that children's weekday physical activity level is lower during winter, meaning seasonality effects exist when assessing physical activity via pedometry (Loucaides, Chedzoy, & Bennett, 2003; Rowlands and Hughes, 2006). These findings indicate that to assess habitual daily physical activity accurately, multiple bouts of assessment throughout the year may be necessary.

References

Baranowski, T., Thompson, W. O., DuRant, R. H., Baranowski, J., & Puhl, J. (1993). Observations on physical activity in physical locations: Age, gender, ethnicity, and month effects. *Research Quarterly for Exercise and Sport, 64*, 127–133.

Beets, M., Patton, M. M., & Edwards, S. (2005). The accuracy of pedometer steps and time during walking in children. *Medicine & Science in Sports & Exercise, 37*, 513–520.

Beighle, A., & Pangrazi, R. P. (2006). Understanding children's physical activity level: Activity time and steps per minute. *Journal of Physical Activity and Health, 3*, 221–229.

Fisher, A., Reilly, J. J., Montgomery, C., Kelly, L. A., Williamson, A., Jackson, D. M., et al. (2005). Seasonality in physical activity and sedentary behavior in young children. *Pediatric Exercise Science, 17*, 31–40.

Goran, M. I., Nagy, T. R., Gower, B. A., Mazariegos, M., Solomons, N., Hood, V., et al. (1998). Influence of sex, seasonality, ethnicity, and geographic location on the components of total energy expenditure in young children: Implications for energy requirements. *American Journal of Clinical Nutrition, 68*, 675–682.

Hedges, L. V. (1981). Distributional theory for Glass's estimator of effect size and related estimators. *Journal of Educational Statistics, 6*, 107–128.

Le Masurier, G., Beighle, A., Corbin, C., Darst, P. W., Morgan, C. F., Pangrazi, R. P., et al. (2005). Pedometer-determined physical activity levels of youth. *Journal of Physical Activity and Health, 2* 159–168.

Loucaides, C. A., Chedzoy, S. M., & Bennett, N. (2003). Pedometer-assessed physical (ambulatory) activity in Cypriot children. *European Physical Education Review, 9*(1), 43–55.

Morgan, C. F., Pangrazi, R. P., & Beighle, A. (2003). Using pedometers to promote physical activity in physical education. *Journal of Physical Education, Recreation, and Dance, 74*(7), 33–38.

Pivarnik, J. J., Reeves, M. J., & Rafferty, A. P. (2003). Seasonal variation in adult leisure-time physical activity. *Medicine & Science in Sports & Exercise*, 35, 1004–1008.

Rowlands, A. V., & Eston, R. G. (2005). Comparison of accelerometer and pedometer measures of physical activity in boys and girls, ages 8–10 years. *Research Quarterly for Exercise and Sport, 76,* 251–257.

Rowlands, A. V., & Hughes, D. R., (2006). Variability of physical activity patterns by type of day and season in 8–10-year-old boys. *Research Quarterly for Exercise and Sport, 77,* 391–395.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine & Science in Sports & Exercise, 32,* 963–75.

Schneider, P. L., Crouter, S. E., Lukajic, O., & Bassett, D. R. (2003). Accuracy and reliability of 10 pedometers for measuring steps over 400-m walk. *Medicine & Science in Sports & Exercise, 35,* 1779–1784.

Tremblay, M. S., Barnes, J. D., Esliger, D.W., & Copelane, J. L. (2005). Seasonal variation in physical activity of Canadian children assessed by accelerometry [Abstract]. *Pediatric Exercise Science, 17,* 73.

Tudor-Locke, C. D., Lee, S. M., Morgan, C. F., Beighle, A., & Pangrazi, R. P. (2006). Children's pedometer-determined physical activity patterns during the segmented school day. *Medicine & Science in Sports & Exercise. 38,* 1732–1738.

Tudor-Locke, C. D., Pangrazi, R. P., Corbin, C. B., Rutherford, W. J., Vincent, S. D., Raustorp, A., et al. (2004). BMI-reference standards for recommended pedometer-determined steps/day in children. *Preventive Medicine, 38,* 857–864.

Uitenbroek, D. G. (1993). Seasonal variation in leisure time physical activity. *Medicine & Science in Sports & Exercise,* 25, 755–760.

Vincent, S. D., & Pangrazi, R. P. (2000). Determining baseline physical activity levels in children. *Pediatric Exercise Science, 14,* 432–441.

Vincent, S. D., Pangrazi, R. P., Raustorp, A., Tomson, L. M., & Cuddihy, T. F. (2003). Activity levels and body mass index of children in the United States, Sweden, and Australia. *Medicine & Science in Sports & Exercise, 35,* 1367–1373.

Authors' Note

Please address all correspondence concerning this article to Aaron Beighle, Assistant Professor, Department of Kinesiology and Health Promotion, 120 Seaton Building, University of Kentucky, Lexington, KY 40506.

E-mail: beighle@uky.edu