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Changes in physical activity in the school, afterschool, and evening periods during the transition from elementary to middle school

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Abstract

BACKGROUND—We examined longitudinal changes in children's physical activity during the school day, afterschool, and evening across 5th, 6th and 7th grades.

METHODS—The analytical sample included children who had valid accelerometer data in 5th grade and at least one other time-point, and provided complete socio-demographic information (N = 768, 751 and 612 for the 3 time-periods studied). Accelerometer-derived total physical activity (TPA) and moderate-to-vigorous physical activity (MVPA) were expressed in minutes per hour for the school day (~7:45 a.m. to 3:30 p.m.), afterschool (~2:25 to 6:00 p.m.), and evening (6:00 to 10:00 p.m.) periods. We used growth curve analyses to examine changes in TPA and MVPA.

RESULTS—School day TPA and MVPA declined significantly; we observed a greater decrease from 5th to 6th grades than from 6th to 7th grades. Afterschool TPA declined significantly, but MVPA increased significantly among girls and remained stable for boys. Evening TPA decreased significantly and MVPA declined significantly in girls and remained stable among boys.

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CONCLUSIONS—To inform the development of effective intervention strategies, research should focus on examining factors associated with the decline in physical activity during the transition from elementary to middle school, particularly during the hours when children are in school.

Keywords

physical activity trajectory; child health; physical activity; growth curve analyses

Consistent evidence shows that physical activity declines with age in children,[1,2] and the decline becomes more notable as they move through adolescence.[3] However, little is known about whether the overall decline in physical activity is due to a decrease across all time-periods of the day or within certain periods. Examining the patterns of change over time will help researchers and practitioners develop intervention strategies that target periods of the day that offer the most potential for increasing participation in physical activity.

The evidence on changes in objectively-measured physical activity during various periods of the day in children is limited.[4–8] To date, 3 studies[5–7] have examined changes in school physical activity over 3–5 years, and they consistently observed a signficant decline in total physical activity (TPA), light physical activity (LPA) and moderate-to-vigorous phsycial activity (MVPA). Changes in afterschool physical activity were also examined in 3 studies.[5,6,8] Two of the studies[5,8] found that children's afteschool LPA and MVPA descreased significantly over a 4- to 5-year period, but one[6] showed a non-significant increase over a 3-year period. However, there is limited data on longitudinal changes in PA during evening hours among children and adolescents. The evening period deserves more research attention because several researchers[9,10] have suggested that evening MVPA makes a significant contribution to help children achieve recommended amounts of daily physical activity.

One methodological limitation of the exisiting longitudinal studies is that they only examined linear changes in period-specific physical activity over time. However, there is evidence that age-related changes in children's overall MVPA appear to be non-linear, with the decline reaching the peak in late childhood and attenuating in adolescence.[11,12] Therefore, additional longitudinal studies that use multiple time-points are needed to capture precisely the trajectory of period-specific physical activity among children and adolescents. Our study seeks to fill these gaps by using growth curve models to examine the trajectory of children's physical activity in the school day, afterschool, and evening periods across 5th, 6th, and 7th grades.

METHODS

Participants

Data are from the Transitions and Activity Changes in Kids (TRACK) study. TRACK is a multi-level, longitudinal study investigating the factors that influence changes in children's physical activity during the transition from elementary to middle school. We obtained written informed consent and assent from the primary guardian and each child, respectively,

before beginning any of the study procedures. TRACK recruited children from 21 public elementary schools in 2 South Carolina school districts. Children in 5th grade were invited to participate in the study, which included annual follow-ups through 7th grade. Of the 1083 children recruited in 5th grade, 1020 (94%) and 958 (88%) completed the follow-up measurement at 6th and 7th grade, respectively. Valid accelerometer data were collected from 92% of children measured in 5th grade (N=992), 85% in 6th grade (N=866), and 80% in 7th grade (N = 764).

