Seasonal Variations in Meeting Physical Activity Recommendations and Development of Overweight during Adolescence

Melanie L. Kornides, ScD,¹ Eric B. Rimm, ScD,^{2–4} Jorge E. Chavarro, MD, ScD,^{2–4}
Matthew W. Gillman, MD, SM,^{2,5} Bernard Rosner, PhD,^{3,6} and Alison E. Field, ScD⁷

Abstract

Background: Few longitudinal studies have examined seasonal variation in meeting physical activity (PA) recommendations in association with incident overweight among adolescents.

Methods: We assessed self-reported, season-specific PA among 12,949 adolescents in two US cohorts (Growing Up Today Studies 1 and 2). We examined the relationship between the number of seasons per year that adolescents met the recommended amount of moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA), respectively, and the development of incident overweight at the next survey period. The sex-specific analyses controlled for follow-up time, survey month, age, race/ethnicity, sexual maturation, television viewing, region of the country, and intakes of sugar-sweetened beverages and fried foods away from home.

Results: About one-third (34%) of adolescents met the MVPA recommendation of 60 minutes/day, and one-quarter (24%) the VPA recommendation of 3 hours/week, for four seasons of the baseline year. The risk of becoming overweight was 23% (95% confidence interval [CI]: 5%–45%) higher for girls who met the MVPA recommendation for 2 (vs. 4) seasons/year. The risk was similar for girls who met the recommendation for 1 (vs. 4) season/year (odds ratio=1.23, 95% CI: 1.05–1.44). The number of seasons each year boys met the MVPA recommendation, or girls or boys met the VPA recommendation, was not associated with an increased risk of incident overweight.

Conclusions: Meeting the MVPA recommendation for 1 or 2 (vs. 4) seasons/year is related to higher risk of becoming overweight among adolescent girls but not boys. Interventions to increase PA levels each season may contribute to overweight prevention efforts among girls.

Keywords: exercise; health behavior; pediatrics; physical activity; weight status

Introduction

Adolescence is a critical period for obesity prevention as excess weight gained during this developmental stage increases the risk of persistent overweight and obesity throughout adulthood.^{1,2} Physical activity (PA) may have a protective effect against the development of overweight during adolescence; adolescents who engage in high levels of PA in high school are more likely to maintain their weight status and are less likely to become overweight or

obese by early adulthood.^{1,3–6} To prevent overweight and obesity, public health experts recommend that children and adolescents engage in PA for at least 60 minutes a day at a moderate-to-vigorous level, and include in that time 3 hours of vigorous PA each week.^{5–8} Previous research has indicated that PA varies by season in both childhood and adolescence, regardless of the type of activity being performed.⁹ The majority of US studies on seasonal variation in PA have found increased activity levels in the spring and summer months, and lower levels in the fall and winter.⁹ However,

¹Department of Population Medicine, Harvard Pilgrim Health Care Institute, Harvard Medical School, Boston, MA.

²Department of Nutrition, Harvard T.H. Chan School of Public Health, Boston, MA.

³Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA.

⁴Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA.

⁵Environmental Influences on Child Health Outcomes (ECHO), National Institutes of Health, Rockville, MD.

⁶Channing Laboratory, Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA.

⁷Department of Epidemiology, Brown University School of Public Health, Providence, RI.

previous studies have been limited to specific regions of the United States and mostly focus on younger age groups. In addition, it is unclear from the prior literature if consistency in meeting PA recommendations for each season throughout the year is important for maintaining weight and preventing the development of overweight during adolescence.

While cross-sectional research suggests that seasonal variation in PA is associated with changes in weight status in children and young adults,^{10–12} longitudinal data on the association of seasonal variation in meeting PA recommendations with the development of overweight in US adolescents are lacking. Measurement burden is one reason for the scarcity of longitudinal data on seasonal PA. Objective measures of PA are the gold standard in accurately quantifying energy expenditure, but can be obtrusive and expensive for repeatedly assessing PA each season across multiple years in large cohorts.¹³ In addition, studies using objective measures may miss important variations in PA and their estimates of yearly PA may be biased.^{14,15} Studies typically objectively measure PA over a brief period (*i.e.*, 7 days) and extrapolate the estimate to represent typical PA.¹⁶ However, many adolescent activities vary across seasons.^{9,15,17} For example, an adolescent who participates in basketball during the fall and winter, but does not participate in any physical activities during the spring and summer, might appear to meet PA recommendations if sampled during basketball season, but not otherwise. Additional limitations to accelerometers are the inability to accurately capture certain activities that are reported more frequently by younger adolescents, such as swimming and bicycling, and underestimation of activities performed in short bursts.^{18,19}

