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Research article

Seasonal differences in physical activity and sedentary patterns: The relevance of the PA context.

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Abstract
The aim of this pilot study was to characterize seasonal variation in the moderate to vigorous physical activity (MVPA) and sedentary behavior of Portuguese school youth, and understand the influence of activity choices and settings. The participants in this study were 24 students, aged 10-13 years. Accelerometers measured daily PA over 7 consecutive days, in different seasons May – June and January – February. In summer, boys accumulated more minutes in MVPA (928 minutes/week) than girls (793 minutes/week). In winter the pattern was reversed with girls accumulating more activity than boys (736 minutes/week vs. 598 minutes/week). The repeated measures ANOVA revealed significant effects for season ($F = 5.98$, $p = 0.023$) and in-school vs. out-of-school ($F = 6.53$, $p = 0.018$). Youth were more active in the summer and activity levels were higher after school than in school. Summer season provided relevant contexts for youth physical activity accumulation. Winter season may have been a significant barrier to boy's preferred PA context. Differences in choices of outdoor or indoor PA, after school, explained the gender differences in seasonal activity patterns.

Key words: Season, accelerometer, physical activity context.

Introduction

Participation in regular physical activity (PA) among children is linked to several health outcomes (Bouchard et al., 1994), as well as to the development of social and academic abilities in youth (Trudeau and Shephard, 2008). Physical inactivity is also known to be associated with an increased risk for overweight and obesity (Hill and Melanson, 1999).

The reported decrease in level of PA during adolescence (Kahn et al., 2008) has led to considerable interest in understanding the factors that influence active lifestyles in youth. If factors influencing behaviors can be better understood it may facilitate efforts to establish and maintain regular healthy habits in the future (Sallis et al., 2000). Numerous studies have been conducted on correlates of physical activity in youth and the literature indicates that children's and adolescents' PA are influenced by a large group of factors, including, environmental, social, psychological and cultural ones (Dishman et al., 2004; Sallis and Owen, 1999, Sallis et al., 2002).

Most developed societies show increased all cause and cardiac mortalities in the winter (Shephard and Aoyagi, 2009). Thus, environmental factors have received considerable attention in recent years and there is clear evidence that they play an important role with regard to PA promotion in youth (Owen et al., 2000). For example, seasonal weather factors such as the temperature differences, amount of precipitation and sunlight exposure have been reported as barriers to PA (Gordon-Larsen et al., 2000; Merrill et al., 2005) and as factors influencing the amount of PA among populations (Berkey et al., 2003). An intervention study (Chan et al., 2006) demonstrated that variations in day-to-day activity were associated with changes in the weather as well as day of the week and season. (Fisher et al., 2005) found that in the United Kingdom, total activity measured by accelerometry was highest in the summer months (May, June, July) among 209 3- to 5-yr-olds. Also, (Mattocks et al., 2007) in a study to estimate the variability of children`s physical activity during 1 yr, and to estimate the effects of month of year, found that there was substantial intraindividual variation in children`s physical activity. A study (Kolle et al., 2009) showed that Norwegian 9-yearolds had higher physical activity levels in spring than in fall and winter. In the two latter seasons, activity levels were particularly low after school hours and on weekends. No seasonal differences in mean physical activity were observed among the 15-year-olds. However, both 9- and 15-year-olds had higher odds of meeting recommended levels of physical activity during spring than during winter. In young children aged 3-4 years-old, variation in seasonal activities of PA was explained by the quantity of time that children spend outside (Baranowski et al., 1993).

A number of studies have evaluated youth PA patterns with objective activity monitors, although few have identified major seasonal barriers and opportunities for physical activity. The direct effect of weather on PA also needs to be objectively assessed to better understand effects on outdoor recreation (Chan et al., 2006). Therefore, the aims of this pilot study were (1) to determine the regular physical activity and sedentary patterns in children aged 10-13 years old, during a regular school week, across two different seasons and (2) to analyze the potential seasonal differences by identifying the contexts (in-school or after-school) where those differences occur.

