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School contextual correlates of physical activity among a national adolescent sample

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ABSTRACT

Schools are an important context to promote adolescent physical activity (PA). However, following ecologic frameworks, little is known about the influence of multiple school contextual levels – environment and policy – on adolescent PA. This study aimed to examine associations of school neighborhood environment factors and state laws with PA, and the moderating effects of school neighborhood socioeconomic status (SES) on these associations. Analyses used cross-sectional data from a national sample of middle (n = 387) and high (n = 591) school adolescents from the Family Life, Activity, Sun, Health, and Eating study conducted in 2014. Outcomes included self-report school-time PA and active transport to/from school (ATS), and estimated minutes/week of school-related moderate-to-vigorous PA (MVPA) and total MVPA. Separate regression models for middle and high school respondents examined state laws (school PA or physical education (PE) time requirements) and school neighborhood factors (density, age, and commute times), and their interactions with school neighborhood SES, in relation to each PA outcome, adjusting for socio-demographic and psychosocial factors. The high school models showed strong PE laws (B[SE]: 0.3[0.1], p = 0.02) and any PA law (B[SE]: 0.3[0.1], p = 0.0003) were related to higher school-time PA, and shorter school neighborhood commute times were related to lower ATS (OR [95% CI]: 0.4 [0.2–0.7]). We found similar associations with estimated school-related MVPA. The middle school models showed no significant state law or school neighborhood main effects. Interactions with school neighborhood SES were not significant. Our findings provide further support for state laws to promote PA in school regardless of school neighborhood SES.

1. Introduction

Physical activity (PA) in adolescence tracks into adulthood and provides many health benefits (e.g., lower adiposity and favorable cardiometabolic biomarkers) (Poitras et al., 2016; Telama, 2009). Yet, the national prevalence of adolescents aged 12–17 engaging in the recommended 60 or more minutes/day (*Physical Activity Guidelines for Americans*, 2018) of PA is low (2016 United States Report Card on Physical Activity for Children and Youth, 2016). School-time PA and active transport (walking/bicycling) can contribute to adolescents' overall PA (Chillon et al., 2011; Institute of Medicine, 2013), but less than a quarter of the recommended PA is achieved in school and few youth (8–15%) report active transport to/from school (ATS) (Institute of Medicine, 2013; McDonald, 2007). Given youth spend a substantial portion of their days in school and before/after-school activities, including ATS, an understanding of the school contextual influences of adolescents' PA can inform efforts to promote this behavior.

Past research on adolescent PA has focused on individual (e.g., socio-demographics) and psychosocial correlates (e.g., self-efficacy and social support) (Biddle et al., 2011; Robertson-Wilson et al., 2008). Yet, ecologic frameworks posit that policy and environment factors are also key determinants of behavior (Sallis and Owen, 2015). However, most published studies have examined policy and school neighborhood factors separately in relation to adolescent PA, and the literature examining the unique contributions of each on multiple adolescent PA outcomes is limited.

Prior studies in the US on school policies report that state laws addressing physical education (PE) or additional PA opportunities (e.g., PA breaks) in school are related to higher adolescent PE participation, total PA, and lower rates of obesity (Morton et al., 2016; Cawley et al., 2007a; Oh et al., 2015; Perna et al., 2012; Taber et al., 2013). Youth who are physically active in school may also be more active after school

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hours (Dale et al., 2000). As such, policies that support PA in school may have effects on behaviors such as ATS, but this hypothesis has yet to be tested.

Youth also spend a substantial proportion of time being physically active in the school neighborhood (Carlson et al., 2016). However, most of the evidence linking neighborhood environments and adolescent PA has focused on the home context, which may yield different associations from the school context. For example, adolescent PA is positively related to home neighborhood land use mix (Ding et al., 2011) but negatively related to school neighborhood land use mix (Hobin et al., 2012). There is more consistent evidence of positive associations between home or school neighborhood residential density and adolescent PA (Ding et al., 2011; Dalton et al., 2011; Wong et al., 2011). School neighborhood factors may also influence PA during school hours, but the evidence is limited. One study found school neighborhood availability of recreation facilities was related to higher school-time PA (Nichol et al., 2009). The effects of other school neighborhood factors on school-time PA are unknown.

