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Patterns of age-related change in physical activity during the transition from elementary to high school

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ABSTRACT

This study was designed: 1) to describe patterns of age-related change in total and moderate-to-vigorous physical activity (MVPA) in children as they transitioned from elementary school to high school, and 2) to determine if those patterns differed across demographic sub-groups formed on the basis of gender, race/ethnicity, parent education (socioeconomic status), and urbanicity. A cohort of children (analysis sample, N = 951) was comprised of students drawn from two public school districts in South Carolina. Physical activity was measured by accelerometry on at least two and up to five occasions between 2010 and 2017. Growth curve analyses were performed to describe the pattern of age-related change in the physical activity variables for the full sample and for demographic sub-groups. A relatively steep age-related decline in total physical activity was observed in children before age 14, with a slower rate after that age. Physical activity was lower in girls than boys, and the age-related rate of decline was steeper in girls. Physical activity patterns did not differ across race/ethnicity groups, but children of parents with less education were more active than children of parents with more education. Children living in rural areas participated in less MVPA than children living in urban settings, and this difference increased with increasing age. These findings indicate that children experience a particularly steep decrease in physical activity as they transition from elementary to middle school, and this trend is particularly prominent in girls, children living in rural areas, and children of parents with college education.

1. Introduction

The health benefits of physical activity in children and youth have been documented extensively. (Janssen and LeBlanc, 2010)Accordingly, national and international public health agencies have established physical activity guidelines for young persons. (Bull et al., 2020; Tremblay et al., 2016; Department of Health. Australia's Physical Activity and Sedentary Behaviour Guidelines. Canberra, 2019; U.S. Department of Health and Human Services. Physical Activity Guidelines for Americans Second Edition., 2018) In the United States (U.S.), the Physical Activity Guidelines for Americans call for school-aged youth, 6 to 17 years of age, to engage in 60 or more minutes of moderate-to-vigorous intensity physical activity (MVPA) on a daily basis. (U.S. Department of Health and Human Services. Physical Activity Guidelines for Americans Second Edition., 2018)While many younger children meet that guideline, studies have shown that compliance decreases dramatically with increasing age. (Troiano et al., 2008)This suggests that reducing the age-related decline in physical activity should be a key goal of public health interventions aimed at promoting health in children and youth.

Reducing the difference in health behaviors among demographic subgroups is widely accepted as a strategy for promoting health and reducing disease in the U.S. (Thornton et al., 2016)This strategy may be applicable to physical activity behavior in children and youth, but there is uncertainty about the extent to which physical activity levels vary across demographic groups. It is clear that physical activity decreases with age as children progress from childhood to adolescence, (Troiano et al., 2008) but previous studies have drawn inconsistent conclusions about the patterns of these changes across demographic groups. (McCormack and Meendering, 2016; Dumith et al., 2011; Miller et al.,

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2018) For example, while studies have consistently reported that physical activity levels are higher in boys than girls, the findings regarding patterns of age-related change in the two sexes have not been as clear. Farooq et al. (Farooq et al., 2020) concluded that a decline in physical activity begins at an earlier age in girls than boys, whereas Reilly et al. (Reilly, 2016) suggested that this decline begins at the age of entry into school and follows similar trajectories in both sexes.

These inconsistencies should be resolved, so that physical activity interventions can focus on reducing age-related decreases in physical activity in demographic sub-groups in which the decline is most pronounced. Further, such interventions should be designed with a knowledge of the critical age ranges during which physical activity decreases most rapidly.

The Transitions and Activity Changes in Kids (TRACK) study provided a unique opportunity to examine age-related change in physical activity in children and youth. (Pate et al., 2019a)Participants in the TRACK study were followed as they transitioned from elementary school to high school, and physical activity was measured on multiple occasions by accelerometry (Pate et al., 2019a). Accordingly, the purposes of this study were: 1) to describe the patterns of age-related change in total physical activity and MVPA in children transitioning from elementary to high school, and 2) to determine if those patterns differed across groups created on the basis of sex, race/ethnicity, socioeconomic status, and urbanicity.