Methods

Participants

The participants in this pilot study were involved in a broader activity assessment project in a school of Porto metropolitan area, Portugal. The original sample included 35 youth (10 and 13 years old) but emphasis in the present study focused on only those youth that had valid

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accelerometer data over multiple seasons. Therefore, the sample of this study comprised 24 students, 12 boys and 12 girls (mean age = 11.04 ± 1.45 years-old). Participants were free from health problems that could affect physical activity levels and provided written informed consent prior to beginning the study. The local school Director and the Portuguese Ministry for Science and Technology also provided permission to conduct this study.

Anthropometry

Stature was measured using the Harpenden Portable Stadiometer (Holtain Ltd, UK), and the values were recorded in centimeters to the nearest mm. Body mass was measured to the nearest 0.1 kg with an electronic weighing scale (Tanita Inner Scan BC 532, UK), with the participants in T-shirt and shorts. Body mass index (BMI) (kg/m2) was calculated from the ratio of weight/height^2.

Habitual physical activity and sedentary activity

Information about habitual physical activity was assessed with the MTI/CSA (Actigraph) 7164 accelerometer – a device that has been used in the majority of accelerometer research studies and for which many validation studies are available (Troiano, 2005). Students and their parents were informed about the utility of the accelerometer and participants were asked to wear the monitor for a full week. In the summer, participants received the monitors on a Monday and returned them the following week, while in the winter the monitoring week started on a Thursday. A full week of activity monitoring has been shown to provide a reliable estimate of daily participation in MVPA in children and adolescents (Trost et al., 2000).

Students wore the accelerometer tightly in the hip, on the right side according to manufacturer recommendations. The MTI was set to record in 1 minute intervals (epoch) and the age-specific cut-points developed by the Freedson group and published by Trost et al. (2002) were used to evaluate levels of physical activity (protocol established to allow the comparison between other studies). This equation has been widely used in the pediatric exercise literature and demonstrated better agreement for categorizing levels of physical activity than other alternative equations (Trost et al., 2006). The age specific cut-points for 10 year old youth were as follows: 1017 counts (3 MET); 3695 counts (6 MET); 6374 counts (9 MET). Values for the 13 year old youth were as follows: 1399 counts (3 MET); 4381 counts (6 MET); 7363 counts (9 MET). At the beginning of the study students had 10 or 13 years old, after 7 months, in the second moment of assessment a few changed their age. The same cut-points values were used in both periods of data collection to allow the between seasons comparison.

The accelerometer data were analyzed by an automated data reduction program (Kinesoft) used to run quality assurance checks and summarize accelerometer data (Esliger et al., 2005). Each of the accelerometer files was manually checked for the daily start time and end time of data collection, in order to provide the real monitored period. Participants had to have at least 8 hours of data to count as a valid day and to have at least 3 valid days to be included; screening procedures consistent with similar accelerometry studies (Mota et al.,2003). To facilitate examination of activity patterns, the minute-by-minute activity counts were processed to determine time spent in MVPA (above 3 METs) and sedentary behavior (<50 counts), for each 60-min segment of the week days monitoring period, from 7:00 am to 12:00 pm.

Only the week days were chosen in order to analyze the relevance of school days context. Further, two daily time periods were calculated according to time spent in MVPA (≥3 MET) by summing the minute's in-school (8:00 – 18:00) and after-school time (18:01-20:00). Emphasis was placed on capturing levels of MVPA since youth physical activity guidelines have emphasized the importance of this intensity range (Cavill et al., 2001). There has been increased interest in capturing lightest activity and, for that reason, the sedentary behavior cut-points were defined as <50 counts, which allowed time spent in sedentary behavior to be determined (Matthews et al., 2008).

