Pediatric Exercise Science, 2009, 21, 421-435

Examination of Physical Activity in Adolescents Over the School Year

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This study monitored the physical activity behavior of adolescent students over a ten month school year. Physical activity was assessed at two month intervals using self-report and objective (Actical accelerometers) measures. Self-report results (n = 547) indicated a decline in physical activity throughout the school year for all grades and genders. The decline was attributed largely to a decrease in organized activity participation. Objective physical activity results (n = 40) revealed a significant decline in activity in the latter half of the school year (February to June). Declining physical activity was attributed to a decrease in vigorous activity which was consistent across grade and gender. Collectively, the results highlight the importance of promoting consistent opportunities for adolescents to be active throughout the school year.

Low levels of physical activity remain a prominent public health concern among North American youth. A recent survey in Canada identified that only 21% of youth are physically active enough to meet the recommended international guidelines (6+ kilocalories per kilogram per day; KKD) for healthy growth and development (3). This statistic, coupled with a desire to explain and combat the dramatic increase in prevalence of obesity among youth (30), have led governing health initiatives (i.e., Healthy People 2010) to recognize physical activity as a leading health indicator (34). Improved measurement of physical activity is a fundamental prerequisite to address the low levels of physical activity, and further our understanding of its relationship with health and disease (e.g., obesity) (5,31).

Over the last two decades, there has been a rapid growth in the use of objective monitoring devices to assess physical activity (9). Among objective measures, accelerometers have gained increasing acceptance as an effective method to gather detailed,

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objective information about levels of physical activity in several populations, including youth (10,37). There are several benefits to using accelerometers to assess physical activity in the youth population in comparison with self-report measures. First, accelerometers accurately evaluate both the quantity (i.e., duration) and quality (i.e., intensity) of physical activity (10) compared with self-report measures which often captures quantity only. Second, accelerometers provide an opportunity to assess patterns of physical activity within a specified time period (i.e., day or over several days; 33). Third, accelerometers remove the potential for socially desirable responses and inaccuracy associated with recall in self-report measures (16). Finally, the relatively small, unobtrusive size of the devices offers minimal interference with ongoing activity (24).

Given the attending benefits of using accelerometers, it is not surprising that the devices have featured prominently in youth physical activity research. Research with accelerometers has offered valid and reliable support to previous self-reported findings suggesting that boys are more active than girls and that physical activity declines during adolescence (23,33). While this objective research has begun to offer evidence to accurately quantify the levels and patterns of physical activity among youth, the majority of the research has been cross-sectional in nature (23,33). Minimal research has objectively evaluated habitual physical activity behavior of adolescents longitudinally (14,15).

As noted above, longitudinal studies based on both self-reported and objective measures of physical activity have consistently demonstrated a decline in physical activity during adolescence (4,14,15,18,29,35). However, further research is necessary to more fully understand how physical activity levels change during adolescence. One important monitoring pattern which has not been examined longitudinally during adolescence is the school year. The monitoring of adolescent physical activity participation during the school year may offer important information relating to the noted declines in physical activity with age and the high number of adolescents not meeting the recommended physical activity guidelines. Further, these findings will assist in determining the timing of appropriate strategies for schools to provide and promote physical activity.

The purpose of this study was to examine the self-reported and objective physical activity behavior of adolescents over a ten month school year. Specifically, the study examined two important questions (1): Do the levels and patterns of adolescents' physical activity change during the school year (2)? Are there differences in the levels and patterns of adolescent physical activity between genders, and grades (i.e., grade 9, 10, 11 and 12)?

Method

Sample

This study was part of the *In Motion* Physical Activity research project; a community-based study that examined the longitudinal self-reported and objective physical activity behavior of adolescents 12–17 years of age. The self-report sample included 547 adolescents ($n_{grade\ 9}$ = 170, $n_{grade\ 10}$ = 152, $n_{grade\ 11}$ = 109, $n_{grade\ 12}$ = 117; 283 females; mean age 16.1 ±1.2 years at baseline). A subsample of adolescents (n = 40, mean age 15.3 ±1.3 years; mean weight 66.5 ± 11.5 kg; mean height 170 ± 10 cm at baseline) was randomly selected from the self-report sample to participate in longitudinal objective measurements of their physical activity. The subsample was

stratified by grade, with five girls and five boys randomly selected within each grade (9–12). The accelerometer sample completed the self-report physical activity questionnaire that was administered to the larger school sample (overall response rate for self-report physical activity questionnaire = 68.9%). No significant differences ($p > .05$) in the self-reported physical activity measures (total KKD) were found between the accelerometer sample and the larger school sample. Written informed consent was received by the participants and their legal guardian before the commencement of the study. The research design and protocol were reviewed and approved by the Behavioral Ethics Research Board at the participating university.