2. Methods

2.1. Study design & Participants

Data were obtained from the Transitions and Activity Changes in Kids (TRACK) Study, a multi-level, longitudinal study of influences on the changes in children's physical activity as they transitioned from elementary (2010) to middle school (2012) and high school (2017). Assessments were completed at 5 time points (i.e., grades 5, 6, 7, 9 and 11), with children's ages ranging between 10 and 17 years. Participants were recruited from 2 school districts in South Carolina, U.S., including 21 elementary schools, 12 middle schools, and 9 high schools. Recruitment assemblies were held at the elementary schools, 5th grade children were invited to participate, and informed consent packets were sent home with the children for parents to read, complete, and return.

Parents provided written consent for children in grades 5 (for grades 5, 6, and 7) and 9 (for grades 9 and 11), while children provided verbal assent in each grade. Students were excluded only if they had an orthopedic or other condition that would invalidate the measure of physical activity (e.g., wheelchair use), and/or intellectual limitations that would preclude completion of the survey. More details on the study recruitment protocols and original TRACK sample can be found elsewhere. (Pate et al., 2019a,b)

The initial sample of 5th grade children (n = 1,244; 45.7% male, 54.3% female) included all children who were measured at least once over the 5 data collection periods. Sample sizes were n = 857 in 5th grade, n = 757 in 6th grade, n = 668 in 7th grade, n = 329 in 9th grade and n = 309 in 11th grade. The samples of children in 5th, 6th and 7th grades were very similar demographically (about 46% male, 38% white, 58% parents with some higher education). However, the samples included in 9th and 11th grades had smaller percentages of males (about 39%) and white race (about 30%). Parental education was similar at all grade levels. We deleted cases with missing data on race/ethnicity (n = 3) and parent education (n = 103). We also deleted cases that did not have at least 2 accelerometer data points (n = 187), which resulted in 951 children available for analyses. The analytic sample did not differ from those who were excluded, except for parental education. While not statistically significantly different, the analytic sample had a higher percent of parents with more than a high school education (81%) compared with those in the full sample (76.5%).

2.2. Procedure

A trained measurement team completed the assessments at school in grades 5, 6, 7, 9 and 11, which occurred over two visits. During the first visit, students completed a survey, had anthropometric measures taken, and received an accelerometer and parent survey. During the second visit, participants returned the accelerometer and parent survey, and received a small incentive. The Institutional Review Board at the University of South Carolina approved all study protocols.

2.3. Measures

Objectively-measured physical activity. Physical activity was measured by ActiGraph accelerometers (GT1M and GT3X models, Pensacola, Florida, U.S.). Children wore the monitors on their right hip for 7 consecutive days at each time point (i.e., grades 5,6,7, 9 and 11). The accelerometer was attached to an elastic belt and worn on the right hip during most waking hours, except when sleeping or doing water-related activities (e.g., bathing or swimming). Data were collected and stored in 1-minute intervals. Non-wear time, i.e., any period of 60 or more minutes of consecutive 0s, was recoded as missing. We calculated minutes per hour spent in light, moderate, and vigorous physical activity using cut-points developed by Freedson et al. (Freedson et al., 2005)Counts greater than or equal to 100 but <2200 counts/minute were considered as light activity and counts greater than or equal to 2200 counts/minute were considered MVPA. Total physical activity was calculated by summing the total time spent in light and moderate-to-vigorous intensity activities. After summing a child's minutes of physical activity in each intensity category, adjustment for intra-subject variability in accelerometer wear time was applied by dividing raw minutes of physical activity by accelerometer wear time in hours. Hence, physical activity variables were expressed as minutes of physical activity (by intensity category) per hour of accelerometer wear time. Participants who had >8 h of wear time on at least two days of the week at each time point were included in the analyses. (Pate et al., 2019a)We did not differentiate between weekend and weekdays and excluded Sundays due to low wear time. Eighty-percent of the 5th grade sample and 87% of the 11th grade sample had accelerometer data that met inclusion criteria and were included in the analysis sample. Missing values were then imputed using a sex-specific multiple imputation method via PROC MI in SAS (Version 9.4; SAS Institute, Inc., Cary, NC, USA).