Activities context

A weekly activity diary was used to record the periods when they didn't wear the MTI, such as sleeping, bath time and swimming. The same diary was used to allow students to take note of their school schedule, a task that they are used to perform in the beginning of the school year. Information and training was given on how students should fill the remaining half-hours of the day. The Portuguese school schedule is approximately from 8:00 to 18:00, this way students only had to recall a small portion of their usual day. The students were instructed to carry the diary sheet with them all week and to include the principal activity they participated in for each half-hour, between 7:00 - 24:00. The activity log provided critical information about the context of children's physical activity in both the summer and the winter seasons.

Season variables

Season has been defined as the natural periods in which the year is divided, which vary by weather conditions, daylight hours and temperature (Tucker and Gilliland, 2007). The weather variables for the present study were collected from the Portuguese Institute of Meteorology. The weather conditions in Portugal vary according to the season of the year and the geographical region. In Northern Portugal, the summer weather is temperate, with approximately 27º average daily temperatures, normally no rain and days with long sunshine exposure time, whereas, in the Winter time, the weather changes to very rainy and windy, with average temperatures dropping to around 7º and reduced sun exposure (less two hours than the summer).

Statistical analysis

Descriptive statistics (Means and standard deviations) were calculated to describe the participant's characteristics and to summarize activity patterns in both seasons. Gender differences were tested by the Mann-Whitney test. The PA activity was analyzed in a "zooming" perspective, i.e. from the week totals and intensities, to periods of the day, then by hour until the context of the activity could be scrutinized. A three-way repeated measures ANOVA (gender x season x day period) was used to examine dif-

ferences between period of the day (in school / out of school) and season (summer / winter). Data was further processed to examine average week days pattern of activity. These analyses compared average activity levels (hour by hour) by season, paired sample t-test and Wilcoxon tests were used to assess the differences between seasons in the MVPA and sedentary behavior. All analyses were performed by using Microsoft Excel (Microsoft Office 2003 for Windows) and the Statistical Package for Social Sciences (SPSS, version 17.0 for Windows; SPSS Inc, Chicago) the level of significance was set at $p \leq 0.05$.

Results

The descriptive data of the sample are shown in Table 1. No statistically significant differences were found for age, height, weight and BMI, according to gender. The activity profiles for males and females, however varied considerably. Boys engaged in considerably more MVPA, during the week days, in the summer time (153 minutes/day) compared to winter time (99 minutes/day). Girls, in contrast, had similar overall levels of MVPA in summer (127 minutes/day) and winter (121 minutes/day). Statistical differences were found between genders only in the MVPA amount in the summer, with boys presenting higher values than girls. Results for sedentary behavior complemented the results for the MVPA analyses. Both genders had higher values during the winter but interestingly boys had higher levels of sedentary behavior in the winter than girls.

Table 1. Descriptive characteristics for participants in the study, mean (SD).

	Girls	Boys
Age (years)	11.50 (1.58)	11.20 (1.55)
Weight (Kg)	46.84 (8.03)	50.19 (12.02)
Height (m)	1.55 (0.08)	1.59 (0.09)
BMI (Kgm^{-2})	19.37 (3.01)	19.83 (3.38)
PA minutes (during week days)		
MVPA (Summer)	127 (36.50)	153 (32.41)*
MVPA (Winter)	121 (60.02)	99 (52.31)
Sedentary (Summer)	366 (115.33)	358 (71.02)
Sedentary (Winter)	428 (148.78)	517 (251.04)
Counts·min^{-1} (Summer)	530 (154.48)	655 (149.45)
Counts·min^{-1} (Winter)	426 (197.73)	546 (281.94)

* $p < 0.05$

The repeated measures ANOVA revealed significant effects for season ($F = 5.98$, $p = 0.023$) and period ($F = 6.53$, $p = 0.018$). These results demonstrate that youth were more active in the summer and that activity levels were higher after school than in school. Gender differences in the patterns are apparent as boys engaged in significantly more in MVPA during summer time (compared to girls), while the opposite occurred in the winter time but without statistical significance. Boys and girls demonstrate differential patterns of activity in/out of school during the summer and winter months. This interaction is graphed in Figure 1 to illustrate the effect. As evident in the stacked bar graphs, out of school activity makes up a sizable part of boys activity in the summer but considerably less in the winter. This pattern is not evident in girls.