The study site was a midsized public high school (enrollment ?700) located in a typical small Canadian city (population ?34,000). The physical activity opportunities offered at the school included both intra- and extramural activities (i.e., floor hockey, cross-country, football, soccer, basketball, volleyball, curling, badminton, track and field, and golf). The school's physical education curriculum was semestered, with students enrolled in either the first (September-December) or second term (January-June) of the school year. Physical education was a required class for grades 9 and 10 and an elective for grades 11 and 12. Five data collection periods were conducted between October and June, two months apart.

Measures and Procedures

Self-Report Survey. The Modified Activity Questionnaire for Adolescents (MAQ-A, 1) was used to assess participants' self-reported physical activity over a school year. While the original measure was designed to evaluate an adolescents' physical activity over the past 12 months, a modified version of the instrument was used in this study to assess an adolescent's physical activity over the past month. Within the questionnaire, participants were first asked to identify the organized physical activities they had participated in over the last four weeks. Organized physical activities were defined as activities in which they had sign-up or registered for (e.g., ice hockey, gymnastics). To assist the participants, a list of 36 activities was provided along with spaces to indicate any additional activities not listed. A second part of the questionnaire, requested that participants identify the nonorganized physical activities they had participated in over the past four weeks. Nonorganized activities were defined as activities adolescent's did not register or sign-up for (e.g., pick-up basketball; street hockey). For each of the identified activities within the two parts of the questionnaire (organized activities and nonorganized activities), participants were asked to provide information pertaining to the duration (i.e., the number sessions per week, the average number of minutes per session over the last month) and intensity of the activity. Based upon this information, the level of energy expended (kilocalories per kilogram per day; KKD) was then calculated for each activity. The individual activity values were then summed for each of the two parts of the questionnaire (organized activities, nonorganized activities) to provide indications of a participant's level of energy expenditure (KKD) for organized activities, nonorganized activities and overall. The MAQ-Q has been found to be a reliable and valid measure of physical activity with adolescents (1).

Accelometry. Objective physical activity was measured using the Actical accelerometer (Mini Mitter Co., Inc. Bend, OR). The Actical is a small (28× 27 x10

mm), light (17 g) omnidirectional accelerometer, which is sensitive to movement in all directions. This device contains a sensor that integrates filtered and digitized accelerations over a user-specified time interval (i.e., epoch) and stores the summed values at the end of each epoch (32). The Actical device can detect movements in the range of 0.5–3 Hz and 0.5–98.1 m/s2 (Mini Mitter Company Inc., 2003) and, for the purposes of this study, was set to record over a 1-min epoch. The wide range of sensitivity of the accelerometer permits the detection of sedentary movements as well as high-energy movements (22). Predicted average energy expenditure and levels of physical activity intensity were calculated based upon the raw counts using the Actical software (Mini Mitter Co., Inc. Bend, OR, version 2), which categorizes the average energy expenditure using adolescent-specific cut points (i.e., Light to Moderate = 0.01 kcal/min/kg) and Moderate to Vigorous = 0.05 kcal/min/kg). The validity of the Actical has been demonstrated in youth (21,22) with strong correlations between activity counts and energy expenditure. The technical reliability of this instrument has been also demonstrated (8).

Anthropometric measurements were conducted by trained staff at each data collection period according to the International Society for the Advancement of Kinanthropometry (13). Weight was measured using a calibrated digital scale and recorded to the nearest 0.1 kg. Height was measured three times, using a stadiometer, and the average of the two closest values (within 0.2 cm) was calculated and recorded.