In the current analysis, children who had valid accelerometer data in 5th grade and at least one other time-point (6th and/or 7th grade) and provided completed socio-demographic information on sex, race/ethnicity, and parental education were included in the analyses. The final analytic sample consisted of 768, 751 and 612 children for the 3 time-periods studied.

Instrumentation

Physical activity—Children's physical activity was measured by ActiGraph GT1M and GT3X accelerometers (Fort Walton Beach, FL). Each child wore the monitor on his or her right hip for 7 consecutive days during waking hours, except when bathing or swimming. Accelerometer data were collected and stored in 60-second epochs.[13] Any period of ≥ 60 minutes of consecutive zero counts was defined as non-wear time and set to missing. Accelerometer counts were categorized by intensity using an age-specific prediction equation generalized to the mean age of the TRACK cohort.[14] An intensity-threshold of <100 counts per minute (cpm) was used to distinguish sedentary from light physical activity (LPA). The intensity-threshold for MVPA was ≥ 2200 cpm, corresponding to 4.0 metabolic equivalents (METs; 1 MET= 3.5 mL O_2 log^{-1} min^{-1}).

In the present analysis, only activity counts from the 5 weekdays were used. Each weekday was divided into 3 time-periods. The school day period was defined as the time between 7:45 am and 2:25 pm for 5th grade and between 8:30 am and 3:30 pm for 6th and 7th grades. The afterschool period was defined as the time between 2:25 pm and 6:00 pm for 5th grade and 3:30 and 6:00 pm for 6th and 7th grades. The evening period was defined as the time between 6:00 pm and 10:00 pm for all grades. Although the time for school day and afterschool periods may vary between schools, the times selected to define these periods reflect a plausible division of a typical weekday for children in 5th, 6th and 7th grades in the United States.

Children who provided socio-demographic information in 5th grade and met the following time-period specific inclusion criteria were included in the analyses. For the school day analysis, children were required to provide ≥60% of wear time data during the school day on at least 2 days in 5th grade and at least one other time-point in 6th and/or 7th grade. For the afterschool analysis, children had to meet the school day criteria for wear time and provide ≥60% of wear time data during the afterschool hours on at least 2 days. For the evening analysis, children needed to meet the school day criteria for wear time and have worn the accelerometer for ≥60% of evening hours on at least 2 days.

For each period, any days with wear time less than the specified criteria were classified as missing. Five data sets were imputed for missing days and averaged by sex using the SAS

PROC MI procedure (Version 9.4, SAS Institute).[15] Prior to imputation, an average of 89%, 84%, and 72% of the children had complete accelerometer data for 3 or more days during the school day, afterschool, and evening periods over the 3 years, respectively. For each child, we calculated the average minutes per hour (min/h) spent in MVPA and TPA (LPA +MVPA) during the school day, afterschool, and evening periods based on 5 days of weekday data.

Socio-demographics—At each measurement, children completed a questionnaire to report their age in years, sex, and race/ethnicity. Parents reported their highest level of education (high school or less, more than high school), and this item was used as a proxy-measure of a child's socioeconomic status (SES).

Data Analysis

Descriptive statistics were performed to describe the distribution of the study variables at each measurement time-point. Growth curve analyses were used to examine the variations in individual child's TPA trajectory and MVPA trajectory during the school day, afterschool, and evening periods across 5th, 6th and 7th grades. Growth curves or random coefficient analyses allow for the estimation of between-person differences in within-person change.[16] This method is particularly suitable to model the current data because it allows for the inclusion of partially missing data and clustering at higher levels (eg, measurement time-point nested within children).[16]

Three-level growth curve models were developed, with the measurement time-points (5th, 6th and/or 7th grade) (level 1) nested within a particular child (level 2), who was further nested within school (level 3). For each of the time-periods, we conducted 2 sets of analyses. In the first set, we developed the unconditional mean models that only included the intercept in the model. These models provided information about the total outcome variation between- and within-individuals, and determined whether multilevel models were warranted. In the second set of analyses, we conducted the full growth curve models that included time as the independent variable and race/ethnicity and SES as the covariates. These models also tested a quadratic term for time. In cases where the quadratic effect was not significant, it was dropped from the model, and the model was re-run including only the linear effect. We also included a time by sex interaction term to test whether the MVPA and TPA trajectory during each time-period differed by sex. As the time by sex interaction effect was statistically significant for most of the models, sex-specific models were fitted.