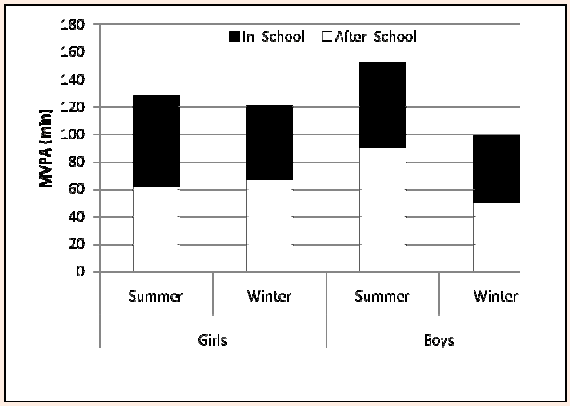

Figure 1. Seasonal differences in MVPA (min) according to in-school (8:00 – 18:00) and after-school (18:01 – 20:00) periods , repeated measures analyses of variance.
After-school period (season by gender interaction: $F = 7.852$, $p = 0.010$)
In-school period (season by gender interaction: $F = .12$, $p = 0.915$)

Figure 2 highlights the difference in MVPA (by hour) between the summer and winter seasons in both genders. The difference scores are computed as Summer – Winter so values above the x-axis indicate higher levels of activity for that time period in the Summer. As is evident in the figure, Boys demonstrate a larger decrease in the total week volume of MVPA amount in the winter (Boys: Summer-Winter = 330 minutes vs Girls: Summer-Winter = -57 minutes). The seasonal difference by hour presents a distinct pattern between genders. Boys had six time periods with higher MVPA amount in the summer than winter; there were several time periods (19:00 and 20:00) in which the summer-winter difference exceeded 10 minutes of MVPA. Girls, in contrast, had several periods (18:00 and 20:00) in which activity levels were higher in the winter by more than 10 minutes. It is important to point out that the main differences, for both genders, occurred during non-school hours.

Figure 3 shows the difference in sedentary time (by hour) between the summer and winter seasons in both genders. The difference scores are computed as Summer – Winter so values below the x-axis indicate higher levels of sedentary behavior for that time period in the Winter. Girls showed only one period in their day, with significant differences between seasons (the 11:00) hour period corresponding to the morning recess. On the other hand, boys presented higher differences in sedentary time between the two seasons with the largest differences between 15:00 to 21:00 (corresponding to the afternoon and after-school periods).

Data from the activity log were processed to explain the differential gender pattern of activity in summer and winter data. The results in Table 2 summarize the frequency of different physical activities that youth reported participating in during the key after-school time period (18:01 – 20:00). This range was selected since it was the period the MVPA differed the most between seasons, in both genders. Repeated measures ANOVA was run to examine the season by gender interaction specifically during the after school time period. As expected, the season by gender interaction was significant ($F =$