The day before the data collection period, participants were fitted with the Actical and instructed on proper positioning, as well as care for the device. Participants wore the device on an elastic waist belt over their right hip which is the most common place to attach the device as it is close to center of a participant's body mass (5). Each device was programmed to begin reading activity counts at 6:00 a.m. the following morning to allow for a period of adaptation to the device. All participants were provided with a 7-day log sheet on which they were to record the on/off time for wearing the device (e.g., time device put on in morning, time device removed at night). Participants were also asked to record the activity they were involved in when the device was removed (e.g., sleeping, shower). At the end of the 7-day period the research team returned to the school to collect the Actical devices and log sheets from participants.

Every attempt was made to have each participant wear the same Actical device for each data collection period. To facilitate this, the serial number of each participant's device was recorded and tracked during the project (32).

Compliance. Several strategies were used to optimize adherence to the Actical data collection protocol including both written and oral instructions regarding the protocol, a log sheet with a written reminder as to when the device was to be returned, and an oral reminder by a teacher to return the device one day before the end of the data collection period. In addition, each participant who completed the data collection at the mid point of the study was provided with a $3.00 coupon for the school cafeteria and received a $75.00 gift certificate from a local sports store at the end of the study.

Data Reduction. The raw data for each subject was downloaded to a PC using the Actical software. All data were processed for reduction by the same individual

using decision rules based on the most stringent data processing algorithm identified by Mâsse and colleagues (2005). Specifically, data reduction recommendations regarding wearing period of the day, minimal wear requirement for a valid day, and identification of spurious data were followed. While numerous validation studies have been published for accelerometers, a lack of standards regarding data reduction has limited the comparability of results between studies (17).

To further enhance the validity of the data reduction process, the subjective log sheet, when provided by the subject as an accurate representation of wear time, was used as a guide in determining the start and end times for wearing, nonwearing and sleep time periods. For all subjects, the objective accelerometer data were given precedence.

A wearing interruption, defined as output equal to zero for 20 or more consecutive minutes was excluded from analysis, assuming the device was not being worn during these periods (17). The number of wearing interruptions was recorded and the length of time that the monitor did not record any activity (e.g., sleep, shower, subject removed for activity) was calculated. Total wake time may also be affected by the fact that participants often remove the monitor near the time of sleep but may remain awake for minutes or hours before they actually fall asleep. Given that the focus of the analysis is on moderate to vigorous activity only, the discrepancy in these counts was not of concern. Spurious data, defined as output greater than zero that was constant for 10 or more consecutive minutes, was also excluded from analysis, as it was assumed that these periods of data are outside the range of plausibility (17).

A standard measurement day was defined as the length of time during which at least 70% of the study population had recorded accelerometer data. If the proportion of nonmissing data in a time period was less than 80% of a standard measurement day then the data for that collection day for the participant was not considered valid (17). After consideration, imputation of missing data were not performed. It is recognized that the selection bias due to days dropped or days kept is a limitation of this study. Subjects were included in the analysis only if they had a minimum of five days of valid data (consisting of at least four of five weekdays and at least one of two weekend days) (32). All subject data, once reduced, were exported into Microsoft Excel spreadsheets that were used to calculate weekly averages for total counts, total minutes, and number of minutes of moderate, and vigorous physical activity for each subject in each data collection period.

Data Analysis (for Self-report and Objective Physical Activity). Gender, and grade level differences in the self-report (overall KKD, organized KKD, nonorganized KKD) and objective (average activity per day, moderate physical activity, and vigorous physical activity) physical activity variables were evaluated using generalized estimating equations (GEE), given that the data analyzed needed to account for different subjects having different numbers of repeated measurements over the five time points (38). The coefficients and p-values for the variable "time" were examined to see how the trend of physical activity changes over the five measurement occasions, and whether this trend was statistically significant ($p < .05$). The interactions between time and gender, and between time and grade were examined to see whether the pattern of physical activity varied significantly

among different genders, and grades over the school year. Statistical analyses were conducted using Statistical Analysis System (SAS) 9.0.