Given the limitations, cost, and heavy participant burden of objectively measured PA in adolescents, self-report has the potential to contribute valuable information on the relative differences in PA levels across multiple seasons and years in this population. Repeated measures of self-reported PA may be particularly useful in bridging the gap in knowledge specific to how PA varies by season over the course of adolescence, and the longitudinal associations with incident weight status changes. Our objective was to determine prospectively in two US-based cohorts of adolescents how self-reported seasonal variations in meeting moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) recommendations are related to the development of overweight.

Methods

We used data from the Growing Up Today Study cohorts (GUTS 1 and GUTS 2). Both longitudinal cohorts were recruited from the offspring of women participating in the Nurses' Health Study II (NHS II).²⁰ In 1996, 9039 girls and 7843 boys, aged 9–15 years, enrolled in the GUTS 1 study. In 2004, 6002 girls and 4917 boys, aged 9–15 years, enrolled in GUTS 2. The studies were approved by the Human Subjects Committee at Brigham and Women's Hospital. Details of the study are described elsewhere.^{21,22}

Adolescents with complete PA and BMI data on one survey, and BMI on the sequential following survey period were eligible for the current study. We excluded participants who were overweight at baseline (year = 1997 and 2004 for GUTS 1 and 2, respectively; $n = 4743$), missing weight status at baseline ($n = 4700$), missing weight status at first follow-up ($n = 2688$), or missing covariate information ($n = 980$). We also excluded participants with outlying values for BMI, height, or change in height between survey periods detected through the generalized extreme studentized deviate many-outlier procedure²³ ($n = 186$), and those in Hawaii, Alaska, Northern Rockies, or outside the United States ($n = 14$). After these exclusions, 14,490 adolescents were eligible for the study at baseline (8721 from GUTS 1 and 5769 from GUTS 2). Adolescents with missing data after baseline did not differ from those remaining in the study with respect to meeting MVPA or VPA recommendations at baseline, nor was one cohort more likely to have missing information than the other postbaseline. Adolescents who were older, reported higher hours of television viewing, and those who were postmenarche (girls) or later tanner stage (boys) at baseline were more likely to have missing information after baseline ($p < 0.05$).

PA was assessed in 1997, 1998, 1999, and 2001 for GUTS 1 and in 2004, 2006, and 2008 for GUTS 2. Participants from both cohorts self-reported the weekly hours each season that they engaged in the following sports or leisure-time activities: basketball, baseball/softball, biking, dancing and aerobics, hockey/lacrosse, running/jogging, swimming, skateboarding, rollerblading/roller-skating or ice-skating, soccer, tennis, cheerleading, strength training, volleyball, walking, and football (boys only). GUTS 1 participants additionally reported on outdoor chores, martial arts/karate, and wrestling. GUTS 2 participants additionally reported Stairmaster, elliptical, rowing machine, and gymnastics.

In a previous validation study, we found that the seasonal format questionnaire improved accuracy of adolescents' self-reported PA by reducing overreporting compared to an annual format questionnaire (*i.e.*, estimate of PA over the past year).²⁴ Previous research comparing accelerometer to self-report for adolescents' MVPA across a range of sports/activities found the average time spent in each activity to be within several minutes between the two measures, with the exception of walking and outdoor chores.¹⁸ In self-report, adolescents overestimated the time and intensity of walking and outdoor chores, whereas accelerometer-captured time and intensity for each of these activities almost exclusively fell below MVPA thresholds.¹⁸ To correct for this overestimation, we excluded both of these activities from the MVPA measure.