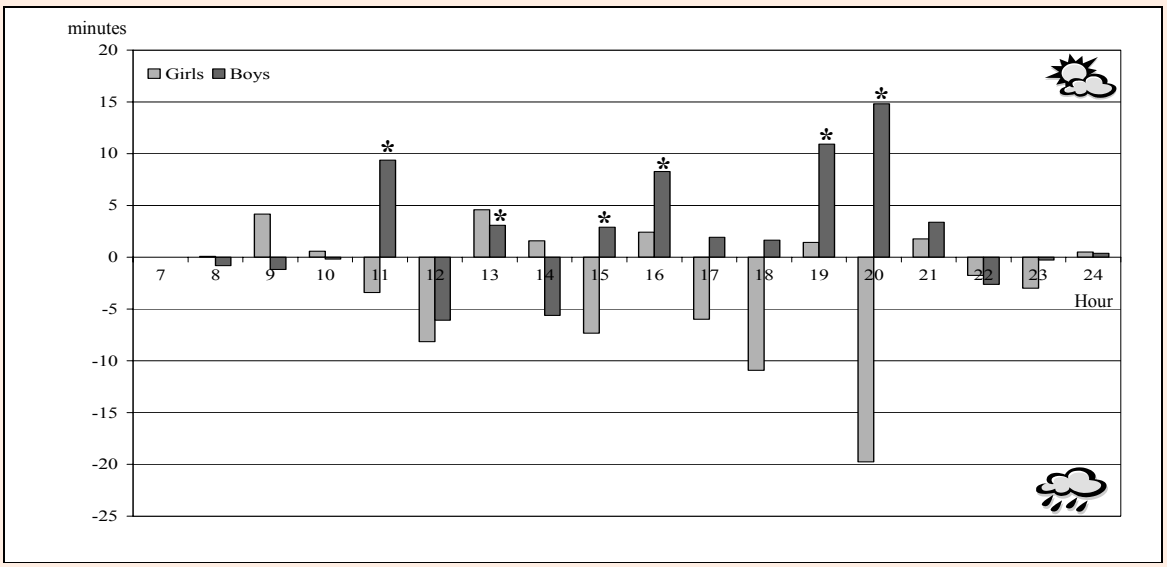

Figure 2. Mean differences in MVPA (min) between seasons (Summer – Winter) according to gender. * $p < 0.05$ difference between seasons in boys

7.852, p = 0.010). The contextual basis for the differences in PA can be seen in the frequency of activities reported during this time period. Boys reported lower values of outdoor PA (manly football as reported in the diary) in the winter and no walking or indoor PA. For girls, there were little differences in the context of PA. The PA levels of girls had smaller seasonal differences because the activity contexts were not that different.

There was also a change in reporting of Tutoring/Homework time after school (youth in Portugal have settings available after school where students go to do their homework, to get help in the classes, or to study). None of the girls reported participation in this context; only boy's made reference to this particular context. They increased participation in this category in the winter, parallel to lower levels of MVPA (and higher levels of sedentary time) during the 15:00 to 21:00 hour period.

Discussion

The season effect on physical activity has been previously studied but the majority of studies have used subjective measures. In this study we used accelerometers, complemented by a diary and weather information, to access the children's habitual PA during a typical school week in the summer and winter time, respectively. Assessing the amount of PA in different seasons of the year is pertinent because, obesity levels among children have been higher when measured in autumn and winter (December–March) than when measured in summer (May–September). This difference may result from higher levels of activity due to the increased availability of outdoor recreational facilities, and weather that supports activity behaviors (Dietz and Gortmaker, 1984).