Results

Self Report Main Analysis

Overall, adolescent participants demonstrated a significant decline in self-reported physical activity (KKD) over the school year ($p < .01$; Figure 1). There was a decline in self-reported physical activity, considered below the recommended international guidelines to obtain health benefits (6+ KKD, 6), in April and June. However, applying the more conservative criterion of 8+ KKD (27) to account for potential errors in overreporting (2) and national standards for reporting physical activity (7), showed that adolescents were on average below recommended levels over the entire school year. The decline in physical activity appears to be attributed to a decrease in organized (Grade 9–12) and nonorganized activities (Grade 12 only; $p < .01$). A comparison of energy expenditure between organized and nonorganized activities over the five time points showed that mean nonorganized KKD was significantly higher than organized KKD at Time 1, and Time 3 through Time 5 ($p < .01$, Figure 1); however, this difference was not significant at Time 2.

Variation by Gender. A significant downward trend in self-reported physical activity was shown over the five time points for both genders ($p < .01$); with males reporting a greater average rate in decline in physical activity in comparison with

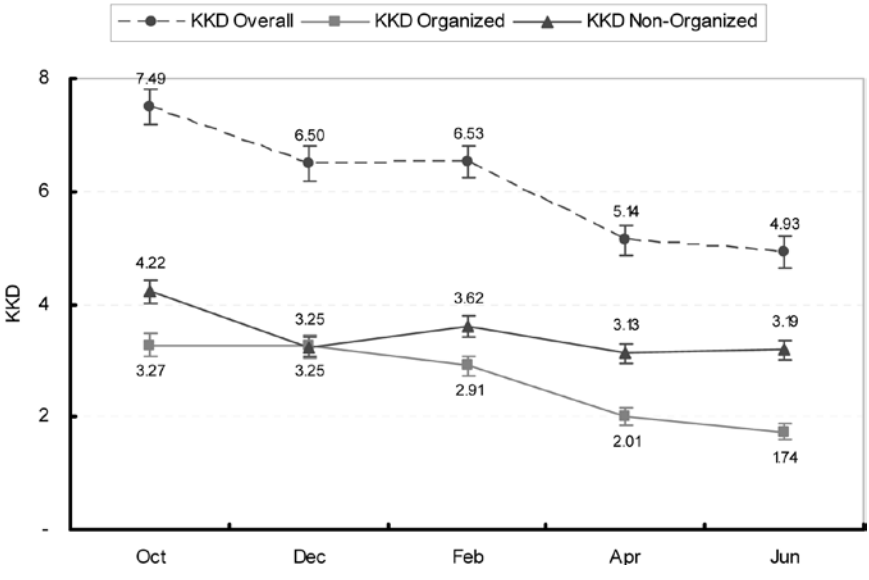


Figure 1 — Self-report physical activity over the school year.

females. Further examination indicated that both organized and nonorganized activities could be attributed to the decline in physical activity found with both males and females ($p < .01$). Male adolescents were more likely to participate in physical activity than female adolescents (see Table 1) and reported significantly higher KKD than female adolescents ($p < .05$) from Time 1 through Time 4. However, no significant differences between male and female adolescents ($p > .05$) were found at Time 5. An examination of the organized and nonorganized activities by gender suggest that the differences in gender for Times 1, 3, 4 and 5 may have been attributed to male adolescents engaging in more nonorganized activities than females over the course of the study ($p < .01$).

Table 1 Mean KKD by Gender and Grade Over Five Time Points

Gender		Time 1*	Time 2	Time 3	Time 4	Time 5
Female	N	282	283	283	282	283
	Mean KKD	6.14	5.87	5.87	4.58	4.60
	Std.Error	0.36	0.38	0.35	0.31	0.33
	Std.Deviation	6.01	6.43	5.97	5.14	5.62
Male	N	262	263	263	263	263
	Mean KKD	8.97	7.20	7.26	5.76	5.30
	Std.Error	0.53	0.47	0.45	0.44	0.43
	Std.Deviation	8.65	7.58	7.33	7.11	6.92
Grade		**Time 1**	**Time 2**	**Time 3**	**Time 4**	**Time 5**
9	N	169	170	167	168	166
	Mean KKD	7.19	6.90	7.48	6.06	5.87
	Std.Error	0.59	0.56	0.52	0.50	0.52
	Std.Deviation	7.68	7.31	6.78	6.50	6.69
10	N	150	150	150	152	151
	Mean KKD	7.63	6.48	6.27	4.92	5.08
	Std.Error	0.58	0.56	0.54	0.52	0.49
	Std.Deviation	7.07	6.81	6.60	6.38	6.05
11	N	109	108	107	106	106
	Mean KKD	6.87	6.54	6.15	5.35	4.68
	Std.Error	0.64	0.67	0.65	0.58	0.66
	Std.Deviation	6.70	6.93	6.77	6.01	6.79
12	N	117	117	117	116	117
	Mean KKD	8.33	6.00	6.03	4.10	3.81
	Std.Error	0.79	0.65	0.60	0.51	0.50
	Std.Deviation	8.56	7.06	6.49	5.50	5.40