Metabolic equivalents of task (METs) were used to classify the intensity of each sport or activity as moderate (3–6 METs) or vigorous (>6 METs).²⁵ We summed the weekly time spent in MVPA (≥ 3 METs) for each season across all reported sports and leisure-time activities for that season. We then identified participants who met the recommended 60 minutes or more a day of MVPA for each season/survey year, as well as averaged across the survey

year. For the season-specific estimates, to qualify as meeting the MVPA recommendation for all four seasons, an adolescent would need to meet the recommendation for each individual season (spring, summer, fall, and winter) within that survey year. The same procedure was used to identify adolescents who additionally met the recommendation for time spent in VPA (>3 hours/week in sports and leisure-time activities classified as >6 METs) for each season/survey year, and average across each survey year.

The main outcome was the development of overweight between survey periods. We calculated adolescent BMI using self-reported height and weight. The validity of repeated measures of self-reported height and weight in adolescent populations has previously been established.^{26,27} Similar to adults, adolescents have been found to underreport weight and/or overreport height.²⁷ However, the resulting underreporting of BMI is consistent across measurements and is valid for investigating serial changes in weight status.²⁶ We excluded participants with biologically implausible BMI (see above for exclusion criteria). We classified adolescents as normal weight versus overweight using International Obesity Task Force cutoffs.²⁸ At age 18 and older, we used a BMI cut point of ≥ 25 to define overweight. In a sensitivity analysis, we examined continuous changes in BMI between each survey period (results not shown).

Adolescents self-reported race/ethnicity at baseline. We assessed menarcheal status on each survey among girls and classified sexual maturation as either pre- or postmenarche for each survey year. We used self-reported validated Tanner stage ratings for pubic hair development for each survey year to estimate boys' sexual maturation status.²⁹ We assessed intake of sugar-sweetened beverages (SSB) and fried foods away from home (FFA) using a previously validated food frequency questionnaire designed for children and adolescents.^{30,31} In previous research in GUTS 1, FFA was a reasonable proxy for fast food consumption,³² and both FFA and SSB were independently associated with longitudinal changes in BMI.^{32,33} Participants self-reported total hours of television viewing (TV) (including DVD, video, and prerecorded content) on weekdays and weekends for each survey year. We combined and averaged these over the week to create total daily hours of TV for each survey year.

We categorized participants' home states into nine climate regions in the continental United States as identified by the National Climatic Data Center. (www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php; last accessed August 24, 2017.) Due to the small number of adolescents living within certain regions, we combined the south and southwest, as well as the west and northwest regions, respectively. We excluded participants who resided in Alaska, Hawaii, the Northern Rockies region, or outside the United States due to small sample sizes.

We pooled data from both cohorts and conducted all analyses separately by sex. We compared normal weight adolescents who met the MVPA and VPA recommendations, respectively, for all four seasons in a survey year to those who met for fewer seasons. We fit generalized linear

models for binary data using generalized estimating equations³⁴ to estimate the odds of incident overweight at the next survey period. We allowed the following covariates to time-vary in the models: age (years), sexual maturity, FFA intake (servings per week), SSB intake (servings per day), TV (hours per day), region of the country, month survey was completed, and follow-up time between surveys. All analyses were completed using SAS 9.4 (Cary, N.C.). Statistical tests were two tailed with a critical alpha of 0.05 unless otherwise noted.

Results

The majority of the 14,490 participants in GUTS 1 and GUTS 2 were in early adolescence (11–14 years) at baseline (Table 1). Girls and boys in both cohorts reported higher median weekly hours of MVPA at baseline with a slight decline over the respective study periods (Fig. 1). Median weekly hours of MVPA were higher in the fall and spring, with peak hours in the summer. Adolescents were less active in the winter compared to the other three seasons.

Averaged across all seasons in the respective cohorts' baseline years, 63% of adolescents appeared to meet the MVPA recommendation (Table 2). However, only 34% of the adolescents met the MVPA recommendation for each of the four seasons (spring, summer, winter, and fall) within the baseline year. While 39% of the youth appeared to meet the VPA recommendation on average over the baseline year, only 24% met the VPA recommendation for each of the four seasons.

Girls who met the MVPA recommendation for 2 (vs. 4) seasons in a year were 23% more likely to become overweight from one survey period to the next (Table 3; odds ratio [OR]=1.23, 95% confidence interval [CI]: 1.05–1.45). Similar associations in increased overweight between survey periods were seen among girls who met the MVPA recommendation for 1 (vs. 4) season in a year (Girls OR=1.23, 95% CI: 1.05–1.44). Boys who met the MVPA recommendation for 2 (vs. 4) seasons in a year had lower odds of becoming overweight by the next survey period (OR=0.83, 95% CI: 0.70–0.99). We did not observe significant associations between the number of seasons that girls or boys met VPA recommendation and the development of overweight.