Sociodemographics. Participants self-reported their age, gender, and race/ethnicity. For race, they were asked to check as many categories as applied (white, black/African American, Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, and other [please specify]). They were also asked to identify whether they considered themselves as Hispanic or Latino. Race/ethnicity responses were recoded as Black, White, Hispanic, and Other/Mixed Race. Parents reported their highest level of education as a proxy for socioeconomic status; responses were re-coded into two groups: greater than high school or high school or less. The variable 'urbanicity' was calculated using the 2006 U.S. Census Bureau designations. (Ratcliffe et al., 2016)

2.4. Statistical analyses

Descriptive statistics for the 5th grade sample were calculated. Growth Curve analyses were calculated using PROC MIXED in SAS Version 9.4 (SAS Institute, Inc., Cary, North Carolina, U.S.) to assess change in physical activity over time for accelerometer-derived physical activity (i.e., total, log-transformed MVPA, light activity). First, unconditional growth models were calculated for each physical activity variable. A series of unconditional growth models, which included only age, was also calculated by demographic groups for total physical activity. Then, separate models that included one demographic variable at a time were calculated for each physical activity variable. Least squares means were then calculated (using untransformed MVPA) to create graphs to

display the difference between demographic groups (e.g., boys versus girls). Final models for each physical activity variable were then run that included all demographic variables at one time (gender, race, parent education and urbanicity). Analyses included age and age^2 as independent variables, as well as interactions between age and all the predictor variables (sociodemographics). In all models, age was treated as a random variable and children were nested in schools. For ease of interpretation, age was centered by subtracting the grand mean of the variable. Statistical significance level was set to $p < 0.05$.

3. Results

3.1. Sociodemographicand physical activity characteristics of the sample

Table 1 presents the sociodemographic characteristics for the 5th grade sample of participants (n = 951). On average, the sample was 10.5 (0.5) years old and about 45% male. Thirty-eight percent of the sample was black, 37% was white, 16% was other/mixed race, and 9% was Hispanic.

Table 2 presents the mean (SD) minutes per hour of accelerometer-derived physical activity for total physical activity, MVPA, and light physical activity at each time point for the total group by age. It is noteworthy that the majority of total physical activity consisted of light physical activity.

3.2. Unconditional linear models

Fig. 1 presents least squared means from unconditional linear models for total physical activity, MVPA and light physical activity. The unconditional growth models are displayed in Table 3 for total physical activity by total group and by subgroups determined by demographic variables. These models indicate the initial mean physical activity and the decrease each year. For the total group, total physical activity was 26.89 (±0.14) min/hr and declined by −1.76 min/hr per year. The rate of decline in min/hour of total physical activity was greater for younger (for ages 10–13, the slope is −2.58) compared to older (for ages 14–17, the slope is −0.51) youth.

Initial values for total physical activity by subgroup were higher for boys (28.11±0.21 min/hour), black children (27.33 ± 0.25 min/hour), children whose parents had a high school education or less (27.2 ± 0.22 min/hour), and children who lived in an urban area (27.00 ± 0.18 min/hour), versus their counterparts. Decline per year (i.e., from 10 to 11 years of age) also varied, with steeper declines for girls (-1.85 min/hour), white children (-1.89 min/hour), children whose parents had less than a high school education (-1.81 min/hour), and those in urban areas (-1.82 min/hour), compared to their counterparts.

3.3. Unconditional growth models

Figs. 2-4 provide the least squares means from a series of growth curves for total physical activity, MVPA, and light physical activity for each demograpic variable. For total physical activity, MVPA and light physical activity there were significant differences ($p < 0.05$) over time by gender, with boys having higher physical activity than girls, and the differences increased as the children became older. There was a significant main effect of parent education for light physical activity, with children whose parents' education was high school or less maintaining more light physical activity over time. There was a significant Hispanic by age interaction for MVPA, with higher levels of MVPA that increased over time. There was also a significant urban/rual interaction by time,

Table 1
Sociodemographic Characteristics of 5th grade sample.

Characteristic	Objective physical activity sample (n = 951)
Age, mean (SD)	10.6 (0.5)
Gender, % Males	44.6%
Race/ethnicity, %	
Black	38.3%
Hispanic	9.1%
Other/Mixed	16.1%
White	36.5%
Parent education, % greater than High School	58.1%
Rural, %	31.7%

Table 2
Mean (SD) minutes per hour of accelerometer-derived physical activity for the total group by age.