*1 participant did not identify gender

Variation by Grade. For all grades, total energy expenditure (KKD) for self-reported physical activity demonstrated a significant decline over the five time points ($p < .01$; Table 1). Smaller decreases in physical activity were found with Grade 9 participants and larger decreases were reported by Grade 12 participants. Organized sport participation varied as Grade 11 and 12 participants' mean organized KKD demonstrated a downward trend over the 5 time points while Grade 9 and 10 participants' demonstrated an increasing trend from Time 1 to Time 2, followed by a downward trend from Time 3 through Time 5. Overall, adolescents in Grade 9 were more likely to participate in organized activities than the other grades over the school year. No significant differences were found for nonorganized sports participation for Grade 9, 10 and 11 over the school year. However, mean nonorganized KKD of Grade 12 participants showed a steady decrease over time. Based on these findings, the decrease in overall total energy expenditure (KKD) reported by Grade 9, 10, and 11 participants could be attributed to a decline in organized activity, while the decrease in overall KKD among Grade 12 students could be attributed to a decline in both organized and nonorganized activities.

Accelerometry Main Analyses

Application of the data reduction criteria to the objective data resulted in 141 valid data sets (70.5% of the possible data sets at the 5 time points; Table 2). Twenty-five participants (63%) had valid data (4 valid week days + 1 weekend day) for at least four of the five data collection periods. There were no significant differences for gender, grade, height or weight at baseline between the participants with valid data (compliant) and those with invalid data (noncompliant). Further, there were no significant differences in average wear time between the five data collection points ($p > .05$). No significant physical activity differences were found between compliant and noncompliant participants at baseline and along the other four time points ($p > .05$).

Average physical activity (counts per day) declined consistently over the school year ($p < .01$; Table 3). In addition, the increases in physical activity count and intensity from October to December were not sustained in the latter part of the school year (i.e., February, April, and June). This pattern of decreasing physical activity was attributed to a decline in vigorous intensity activity ($p < .01$) rather than moderate intensity activity ($p = .65$; see Table 3).

Variation by Gender. The pattern of decline in physical activity over the school year was consistent for males and females (see Figure 2a). For both genders, the level of decline in physical activity was attributed to a decline in vigorous physical activity ($p < .01$) rather than moderate physical activity ($p = .63$) over the school year (see Figure 2b and Figure 2c). The trajectory of the average activity counts per day was not statistically different between males and females ($p = .37$; interaction between sex and time) over the five time points.

Variation by Grade. Figure 3a illustrates that the average activity per day declined over the school year in all four grades. The findings also showed that there were differences in the trajectory of this decline among the grades ($p < .01$). Fur-

Table 2 Valid Datasets Across School Year

		Total Number of Usable Data Sets (/20)		Wearing time (min·d^{-1})	
Time	**N (/40)**	**Male**	**Female**	**Mean**	*SD*
Oct.	35	18	17	868.2	45.0
Dec.	23	13	10	900.2	62.1
Feb.	29	13	16	888.6	49.4
Apr.	26	10	16	877.8	44.3
Jun.	28	14	14	891.1	46.0
	141 (70.5%)	68 (68.0%)	73 (73.0%)		