These study findings are consistent with the extant

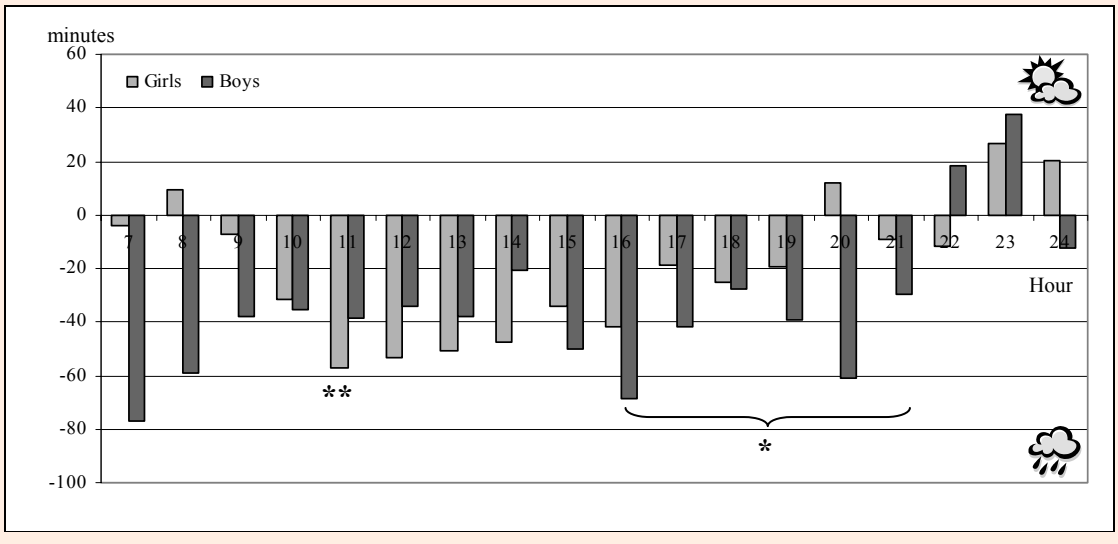

Figure 3. Mean differences in sedentary activity (min) between seasons (Summer – Winter) according to gender. * $p < 0.05$ difference between seasons in boys, ** $p < 0.05$ difference between seasons in girls

Table 2. Mean MVPA minutes (SD) and Sedentary behavior on week days after-school period, and the context of those activities (reported by diary), according to gender and season.

	Girls		Boys	
	Summer	**Winter**	**Summer**	**Winter**
After-School MVPA (min)	62 (25.66)	67 (40.93)	90 (29.68) *	50 (17.59)
Sedentary behavior (min)	166 (56.55)	180 (61.03)	131 (32.88)	182 (83)
After-School Activities (frequencies - blocks of 30 mins)				
TV	22	26	21	11
PC-PS2[a]	3	2	11	7
Study	6	7	0	2
Tutoring-time	0	0	7	9
Walking	12	3	7	0
Indoor PA	12	6	7	0
Outdoor PA	1	0	22	6

* $p < 0.001$, [a] PC-PS2 – computer time and console gaming.

literature on children's physical activity (Trost et al., 2002) and (Riddoch et al., 2007), that show that age-matched boys are generally more active than girls. Interestingly, the data from the winter showed girls with more MVPA than boys. While this finding was not statistically significant it is a noteworthy outcome deserving further comment and study. Our analyses revealed that the volume of MVPA decreased in winter by an average of 5.45 hours/week in boys but only by 1.1 hours/week in girls, which is in concordance with a study by Pate et al.(1997) that showed that boys reported weather as the most significant barrier, whereas girls indicated that time constrains due to homework were more problematic.

The time period of the day with the higher differences between genders, both in MVPA and sedentary behavior, was after school (18:01 – 20:00). Closer examination of the participant's diaries in this time period revealed that boys had more dramatic changes in the contexts and settings of the activity between seasons. Girls, on the other hand, tended to maintain more consistent patterns. The tendency for girls to perform more activity in indoor PA contexts (manly dance and basketball as reported in the diary) may contribute to the more stable activity patterns observed across seasons.

Research on seasonality is complicated by a number of factors. One challenge is that comparisons are dependent on initial levels of physical activity. One previous study found that the more active the individuals are in the summer, the larger the reduction of activity in the winter; However, those who were inactive in the summer tend to remain inactive in the winter (Plasqui and Westerterp, 2004). Thus, there may be a ceiling effect which causes most youth to be characterized as less active in the winter. The results of this study agree with this and other studies documenting declines in activity from summer to winter (Rowlands et al., 2009). Girls may not have decreased activity as much in winter since the levels in the summer were not as high in Summer.

A previous study of 10-17 year old Portuguese students (n = 6131) reported greater participation in physical activity during the spring/summer period, reflecting a similar seasonal influence (Santos et al., 2005). Many environment factors contribute to an individual's willingness to engage in PA, Chan and colleagues (Chan et al., 2006) showed significant interactions between day of the week and month indicating that patterns of activity during the week were not independent of season. A recent review of the evidence (Tucker and Gilliland, 2007) concluded that levels of physical activity vary with seasonality and that poor or extreme weather (precipitation, cold weather and wind) are likely deterrents to physical activity in the winter.