	Age (years)							
	10	11	12	13	14	15	16	17
PA	Mean(SD)							
Total PA	28.4 (4.5)	26.5 (4.8)	23.5 (4.7)	22.6 (4.9)	20.2 (5.6)	17.3 (4.3)	18.4 (6.0)	18.7 (5.8)
MVPA	2.9 (1.8)	2.7 (1.6)	2.6 (1.8)	2.6 (1.9)	1.7 (2.1)	1.4 (1.5)	2.1 (3.1)	2.3 (3.4)
Light PA	25.5 (3.6)	23.8 (4.1)	21.0 (3.8)	20.0 (3.9)	18.5 (4.5)	17.3 (4.3)	16.3 (4.5)	16.4 (4.4)
Hours/ day of Wear	12.7 (1.5)	12.4 (1.6)	11.7 (1.7)	11.2 (1.5)	10.9 (1.6)	10.8 (1.8)	11.2 (1.5)	11.3 (1.4)

Note: PA, physical activity; MVPA, moderate-to-vigorous physical activity

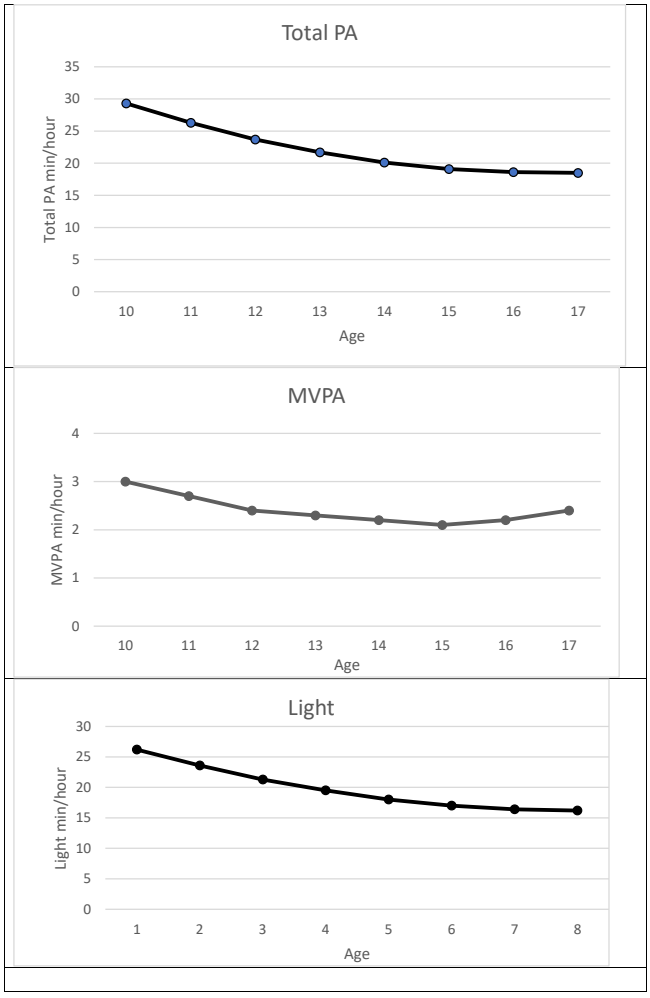


Fig. 1. Total, moderate-to-vigorous, and light physical activity for total group, Note: PA, physical activity;

Table 3
Results of unconditional linear models estimates (SE) for total physical activity (min/hour) for total group and by demographic groups.

Total groups	Initial	Physical Activity Change by Age
	26.89 (0.14)***	−1.76 (0.05)***
Gender		
Boys	28.11 (0.21)***	−1.58 (0.09)***
Girls	25.85 (0.19)***	−1.85 (0.06)***
Race		
Black	27.33 (0.25)***	−1.67 (0.08)***
Hispanic	26.78 (0.49)***	−1.83 (0.23)***
Other	26.46 (0.37)***	−1.80 (0.15)***
White	26.71 (0.22)***	−1.89 (0.08)***
Parent education		
High school or less	27.20 (0.22)***	−1.81 (0.22)***
Greater than high school	26.67 (9.19)***	−1.73 (0.07)***
Urbanicity		
Rural	26.69 (0.23)***	−1.68 (0.08)***
Urban	27.00 (0.18)***	−1.82 (0.07)***

*** $p < .001$

with children in urban areas engaging in more MVPA and the difference increasing with increasing age.

3.4. Adjusted growth models

Adjusted models for objectively-measured physical activity are presented separately for total physical activity, MVPA and light physical activity. The models were adjusted for gender, race/ethnicity, parent education, and urbanicity simultaneously (Table 4).