We conducted all analyses using SAS 9.4 version (Cary, NC). Growth curve models were fitted by using PROC MIXED procedures[17] with the maximum likelihood estimation method. Time was coded as 0, 1, and 2 for 5th, 6th, and 7th grades, respectively. Both intercept and slopes were specified as random effects to examine whether there was significant variation in the mean and growth rate of period-specific TPA or MVPA at each nested level of the data. Because the rate that TPA and MVPA changes over time during each time-period is of interest, the random effects of the slope were presented. All models used an unstructured error covariance matrix because initial analyses indicated that associations were different between time-points.

RESULTS

Descriptive statistics of all the variables, stratified by sex, time-period, and measurement time-point, are presented in Table 1. More children met the inclusion criteria for the school day period, compared to the afterschool and evening periods. Nonetheless, the analytic samples for the 3 time-periods were not significantly different in terms of SES and race/ethnicity. The variance components of the unconditional mean models indicated that the growth rate of TPA and MVPA varied significantly within children, across children, and across schools (data not shown), which supports the use of multilevel modeling.

Final Growth Curve Models

Results for the growth curve models for boys and girls are presented in Tables 2 and 3. In these adjusted models, the beta coefficients for the intercepts represent the initial value of the MVPA or TPA for each time-period in 5^{th} grade. The value for the time variables is the slope, reflecting the rate of change in TPA or MVPA over time. A positive beta value indicates an increase in the physical activity variables over time, whereas a negative value indicates a decrease over time.

The final models show that adjusting for race/ethnicity and SES as time-invariant covariates slightly reduced the random effects terms, but all significant associations that emerged in the unconditional models were retained. All 3 measures of goodness of fit indicated that the final models had a slightly better fit than the unconditional models (data not shown). However, these covariates only made a small contribution to the unexplained variance of the rate of change in the physical activity variables at the child and school levels.

Boys' physical activity trajectory in different periods of the day—As Table 3 shows, the final growth curve model shows that there are significant linear (β= −4.7, SE=0.57, p < .0001) and quadratic (β=0.95, SE=0.26, p = .0002) effects of time for the school day TPA trajectory among boys. The linear (β= −3.63, SE=1.12, p = .004) and quadratic effects (β=1.12, SE=0.55, p = .043) of time for evening TPA also reached statistical significance. These findings suggest that boys' average TPA during the school day and evening periods declined significantly over time, and the rate of decline from 5^{th} to 6^{th} grade was greater than from 6^{th} to 7^{th} grade. The results also show a significant linear decline in boys' afterschool TPA (β= −1.35, SE=0.40, p = .0002) across 5^{th}, 6^{th}, and 7^{th} grades.

Likewise, there were significant linear (β= −0.69, SE=0.19, p = .001) and quadratic (β=0.24, SE=0.08, p = .002) effects of time for the school day MVPA trajectory among boys. These findings indicate that boys' average school day MVPA declined as they aged, with the decline from 5^{th} to 6^{th} grade being greater than from 6^{th} to 7^{th} grade. Boys' afterschool MVPA (β=0.52, SE=0.34, p = .14) and evening MVPA (β=0.33, SE=0.29, p = .26) remained stable from 5^{th} grade to 7^{th} grade.

Girls' physical activity trajectory in different periods of the day—As Table 4 shows, after controlling for race/ethnicity and SES as the covariates, there were significant linear (β= −7.45, SE=0.51, p < .0001) and quadratic (β=2.08, SE=0.23, p < .0001) effects of

time on school day TPA trajectory for girls. These findings indicate that girls' average school day TPA decreased significantly over time, with the rate from 5th to 6th grade being greater than from 6th to 7th grade. The results also show a significant linear decline in girls' afterschool TPA (β= −2.33, SE=0.03, p< .0001) and evening TPA (β= −2.93, SE=0.22, p < .0001) across 5th, 6th, and 7th grades.