A novel aspect of the present study is the detailed temporal profiling of the accelerometer data and the additional information provided about the context of PA. The accelerometer data revealed periods where youth tended to be more active or less active (as a group) and the activity logs provided information to explain the differences in the amount of MVPA and/or sedentary behavior. For example, in boys, three clear peaks were evident in the summer (the first context comprised the morning recess; the second the after-lunch period and the third is related to after-school activities).

In both seasons, the 18:01 to 20:00 period showed higher levels of MVPA, corresponding to after-school time. Therefore, as reported in other studies (Kolle et al., 2009), extra-curricular activities played an important role on MVPA levels. Boys had distinctly different activity patterns in this time period with considerably less MVPA and more sedentary behavior during the winter time. Girls, in contrast, had more consistent patterns across seasons. This difference can be attributed to differential effects of weather/season on their activity preferences and patterns. Boy's preferred PA context in the summer was outdoor PA while in the winter this context was replaced by more sedentary choices. This differential pattern suggests that, during the winter, boys are more likely to use this after school time periods in a more sedentary way. These results are confirmed by (Rowlands et al., 2009) that showed , on an intra-individual level, the most variable component across season was the frequency of activity bouts, particularly bouts of higher intensities.

Weather has frequently been reported to have an impact in the individual's PA. Both questionnaire data and objective measurements show that many groups from children to the elderly increase their physical activity from winter to spring or summer (Shephard and Aoyagi, 2009). Time spent outdoors is an important correlate of physical activity (Baranowski et al., 1993, Sallis et al., 1993) but this access is clearly limited during winter months. The previously mentioned review (Tucker and Gilliland, 2007), reported that 27 of 37 articles (73%) found significant weather effects on physical activity behaviors. One study (Loucaides et al., 2004) revealed

that weather accounts for as much as 42% of variance in measured physical activity. Four of the 37 articles specifically acknowledged season or 'bad weather' as a perceived barrier to participation in physical activity.

If weather is preventing people from participating in physical activity, measures must be taken to help overcome this barrier. Specifically, there is a need to provide more opportunities for indoor physical activity during the cold and wet months of the year (Sallis et al., 2000). A review of environmental and policy interventions (Sallis et al., 1998) highlighted the importance of providing additional activity opportunities in the winter. Parents have identified that the warmer seasons are more conducive to physical activity for their children and that colder seasons pose greater challenges (Irwin et al., 2005). Parents, however, have also identified the need for indoor facilities to provide the opportunity for year-round participation in physical activity (Tucker et al., 2006). Our results confirm the importance of indoor activities because it clearly explained the smaller decline in activity for girls in the winter months.

Additional research is clearly needed to better understand factors that may explain seasonal differences in activity. The weather or sunlight exposure cannot be changed, but knowledge of how weather conditions affect physical activity can help policy makers and providers of health care to adapt recommendations to mitigate its effects (Chan and Ryan, 2009).The seasonal patterns suggest that physical activity interventions must be modified during different seasons of the year (to specifically increase involvement in winter months).

It is important to acknowledge as a limitation that the findings of this pilot study are based on data taken from a relatively small and locally specifically sample, and maturation was not controlled, on the other hand it was a concern to include a balanced sample in terms of age and gender. However, it is also important to recognize as a strength that the meticulous temporal processing of accelerometer data and the linking with qualitative information such as activity logs, provide a framework for identifying the critical contexts where physical activity and sedentary behaviors occur. Public health recommendations should underline the importance of maintaining physical activity during adverse environmental conditions by adapting clothing, modifying behaviour and exploiting any available air-conditioned indoor facilities (Shephard and Aoyagi, 2009).

Conclusion

By linking accelerometry data with qualitative information such as activity logs to assess physical activity, it was provided a framework for identifying the critical contexts where and when physical activity and sedentary behaviors occur. Physical activity interventions must be modified during different seasons of the year.

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Key points

- Detailed temporal profiling of the accelerometer data.
- Information provided about the context of PA.
- Boys had different activity patterns with considerably less MVPA and more sedentary behavior during the winter time.
- Girls had more consistent PA patterns across seasons.

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