3.4.1. Gender

After adjusting for all demograpic variables, we observed significant main effects for gender as well as age by gender interactions for total physical activity, MVPA, and light physical activity. Specifically, for each category of physical activity, physical activity declined with age, with males having a higher level of physical activity than females (e.g., males have 2.27 min/hour more total physical activity than females). A positive quadratic effect showed that the rate of decline leveled off over time.

3.4.2. Race/Ethnicity

As shown in Table 4, the adjusted models found no significant main effects or age by race/ethnicity interactions.

3.4.3. Parent education (Socioeconomic Status)

After adjusting for other demographic variables, we observed significant main effects for parent education and the relationships with total and light physical activity. Specifically, children with parents whose education was high school or less engaged in more total (i.e., 0.74 min/hour) and light (i.e., 0.64 min/hour) physical activity compared with children whose parents had more than a high school education.

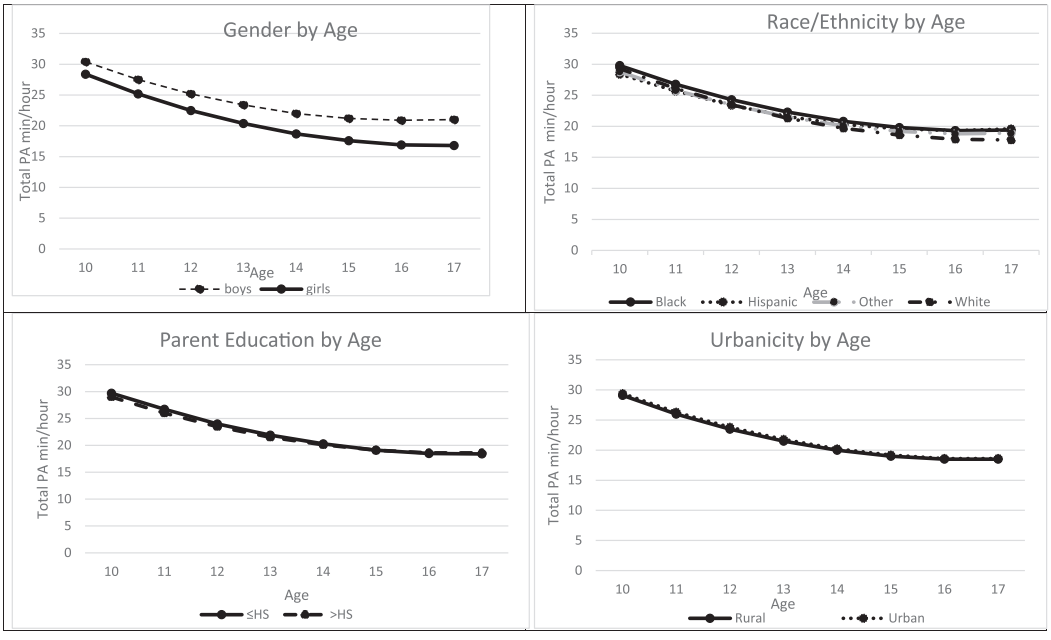
3.4.4. Urbanicity

The adjusted models showed significant main effects and negative age by urbanicity interactions for MVPA. Specifically, MVPA declined with age, with children living in urban areas having higher levels of MVPA compared with children living in rural areas.

4. Discussion

4.1. Total group

Numerous studies and systematic reviews have observed, with great consistency, that physical activity decreases during the transition from childhood to adolescence. (Farooq et al., 2020; Reilly, 2016)However, previous studies have drawn inconsistent conclusions about the pattern of this age-related decline. (Dumith et al., 2011; Farooq et al., 2020; Reilly, 2016)A major conclusion of the present study was that total physical activity in a diverse cohort of children living in South Carolina decreased at an overall rate of 1.76 min per hour per year of observation between ages 10 and 17 years. However, that rate varied across the observed age span and was considerably steeper between ages 10 and 13 years (-2.58 min per hour) than between ages 14 and 17 years, during which only a modest annual decrease occurred (-0.51 min per hour).