For school day MVPA, significant linear (β= −0.75, SE=0.11, p < .0001) and quadratic (β=0.29, SE=0.05, p < .0001) effects of time were observed in girls. These indicate that girls' average school day MVPA declined significantly over time and that the rate of decline from 5th to 6th grade was steeper than from 6th to 7th grade. Girls' afterschool MVPA (β=0.25, SE=0.10, p = .02) increased linearly over time, while evening MVPA (β= −0.50, SE=0.78, p < .0001) declined linearly across 5th, 6th and 7th grades.

DISCUSSION

The major finding of the present study was that children's school day TPA and MVPA declined significantly over time, with the declines being greater from 5th to 6th grade than from 6th to 7th grade. Although a significant age-related decline in school day physical activity has been reported previously,[5–7] our results extend this work by demonstrating that a more profound decline occurs during the transition from elementary to middle school. These findings pinpoint the need to examine the factors that contribute to the decline specifically during this transition period. In addition to biological and psychosocial factors, reductions in school physical activity opportunities in middle schools could be another potential factor. According to SHPPS 2014,[18] 90% of elementary schools offer regular physical activity breaks, such as recess, outside of physical education (PE) during the school day, but only 66% of middle schools offer such breaks. Although few elementary schools require PE either on a daily basis or 3 times per week (3.6% and 15.3%), even fewer middle schools require PE at that frequency (3.4% and 8.5%.)[18] Future studies are needed to quantify the differences in school environments between the 2 settings and investigate their effects on changes in children's physical activity during the school day.

During the school day period, boys' and girls' TPA declined annually by 30 minutes and 43 minutes between 5th and 6th grades and 22 and 26 minutes between 6th and 7th grades. MVPA decreased annually by 2 minutes for both boys and girls between 5th and 6th grades, and 4 minutes between 6th and 7th grades. These findings suggest that most of the declines in school day TPA could be attributed to a decrease in light-intensity physical activities. Although there is limited evidence documenting the health benefits of light-intensity physical activity in children and adolescents,[19–22] this is the activity level in which most of the decline in minutes of activity was observed. Therefore, future interventions that are designed to maintain TPA during the school day may be important. Although the amount of decline in school day MVPA was much smaller than the decline in TPA, it is worth noting that children's school day MVPA at baseline was already low – 15 minutes for girls and 21 minutes for boys in the 8-hour school day period. Future studies should continue to investigate effective strategies for increasing MVPA during school.

Children's afterschool TPA declined significantly over time, but afterschool MVPA increased significantly in girls and non-significantly in boys. Despite an increase in MVPA, the total amount of time children engaged in MVPA during the afterschool period was modest. Given a 3-hour afterschool period, children engaged in TPA for nearly 50% of that time (26 to 31 minutes per hour across years), but spent less than 2.5% in MVPA (2.9 to 4.5 minutes per hour across years). Further studies should examine whether the increase in afterschool MVPA is associated with changes in the types of activities children engage in during the after school hours. This information would inform future afterschool interventions designed to convert minutes in light intensity to moderate-to-vigorous intensity physical activities.

The current findings on afterschool MVPA are inconsistent with previous studies that generally reported a significant decline in MVPA during the afterschool hours. The discrepancies between studies could be related to the heterogeneity in the definition of the afterschool period. Unlike our definition (ie, approximately 3:00 to 6:00 p.m.), others studies defined afterschool as 3:00 to 9:00 p.m.,[6] 3:00 to 10:00 p.m.,[8] or 3:00 to 11:00 p.m.[5] The inclusion of the evening hours in the afterschool period may have masked the increasing trend in afterschool MVPA, because we found that MVPA in the evening declined in girls and remained stable in boys. Future studies are needed that use a standard definition of the afterschool period to allow for comparison across studies.