Discussion

The majority of adolescents in these two, US-based, longitudinal cohorts did not meet the MVPA or VPA recommendations for all four seasons each survey year. However, when we averaged PA levels from all seasons over the entire year, almost two-thirds (65%) of adolescents appeared to meet the MVPA recommendation due to their high levels of PA for at least a few seasons in a given year. We found that consistency in getting at least 60 minutes a day of MVPA for each season in a year is important for preventing the development of overweight in

Table 1. Baseline Characteristics of the GUTS 1 (Year=1997) and GUTS 2 (Year=2004) Cohorts

	GUTS 1		GUTS 2	
	Girls (n = 5128)	Boys (n = 3593)	Girls (n = 3286)	Boys (n = 2483)
Demographic characteristics				
Age				
Mean (SD)	12.6 (1.6)	12.4 (1.6)	13.1 (1.8)	12.9 (1.9)
Race/ethnicity, n (%)				
White	4769 (93)	3341 (93)	3023 (92)	2309 (93)
Other	359 (7)	252 (7)	263 (8)	174 (7)
Region of the country, n (%)				
Southeast	308 (6)	216 (6)	230 (7)	174 (7)
South and Southwest	410 (8)	252 (7)	197 (6)	174 (7)
West and Northwest	718 (14)	539 (15)	493 (15)	372 (15)
Upper Midwest	718 (14)	503 (14)	559 (17)	372 (15)
Central Midwest	1179 (23)	826 (23)	723 (22)	546 (22)
Northeast	1795 (35)	1293 (35)	1084 (33)	844 (34)
Sedentary behavior and diet				
Television viewing				
Hours/day: mean (SD)	2.1 (1.4)	2.4 (1.6)	2.3 (1.5)	2.4 (1.6)
Sugar sweetened beverage				
Servings/day: mean (SD)	0.9 (0.9)	1.0 (1.0)	0.9 (0.9)	1.2 (1.1)
Fried food away from home				
Servings/week: mean (SD)	1.2 (1.3)	1.5 (1.3)	1.1 (1.3)	1.3 (1.2)

GUTS 1 and GUTS 2, Growing Up Today Studies 1 and 2; SD, standard deviation.

Figure 1. Median weekly hours of self-reported MVPA and VPA by cohort, sex, season, and year. GUTS 1 and GUTS 2, Growing Up Today Studies 1 and 2; MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity.

Table 2. Adolescents Meeting Activity Recommendations at Baseline

	Total			GUTS 1		GUTS 2	
	Total (n = 14,490) n (%)	Girls (n = 8414) n (%)	Boys (n = 6076) n (%)	Girls (n = 5128) n (%)	Boys (n = 3593) n (%)	Girls (n = 3286) n (%)	Boys (n = 2483) n (%)
Met MVPA rec ^a							
Year average	9199 (63)	4930 (59)	4269 (70)	3145 (61)	2658 (74)	1785 (54)	1611 (65)
By season							
All 4 seasons	4920 (34)	2539 (30)	2381 (39)	1581 (31)	1514 (42)	958 (29)	867 (35)
3 seasons	2875 (20)	1560 (19)	1315 (22)	986 (19)	797 (22)	574 (17)	518 (21)
2 seasons	2180 (15)	1324 (16)	856 (14)	838 (16)	490 (14)	486 (15)	366 (15)
1 season	2185 (15)	1453 (17)	732 (12)	898 (18)	427 (12)	555 (17)	305 (12)
0 season	2330 (16)	1538 (18)	792 (13)	825 (16)	365 (10)	713 (22)	427 (17)
Met VPA rec ^b							
Year average	5702 (39)	2777 (33)	2925 (48)	1713 (33)	1828 (51)	1064 (32)	1097 (44)
By season							
All 4 seasons	3520 (24)	1586 (19)	1934 (32)	971 (19)	1215 (34)	615 (19)	719 (29)
3 seasons	2309 (16)	1234 (15)	1075 (18)	770 (15)	662 (18)	464 (14)	413 (17)
2 seasons	2098 (14)	1227 (14)	871 (14)	774 (15)	490 (14)	453 (14)	381 (15)
1 season	2107 (15)	1312 (16)	795 (13)	835 (16)	465 (13)	477 (15)	330 (13)
0 season	4456 (31)	3055 (36)	1401 (23)	1778 (35)	761 (21)	1277 (39)	640 (26)

^aMVPA recommendation: 60 minutes a day or more of MVPA.