Note: PA, physical activity;

Fig. 2. Total physical activity from ages 10 to 17 by demographic groups (gender, race/ethnicity, parent education, urbanicity). Note: PA, physical activity;

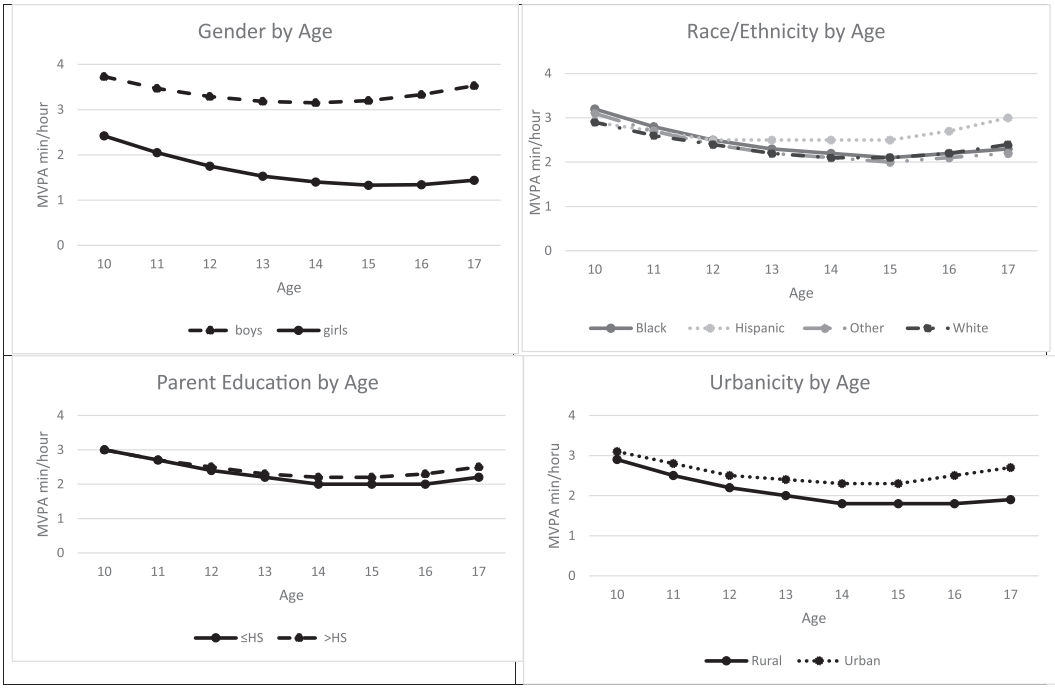


Fig. 3. Moderate-to-vigorous physical activity from ages 10 to 17 by demographic groups (gender, race/ethnicity, parent education, urbanicity).

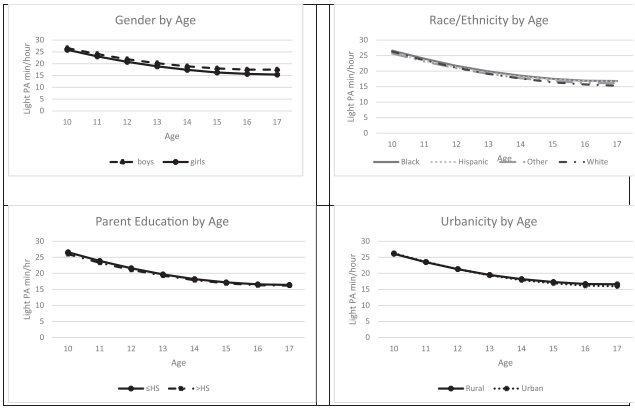


Fig. 4. Light physical activity from ages 10 to 17 by demographic groups (gender, race/ethnicity, parent education, urbanicity).

(Dishman et al., 2017; Sterdt et al., 2014)This suggests that age-related total physical activity decreases relatively steeply as children progress from elementary school to middle school but then plateaus as they transition into high school. Previous research has shown that several factors, representing multiple domains of the Social Ecological Model of health behavior, are associated with children's physical activity as they transition from elementary to middle school. (Elder et al., 2007)These factors include parental support for physical activity, peer support for physical activity, physical activity self-efficacy, sport participation, time spent outside, and access to community physical activity resources. (Pate et al., 2019a; Lytle et al., 2009)Hence, it is likely that adverse changes in these factors contributed to the steep decline in physical activity seen in the cohort observed in this study as it transitioned from elementary to middle school.