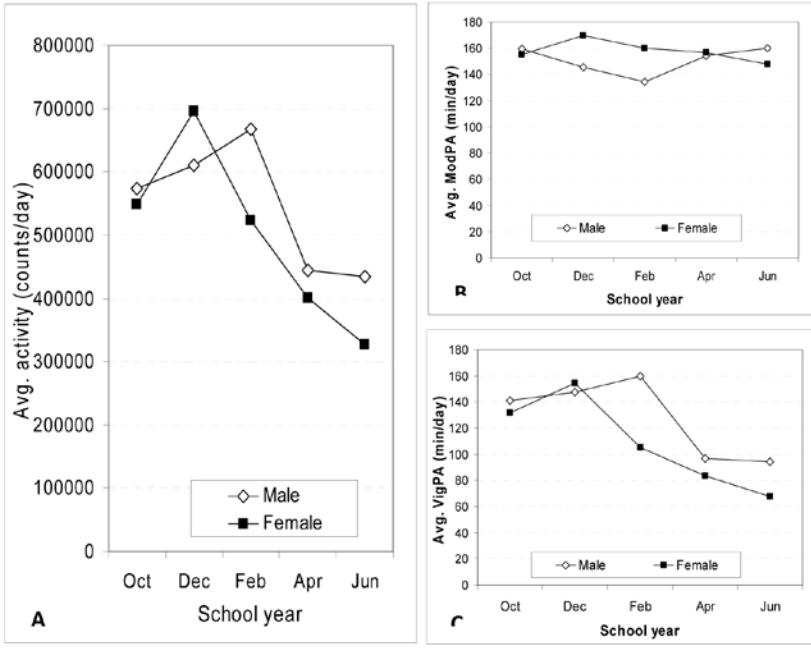
Table 3 Comparing Outcome Variables Across School Year

		Average activity (counts per day)		Average Moderate Physical Activity (min·d^{-1})		Average Vigorous Physical Activity (min·d^{-1})	
Time	**N**	**Mean**	*SD*	**Mean**	*SD*	**Mean**	*SD*
Oct.	35	561350.3	218137.8	157.5	36.0	136.4	51.8
Dec.	23	647766.0	249986.6	156.0	33.1	150.4	55.2
Feb.	29	581450.8	232779.8	149.4	38.5	127.5	63.0
Apr.	26	417384.0	166759.1	155.8	41.3	88.7	48.3
Jun.	28	380215.0	141175.7	154.1	52.4	81.4	47.7

ther analysis revealed that the differences in the trajectory of the average activity per day were attributed to both the difference in trajectory of moderate and vigorous physical activity (See Figure 3b and Figure 3c). Specifically, the level of moderate physical activity over time for the grade 10 participants was significantly less than the grade 12 participants ($p < .01$) and levels of vigorous physical activity over time for grade 9 and grade 10 were significantly greater than grade 12 ($p = .036$ and $p = .049$, respectively). The grade 12 students engaged in significantly less vigorous physical activity during the latter half of the school year than their grade 9 and 10 counterparts.

Discussion

The self-reported physical activity pattern of the adolescent sample demonstrated a steady decline over the school year. Consistent with previous research, physical activity declined with increasing grade and males were more active than females

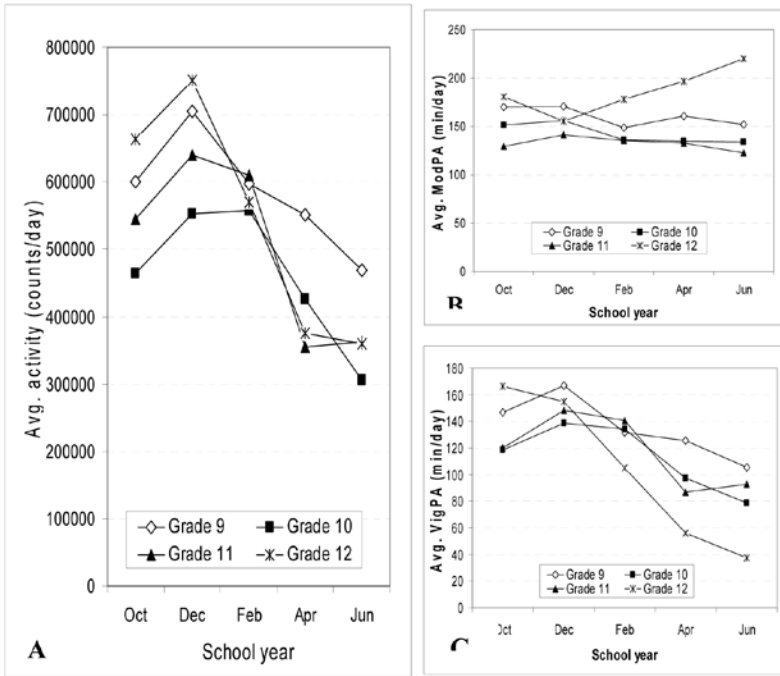


Note. Trends over time in Figure 2-A and 2-C are statistically significant ($p < .05$)