^bVPA recommendation: 3 hours a week or more of VPA

MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity.

adolescent girls. Adolescent girls who met the MVPA recommendation for 1 or 2 (vs. 4) seasons in a year had increased odds of becoming overweight. Adolescent boys who met the MVPA recommendation for 2 (vs. 4) seasons in a year had slightly lower odds of becoming overweight. Our findings suggest that the threshold effects of 60 minutes a day of MVPA to prevent incident overweight differ by sex. We did not observe statistically significant associations with incident overweight for either girls or boys who met the VPA recommendation for fewer than 4 seasons (vs. 4) in a year.

We observed a pattern of lower PA in the winter seasons, and higher PA during the spring, fall, and summer seasons in both cohorts. While previous research has indicated that younger children gain BMI faster in the summer compared to the winter, a similar association has not been seen in adolescents.³⁵ In addition, the pattern we observed does not support the hypothesis suggested by other studies of increased weight gain during the summer months due to low levels of activity during school breaks, but rather suggests that adolescents may be more at risk for weight gain during the winter.³⁵ The association between low winter activity and changes in BMI status is further supported by a previous analysis of PA and BMI changes in the GUTS 1 cohort from 1997 to 1998, which found that BMI decreased

in overweight girls who increased winter activity levels from 1 year to the next.¹⁴

Our study is the first to examine the association of incident overweight with PA levels each season over the course of adolescence in the United States, and demonstrate consistently lower levels of MVPA across multiple winter seasons. Our findings are consistent with the findings of other studies on seasonal variation in PA levels among children and younger adolescents living in similar climate regions to the United States (*i.e.*, warmer spring and summer seasons, and cooler fall and winter seasons).^{36–39} Preschoolers in Northern Ireland were found to have decreased pedometer-measured PA during the winter compared to the spring.³⁶ Lower PA levels in the winter compared to the other seasons were also reported by parents of Canadian preschoolers,³⁷ and in the accelerometer-measured PA of UK 11- and 12-year olds.³⁸ The majority of regional differences seen in variation of seasonal PA indicate that children and adolescents tend to be less active during seasons with colder temperatures.⁹

The association between seasonal variation in PA and the development of overweight among adolescent girls has national policy implications for schools. There is no federal law requiring physical education in US schools, and

Table 3. Odds Ratios for Becoming Overweight Each Year among Adolescents Who Do Not Meet Physical Activity Recommendations for All Four Seasons

	Physical activity recommendation			
	Moderate-vigorous		Vigorous	
	OR ^a (95% CI)	<i>p</i>	OR ^a (95% CI)	<i>p</i>
Girls				
Met recommendation for 4 seasons	1		1	
Met for 3 seasons	1.04 (0.88–1.23)	0.6	1.02 (0.85–1.24)	0.8
Met for 2 seasons	1.23 (1.05–1.45)	0.01	1.08 (0.89–1.30)	0.4
Met for 1 seasons	1.23 (1.05–1.44)	0.01	1.18 (0.98–1.42)	0.08
Met for 0 seasons in a year	1.13 (0.97–1.31)	0.1	1.13 (0.97–1.31)	0.1
Boys				
Met recommendation for 4 seasons	1		1	
Met for 3 seasons	0.98 (0.84–1.14)	0.8	1.10 (0.92–1.30)	0.3
Met for 2 seasons	0.83 (0.70–0.99)	0.04	1.18 (0.99–1.41)	0.07
Met for 1 seasons	0.85 (0.70–1.02)	0.08	1.13 (0.93–1.36)	0.2
Met for 0 seasons in a year	0.91 (0.77–1.08)	0.3	1.11 (0.96–1.29)	0.2

^aAdjusted for follow-up time between surveys, month of survey completion, cohort, age, race, menstrual status (girls), Tanner stage (boys), climate region of country, TV (hours/day), SSB (servings/day), consumption of fried foods away from home (servings/week).