In the present study, MVPA accounted for a modest fraction of total physical activity, and that pattern was consistent across the observed age range. However, while MVPA generally decreased with increasing age, an increase in average MVPA was observed after 15 years of age. This may indicate that some youth experience increases in MVPA as they become involved in sports and other structured physical activity programs during their high school years. (Kemp et al., 2019) Our findings for MVPA are consistent with the findings of Reilly et al., (Reilly, 2016) who concluded that the decline in MVPA begins early in children's school years rather than at the transition into adolescence. Similarly, a study by Carver et al. demonstrated that daily, weekday, and weekend MVPA also declined in a cohort of young Australian children assessed over three time points. (Carver et al., 2011)

4.2. Gender

The level of physical activity (total and MVPA) was higher in males and declined with age, with a slightly higher rate of decline occurring in females. The finding that physical activity declined throughout childhood, versus beginning in adolescence, is consistent with recent reviews of longitudinal changes in MVPA by Reilly (Reilly, 2016) and Farooq et al. (Farooq et al., 2020) However, in contrast to Reilly (Reilly, 2016) and consistent with Farooq et al., (Farooq et al., 2020)the present study found that the rate of decline was slightly greater in girls compared to boys. Our findings, which are based on longitudinal, objectively-measured physical activity data in a diverse sample of boys and girls ages 10 to 17, contribute to a better understanding of physical activity patterns of boys and girls in childhood through adolescence. They also suggest that environmental, policy, and program interventions to prevent declines in physical activity in children should began early in childhood and may need to be tailored separately for boys and girls

4.3. Race/Ethnicity

There were no significant main effects or age by race/ethnicity interactions for physical activity in the adjusted models. This contrasts with previous studies that documented different patterns by race/ethnicity using self-reported physical activity levels. For example, a longitudinal study of physical activity trends from middle school to adulthood in a multiethnic sample showed declines in MVPA, with differing patterns by sex and race/ethnicity. (Miller et al., 2018)Cross-sectional data with 12–17-year-olds from the 2007–2016 NHANES study indicated no significant differences by race/ethnicity for males, whereas

Table 4
Adjusted Estimates (SE) for Objectively-measured Physical Activity growth curve models for Gender, Race/ethnicity, Parent education, and Urbanicity (n = 951).

	Total PA	MVPA (log transformed)	Light PA
Intercept	26.20***	0.68***	24.00***
	(0.30)	(0.04)	(0.25)
Age	−3.20***	−0.19***	−2.85***
	(0.14)	(0.02)	(0.12)
Age (Bull et al., 2020)	0.25***	0.02***	0.21***
	(0.02)	(0.003)	(0.02)
Gender			
Males	2.27***	0.51***	0.90***
	(0.28)	(0.04)	(0.23)
Females	Reference	Reference	Reference
Gender*Age	0.32 ***	0.08***	0.20*
Males	(0.10)	(0.01)	(0.08)
Race/Ethnicity			
Black	0.47	−0.004	0.33
	(0.33)	(0.04)	(0.27)
Hispanic	−0.38	−0.05	−0.34
	(0.51)	(0.06)	(0.42)
Other	−0.39	0.002	−0.47
	(0.41)	(0.05)	(0.34)
White	Reference	Reference	Reference
Race/Ethnicity * Age			
Black*age	0.13	−0.01	0.17
	(0.12)	(0.02)	(0.09)
Hispanic*age	0.32	0.05	0.26
	(0.20)	(0.03)	(0.16)
Other*age	0.15	−0.03	0.19
	(0.16)	(0.02)	(0.12)
White*age	Reference	Reference	Reference
Parent Education			
High school or less	0.74*	−0.003	0.64**
	(0.29)	(0.04)	(0.24)
Greater than high school	Reference	Reference	Reference
Parent Education *Age	−0.14	−0.02	−0.08
High school or Less	(0.10)	(0.01)	(0.08)
Urbanicity			
Rural	−0.60	−0.12**	−0.29
	(0.31)	(0.04)	(0.25)
Urban	Reference	Reference	Reference
Urbanicity*Age	0.09	−0.04*	0.14
	(0.10)	(0.02)	(0.08)

Note: PA, physical activity;
* $p < .05$; ** $p < .01$, *** $p < .001$

females from racial/ethnic minority groups reported lower MVPA than white females. (Armstrong et al., 2018)This suggests that change in children's physical activity over time may exhibit a different pattern by race/ethnicity, depending on how physical activity is measured. Furthermore, race/ethnicity is a social construct; (Cooper and David, 1986; Williams, 1997) therefore, other (modifiable) contextual factors not assessed here (e.g., built environment, access to resources, sports participation) may influence the relationship between physical activity and race/ethnicity.