Figure 2 — Objective physical activity by gender over the school year.

(23,33). However, over the school year, males reported greater average rate of decline in physical activity than females. The overall decline in physical activity was largely attributed to a decreased involvement in organized physical activities. Although grade 12 students also reported a significant decrease in nonorganized activities over the school year. Of notable concern was the low overall levels of physical activity in all grades particularly over the latter part of the school year (e.g., April, June). On average, adolescents in all grades reported physical activity levels below the recommended national levels (8+ KKD) to obtain health benefits across the school year. The low, average levels of physical activity dropped below the international guidelines (6+ KKD, 6) for healthy growth and development during April (time point 4) and June (time point 5).

The objective physical activity data supported the concern for this time period as the participants experienced an initial increase in physical activity during October to December followed by a steady decline in the latter half of the school year (February-June). Overall, the decline of activity in terms of average activity (counts per day) was found to be consistent for gender (males or females), and grade (9–12). In addition, the pattern of decline of physical activity was consistently driven by a decrease in level of vigorous intensity activity rather than moderate intensity activity over the course of the school year.



Note. Trends over time in Figures 3-A and 3-C are statistically significant ($p < .05$)

Figure 3 — Objective physical activity by grade over the school year.

Although minimal research has monitored adolescents' physical activity throughout the school year, the existing literature, and discussions with school personnel can provide several possible reasons to account for the decline in physical activity during the latter half of the school year. First, fewer organized activities may be available (e.g., intramurals, extra curricular activities) within and outside of school in the latter part of the school year. This suggestion is supported empirically by the study's self-report findings and discussions with the school's faculty and administration who identified a decline in the number of structured activity opportunities at the high school during the second semester (January-June).

A second explanation to account for the decline may be part-time employment. The lack of organized physical activity opportunities combined with an increased desire by the adolescents to enjoy the financial benefits of working (11) may have motivated the youth to seek employment as the school year nears its end. Previous research has identified part-time employment among high school youth as a major reason for decreased involvement in physical activity (12). During the last two decades, there has been a 27% increase in the number of youth working part time while attending high school (28). Anecdotally, the school staff reported an increase

in the number of students working in the second semester of the school year. With time being consistently reported as a significant barrier for youth being active (19), more flexible, less structured physical activity opportunities may need to be offered. Such offerings may provide working youth opportunities to be active but not require the time commitment often associated with organized, interschool sports and activities (12). Further research examining the timing and influence of part-time employment on adolescent physical activity during the school year is needed.

Another factor that may have contributed to the observed activity pattern is the physical environment such as climate, weather and seasonal changes. While not controlled for in the study, seasonal variation has been found to be a determinant of physical activity (25). Previous activity research has reported increased levels of activity during the summer months, particularly in temperate and cold climatic regions such as the current study environment (26). However, our self-report and objective findings identified a decrease in activity moving from winter toward summer. One possible explanation to account for this discrepancy may have been attributed to atypical weather conditions during the data collections. However, an examination of the mean temperatures for each of the data collection periods in comparison with Canadian Climate Normals[1] for the study location revealed relatively similar temperature patterns (± 4 °C).

Consistent with previous research (33,35), significant differences in physical activity were found between males and females. Self-report findings revealed that males were more active than females over the majority of the school year (October-April). Further examination of the physical activity contexts indicated that the differences in physical activity were largely attributed to males engaging in significantly more nonorganized activities than females. This novel finding is of importance and may contribute to our understanding of observed gender differences in activity literature. The results may also aid in explaining research reporting that males are more active than females particularly in the context of vigorous physical activity during adolescence (33,35). While not significant, males in our accelerometer sample did engage in higher amounts of vigorous physical activity than females in four of the five time points (October, February, June, April). These nonsignificant findings may be due to the overall small sample size of males and females taking part in the objective component of the longitudinal study; further research to confirm these findings is warranted.