Additionally, the present findings show that evening TPA decreased significantly over time for both boys and girls. Evening MVPA declined significantly in girls, but remained stable in boys. To our knowledge, this is the first study to report longitudinal changes in children's activity patterns during the evening hours. Our findings are in agreement with cross-sectional studies,[10,23] which showed that boys were more likely than girls to participate in higher intensity activity such as exercise or sports in the evening.[10] Given the potential contribution of evening MVPA to overall physical activity,[9,10] more studies are needed to build the evidence base for understanding changes in evening activity patterns among children.

Strengths of the present study include the use of a longitudinal study design, inclusion of a large racially diverse sample, and use of an objective measure of physical activity. Additionally, the inclusion of multiple time-points and the use of multi-level growth curve modeling allowed for more precise estimates of the physical activity trajectory in the specified periods of the day. Several limitations need to be considered. The sample size for the evening period was smaller than the other 2 periods because fewer participants met the evening accelerometer wear criteria. However, our analyses showed that participants included in the 3 periods were not significantly different in age and race/ethnicity. Future studies need to employ more dynamic mapping approaches such as electronic ecological momentary assessment to explore variations in the types of activity children engage in during different periods of the day. The accelerometers may have underestimated children's physical activity, as they cannot be worn for water-based activities and have limited ability to detect activities with little vertical hip movement.

IMPLICATIONS FOR SCHOOL HEALTH

This study observed that children's overall physical activity levels declined as they transitioned from elementary to middle school and that the decreases in physical activity were particularly pronounced during the school day. These findings highlight the important contribution that school-based physical activity makes to children's overall physical activity levels. Further, these findings indicate that there is a need for school districts and schools to adopt and implement innovative strategies for providing children with the physical activity they need to meet national physical activity guidelines.[24] One such strategy is the "whole-of-school" approach to providing students with physical activity during the school day.[25] The whole-of-school model, sometimes referred to as the Comprehensive School Physical Activity Program,[26] has been shown to be effective in increasing children's physical activity and is endorsed in the U.S. Department of Health and Human Service's Physical Activity Guidelines Mid-Course Report as a recommended intervention approach in school settings.[27] Further, this strategy for promoting physical activity in youth is included in the U.S. National Physical Activity Plan[28] and was strongly endorsed in a recent report of the Institute of Medicine.[25] That report recommends that schools take the following actions: require time in physical education and recess that meet national recommendations; provide brief classroom exercise breaks; incorporate physical activity into academic lessons; offer intramural sports and physical activity clubs before and/or after school; adopt joint use agreements that allow school facilities to be used for physical activity programs; and identify staff leaders who will support implementation of these tactics.[25]

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Table 1

Characteristics of the Analytical Sample Stratified by Sex, Time-period, and Time-point, Mean ± SD

	Boys								
	School			**Afterschool**			**Evening**		
	T0 (N=350)	**T1 (N=348)**	**T2 (N=349)**	**T0 (N=338)**	**T1 (N=336)**	**T2 (N=337)**	**T0 (N=275)**	**T1 (N=273)**	**T2 (N=274)**
Age	10.6±0.5	11.5±0.5	12.5±0.5	10.6±0.5	11.5±0.5	12.5±0.5	10.6±0.6	11.5±0.5	12.5±0.5
TPA (min/h)	25.3±5.8	21.6±5.1	20.0±4.7	33.2±6.6	31.9±6.7	30.5±10.1	29.9±7.2	27.9±8.1	27.5±10.1
MVPA (min/h)	2.7±1.7	2.2±1.2	2.3±1.3	4.5±3.4	4.8±3.7	5.3±8.4	4.2±4.0	4.5±5.6	4.9±8.1
	Girls								
	School			**Afterschool**			**Evening**		
	T0 (N=418)	T1 (N=413)	T2 (N=417)	T0 (N=413)	T1 (N=408)	T2 (N=412)	T0 (N=337)	T1 (N=333)	T2 (N=336)
Age	10.6±0.5	11.5±0.5	12.5±0.5	10.6±0.5	11.5±0.5	12.5±0.5	10.6±0.6	11.5±0.5	12.5±0.5
TPA (min/h)	23.8±5.1	18.5±4.7	17.3±4.4	31.5±6.2	29.1±6.2	27.0±7.5	28.2±6.3	25.1±6.2	22.6±6.2
MVPA (min/h)	1.8±1.0	1.3±0.8	1.4±4.4	2.6±1.9	2.7±1.9	3.1±4.6	2.5±2.0	2.2±2.6	1.6±1.7

Note.