4.4. Parent education (Socioeconomic Status)

The adjusted models showed that, regardless of age, children whose parents had less than a high school education engaged in more total physical activity than those whose parents had more than a high school education. These findings are inconsistent with some previous literature. A previous NHANES study using data from 2006 to 2016 indicated that higher income was associated with greater MVPA levels for males and females ages 12–17. (Armstrong et al., 2018) However, our results are consistent with those of a 2018 review of systematic reviews and *meta*-analyses of socioeconomic correlates and determinants of physical activity behaviors which concluded that physical activity in children and adolescents was not significantly associated with parent education level or other indicators of SES. (O'Donoghue et al., 2018)While higher socioeconomic status is often associated with increased physical activity in adults, (O'Donoghue et al., 2018) this relationship may be more complex in youth. (Delisle Nyström et al., 2019; Christiana et al., 2021) Researchers often explain physical activity differences by race/ethnicity in terms of differences in socioeconomic status; however, we saw different patterns between these two demographic variables. Parent education was used as a proxy for socioeconomic status, and it is possible that other measures of socioeconomic status would exhibit different patterns in the data. (O'Donoghue et al., 2018)For example, other measures of social class, such as accumulated wealth or neighborhood characteristics, (Jones, 2001)may show different results.

4.5. Urbanicity

In adjusted models, urban youth had higher levels of MVPA than rural youth, and the decline in MVPA was greater in rural youth over time. It is possible that children living in rural areas may have less access to physical activity facilities and structured sports programs. (Christiana et al., 2021) Comparisons of physical activity between urban and rural youth have yielded mixed findings in the literature. For example, a recent narrative review (McCormack and Meendering, 2016) of cross-sectional studies compared physical activity in rural and urban areas (with inconsistency in how these were determined) in the U.S. Researchers found that five out of sixteen studies showed no difference in physical activity between urban and rural youth, and nine studies showed that urban youth were less active than rural youth. Mixed results were also obtained when objective measures of physical activity were used. (Moore et al., 2013) (Johnson et al., 2010) (Moore et al., 2014) Using acceleromters and two methods to define urbancity, Euler et al. (Euler et al., 2019) found higher levels of MVPA with deceasing urbanization with one definition, but no difference with a second definition. The current study contributes stronger methodology than much of the literature (i.e., longitudinal design and objective physical activity measures). Future work should address the conceptualization and measurement of urbancity.

4.6. Limitations and strengths

This study has several important strengths. A large and diverse sample of children was observed, and a longitudinal study design was employed such that each child provided data at two or more age points. The age range extended from 10 to 17 years, a period greater than most previous studies on this issue. Physical activity was measured objectively with accelerometry, and this methodology allowed examination of multiple expressions of physical activity behavior. However, the study did have limitations. It was conducted with children who were students in public schools in two school districts in one U.S. state. Accordingly, the findings may not be translatable to children living and attending schools in other settings. Also, the age-distribution of the sample was not uniform across the observed age range, and fewer children were available at the older ages than in the younger range. Accordingly the reported physical activity levels at the older end of the age range may not be as reliable as it is for the younger ages.

5. Conclusions

In summary, we observed a relatively steep age-related decline in total physical activity in children between ages 10 and 14 with a slower rate after that age. Total physical activity was lower in girls than boys, and the age-related decline was steeper in girls than boys. This pattern was evident for both total and MVPA. Importantly, no differences in physical activity were seen across race/ethnicity groups. Children of

parents with a high school or less education were more physically active than those whose parents had more than a high school education, but the age-related trends were similar in the two groups. Children living in rural areas engaged in less MVPA than children living in urban areas, and this difference increased with increasing age. These findings indicate that children experience a particularly steep decrease in physical activity as they transition from elementary to middle school, and this trend is particularly prominent in girls, children living in rural areas, and children of parents with more than a high school education. These observations point to the importance of intervening to blunt the age-related decline in physical activity while children are in elementary school, and to the need to target interventions to reach girls and children living in rural areas.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2022.101712.

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