Self-report physical activity findings also revealed differences in physical activity across grade over the school year. Consistent with the literature, physical activity levels decreased with grade (23,33). The context of the physical activity findings (organized vs nonorganized) provided unique insight into the established declining relationship between grade and physical activity. Grade 9 participants were more likely to participate in organized activity than grade 10, 11 and 12 participants. However, no differences in patterns of nonorganized activity were found between grade 9, 10 and 11 students. Grade 12 participants also reported a decrease in organized activity over time. Based upon these findings, the decrease in overall total energy expenditure (KKD) among Grade 9, 10, and 11 participants was attributed to a decline in organized activity, while the decrease in overall KKD among Grade 12 students was attributed to a decline in both organized and nonorganized activities. To account for these findings, further research examining adolescents' preferred physical activity context (structured vs unstructured) by grade over the school year is needed.

The research findings should be interpreted in the context of the study limitations. The primary assessment of physical activity over the school year was a self-

report measure. Another limitation was the small accelerometer sample to objectively measure physical activity over the school year. High initial costs associated with the devices, software and reader constrained the number participants selected from each grade—contributing to the small accelerometer sample size. Additional limitations relate directly to the employment of the Actical devices. Despite the small size of the accelerometer, several participants reported being instructed by coaches and game officials to remove the device for certain activities (i.e., karate, wrestling, volleyball) because of possible injury. Although the log books provided valuable information to assist with the data reduction during the identified periods, the removal of the devices during the activities may have underestimated levels of physical activity for the participants. Further, some nonambulatory activities including cycling and resistance training may not have been appropriately accounted for by the accelerometers (32). A final limitation pertains to the use of 1 min sampling epoch lengths. The often short, intermittent bursts of activity of young children, may suggest a shorter sampling epoch length may be more appropriate for adolescents (32,36). The reader is cautioned in generalizing the findings beyond the study population. Given the small sample size of the accelerometer data, the objective study design in particular should be replicated with a larger sample before firm conclusions are drawn.

Despite these limitations, the study has several unique aspects. To our knowledge, this is the first investigation to monitor adolescent physical activity using objective and self-report measures throughout the ten-month school year. The longitudinal design with five assessment points provided a novel portrait of physical activity patterns of adolescents' throughout the school year. The consideration of physical activity context (structured vs. nonstructured) offered insight into understanding the decline in physical activity during adolescence and gender differences observed in the physical activity literature. The study design was strengthened by the addition of accelerometers to assess objective levels of physical activity on a subsample of youth during each data collection period; providing a reliable estimate of the adolescent's average activity. The application and documentation of stringent decision rules (17) will facilitate comparison of our results with future research. The considerable level of participant adherence (63%) given the reported past compliance with this population (36) suggest that longitudinal research with accelerometers is feasible with youth populations.

The school environment has an important role in promoting and improving the health of youth (20). The pattern of physical activity found among adolescents in this study suggest a need for consistent promotion of organized and nonorganized physical activity opportunities throughout the school year; particularly in the latter part of the year when the number of school-related opportunities for activity or student interest in physical activity may decline. This study offers direct support for the feasibility of combining objective with self-report assessments to longitudinally examine physical activity patterns in youth. Further longitudinal investigations using objective and self-report measures of adolescent physical activity behavior during the school year are needed to support the study's findings.

Notes

Temperature derived from Environment Canada for sample location during specified collection period. Canadian climate normals based upon data from 1971 to 2000 for sample locations.

Acknowledgments

This research was supported through a Community Alliances for Health Research grant provided by the Canadian Institutes for Health Research (CIHR FRN43282). We extend our sincere thanks to the participating school divisions, teachers and students involved in this study. The authors also wish to acknowledge Dale Esliger for sharing his technical accelerometer expertise and Doug Bitner for his assistance with the mechanical testing of the accelerometer devices, and Hang Lai for her assistance with the analysis.

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