CI, confidence interval; OR, odds ratio; SSB, sugar-sweetened beverages; TV, television viewing.

policies for physical education and extracurricular PA opportunities vary by individual states and districts.⁴⁰ Promoting adequate levels of MVPA and VPA during the fall, winter, and spring, when school is in session, will help ensure that adolescents meet PA recommendations year-round. Previous research on adolescents found that an additional day of participation in extracurricular and in-school physical education each week had a corresponding decrease in the odds of being overweight 5 years later by 5%, mainly through maintenance of normal weight.⁴ Participation in physical education 5 days per week reduced odds of overweight by 28%. Our findings of lower PA levels during the winter, and the association of meeting the MVPA recommendation for fewer than 4 seasons/year with overweight in girls, give further evidence in support for middle and high school physical education courses and afterschool sports programs to increase MVPA.

Our observation of a decrease in risk of overweight among boys who met the MVPA recommendation for fewer than 4 seasons/year (vs. 4) may be due, in part, to our use of BMI cut points to define overweight, resulting in a potential misclassification of male athletes' weight status. Highly active male adolescent and young adult athletes are more likely to be misclassified as overweight by BMI cut points compared to body fat percentage due to their high muscle mass.^{41,42} A study looking at the classification of obesity using body fat percentage measured by skinfold thickness compared to BMI cut points in adolescent ath-

letes found male athletes were more likely to be classified as obese by BMI than by body fat percentage.⁴¹

The type of sport that boys participate in may also play a role in our observation of decreased overweight among less active males. Certain sports, including weight training, basketball, hockey, wrestling, and football, may be associated with higher BMI, due to increased muscle mass, but lower body fat percentage, resulting in potential misclassification of weight status.^{42,43} In addition, sports associated with increased muscle mass in boys (*e.g.*, indoor weight training, football) are more likely to be practiced in the fall and winter months, while those associated with weight loss (*e.g.*, outdoor jogging) are more common in the warmer seasons. The boys who met the MVPA recommendations for 3–4 seasons/year (vs. 0–2) in our study may have participated in more of these fall and winter sports associated with increased muscle. Further research is needed to determine the impact that the measurement method of estimating weight status (*e.g.*, skinfold thickness and waist circumference, as opposed to BMI cut points alone) has on the unexpected association we observed between activity and overweight in boys.

It is important to acknowledge other limitations and strengths of our study. The sample was largely white, and although the participants live throughout the United States, neither GUTS 1 nor GUTS 2 is nationally representative. As such, the prevalence of US adolescents meeting the MVPA and VPA recommendations cannot be inferred

from our study. In addition, PA, weight, and height were based on self-reports on an annual survey. The validity of self-reported weight and height in adolescent populations was discussed previously (see Methods).^{26,27} When compared to accelerometer, adolescents tend to overestimate PA by self-report, with the exception of activities conducted in short bursts, which may be underestimated.^{19,44} There are several potential contributors to the discrepancies in PA measured by self-report in comparison to accelerometer. First, accelerometer cannot capture swimming, biking, and strength training, which are frequently reported by younger adolescents.¹⁸ Second, adolescents tend to overestimate the intensity of walking and gardening/outdoor chores on questionnaires, compared to that measured by accelerometer.¹⁸ To correct for this overestimation of MVPA, we excluded walking and outdoor chores from our analyses. Finally, although we controlled for sedentary time in the form of hours of TV, we were unable to control for a potential interaction between sleep and PA in the development of overweight.⁴⁵ Despite these limitations, the study had many strengths, including the longitudinal design allowing for observation of incident weight status changes, large sample size, seasonal activity-specific exposure measurements, and repeated measures collected over the course of adolescence.

Conclusion

Adolescent PA frequently varies by season. Averaging PA over the year may miss these variations. Girls who meet the MVPA recommendation consistently for 1 or 2 (vs. 4) seasons a year may be at increased risk of becoming overweight. Interventions to increase winter activity among adolescent girls in the United States may be a valuable addition to overweight prevention programs.

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Address correspondence to:

Melanie L. Kornides, ScD

Department of Population Medicine

Harvard Pilgrim Health Care Institute

Harvard Medical School

401 Park Drive, Suite 401 East

Boston, MA 02215

E-mail: melanie.kornides@mail.harvard.edu