MVPA=moderate-to-vigorous physical activity; TPA=total physical activity

Table 2

Final Growth Curve Models Examining Changes in Boys' MVPA and TPA in Different Time-periods across Grades 5 to 7, Coefficients (SE), N = 356

	School MVPA	Afterschool MVPA	Evening MVPA	School TPA	Afterschool TPA	Evening TPA
Intercept	2.63 (0.19)***	3.44 (0.33)***	3.93 (0.48)***	24.64 (0.59)***	31.53 (0.58)***	29.36 (0.82)***
Time	−0.69 (0.18)**	0.52 (0.34)	0.33 (0.29)	−4.70 (0.57)***	−1.35 (0.40)**	−3.63 (1.12)**
Time*Time	0.24 (0.08)**			0.95 (0.26)**		1.12 (0.55)**
Variance components (random effects: slope)						
Within-children	1.27 (0.01)***	15.03 (0.86)***	16.55 (1.22)***	13.99 (1.12)***	38.62 (3.25)***	42.45 (4.38)***
Between-children	0.15 (0.08)**	9.60 (1.42)***	11.17 (2.13)***	1.34 (0.89)***	11.16 (3.10)**	8.12 (3.85)**
Between-schools	0.11 (0.05)**	1.03 (0.59)**	0	0.75 (0.43)**	0.97 (0.87)	0.39 (0.65)
Goodness-of-fit						
Deviance	3353.2	5488.5	4394.1	5876.2	6269.6	4951.96
AIC	3379.2	5508.5	4414.1	5902.2	6293.6	4977.9
BIC	3392.1	5518.4	4424.0	5915.2	6305.6	4990.8

Note.

MVPA=moderate-to-vigorous physical activity; TPA=total physical activity

All models adjusted for race and parent education as fixed effects.

** $p < .05$,

*** $p < .0001$.

Table 3

Final Growth Curve Models Examining Changes in Girls' MVPA and TPA in Different Time-periods across Grades 5 to 7, Coefficients (SE), N = 356

	School MVPA	Afterschool MVPA	Evening MVPA	School TPA	Afterschool TPA	Evening TPA
Intercept	1.82 (0.12)***	2.49 (0.15)***	2.80 (0.16)***	23.69 (0.41)***	30.91 (0.48)***	27.95 (0.50)***
Time	−0.75 (0.11)***	0.25 (0.10)**	−0.50 (0.78)***	−7.45 (0.51)***	−2.33 (0.27)***	−2.93 (0.22)***
Time*time	0.29 (0.05)***			2.08 (0.23)***		
Variance components (random effects: slope)						
Within-children	0.09 (0.004)***	3.43 (0.26)***	3.59 (0.21)***	13.65 (1.02)***	23.94 (1.85)***	24.02 (2.07)***
Between-children	0.01 (0.03)	1.34 (0.27)***	0	0.45 (0.78)	8.46 (1.88)***	2.20 (1.66)
Between-schools	0.06 (0.02)**	0.02 (0.06)	0.002 (0.01)	0.47 (0.28)**	0.36 (0.39)	0.02 (0.17)
Goodness-of-fit						
Deviance	2900.6	5055.9	3771.5	6826.0	7420.7	5678.2
AIC	2926.6	5079.9	3793.5	6852.0	7442.7	5700.5
BIC	2926.9	5091.9	3804.5	6864.9	7453.6	5711.1

Note.

MVPA=moderate-to-vigorous physical activity; TPA=total physical activity

All models adjusted for race and parent education as fixed effects.

** p < .05,

*** p < .0001