Several studies also report a relation between SES and adolescent PA, but most of the evidence is focused on individual-level SES (e.g., eligibility for free/reduced lunch) or home neighborhood SES (Johnston et al., 2007; Carlson et al., 2014; Estabrooks et al., 2003). Few studies have focused on school neighborhood SES. For example, a study from Spain found an inverse association between school neighborhood SES and children's ATS (Molina-Garcia and Queralt, 2017), but a study from Canada found no relationship with adolescents' overall PA (Janssen et al., 2006). Given SES at various levels can have independent effects on adolescent health (Janssen et al., 2006; Diez Roux et al., 2002), additional studies on school neighborhood SES can help elucidate the unique contribution of this variable on adolescent PA beyond other SES measures.

The ecologic framework also posits that behavioral correlates across levels interact with one another, but interactions between neighborhood SES and built environment/policy factors have not been fully examined in relation to adolescent PA. For example, one study reported stronger associations of school neighborhood factors with ATS among students in low-income compared to higher-income settings (Zhu et al., 2011). However, the study did not report a formal interaction test, which is needed to demonstrate a statistically significant difference between SES groups.

Thus, the first aim of this study tested the hypothesis that state laws requiring PA/PE in schools and school neighborhood factors that promote walkability are related to higher self-report ATS and school-time PA among a national adolescent sample. To assess the broader effects of these policy and school neighborhood factors on overall PA, we also examined these associations in relation to estimated minutes/week of moderate-to-vigorous physical activity (MVPA). The second aim tested the hypothesis that the associations of the state laws and school neighborhood factors with PA differ across school neighborhood SES levels. We examined these aims separately for middle and high school respondents given the evident differences in their PA levels (Institute of Medicine, 2013; McDonald, 2007) and variations in how state laws are implemented across school levels (Institute of Medicine, 2013; Johnston et al., 2007; Hood et al., 2014).

2. Methods

2.1. Study design and sample

Cross-sectional data came from the National Cancer Institute's (NCI) Family Life, Activity, Sun, Health, and Eating (FLASHE) study of cancer-preventive behaviors and their correlates among adolescents (aged 12–17) and one of their parents/caregivers (aged 18 or older). The present analyses focused on the adolescent sample. The US Government's Office of Management and Budget, the NCI Special Studies IRB, and the Westat IRB approved this study.

Details about the study design, recruitment, and measures can be found in another publication (Oh et al., 2017). In brief, the recruitment stage used the Ipsos Consumer Opinion Panel to identify a non-probability sample of parent-adolescent dyads. Potential participants completed a screening instrument via the web from February–March 2014 to assess eligibility for FLASHE (parent/guardian of an adolescent aged 12–17 years and lived with the adolescent at least 50% of the time). In the screening process, parent participants completed a full household roster from which one eligible adolescent was randomly selected to participate. Most parents reported only one child (40%) or two (35%) in the household. Following screening, eligible parent-adolescent dyads received an email invitation to participate in FLASHE between April–October 2014. Parents provided consent for themselves and their child to participate and adolescents provided assent.

Of the 1945 adolescents who enrolled in FLASHE, 1281 attended a public middle or high school and completed a survey. Of these, 978 had complete data on the variables for the present analyses. Those with missing data did not differ statistically from the analytic sample on key socio-demographics, except race/ethnicity. A higher proportion of non-Hispanic black adolescents and those of 'other' race/ethnicities had missing data than non-Hispanic whites and Hispanics.

2.2. Measures

Survey items are available on the NCI's FLASHE website (https://cancercontrol.cancer.gov/brp/hbrb/flashe.html) and a complete description of the measures from the present analysis is provided in Table 1. The validated 10-item Youth Activity Profile (YAP) questionnaire assessed ATS, school-time PA, non-school time PA, and weekend PA (Saint-Maurice and Welk, 2014). The present study focused on ATS and school-time PA. We dichotomized responses for ATS as 'none' or 'any' due to the high proportion of respondents reporting '0 days' of walking/biking to or from school (about 70%). For school-time PA, we estimated a mean score for the frequency of PA during PE, breaks/study hall, and lunch break.

A calibration algorithm, developed in a previous publication, converted the raw scores from the YAP to four measures of estimated MVPA minutes/week: school-related, non-school time, weekend, and total (Table 1) (Saint-Maurice et al., 2017). This procedure provided more accurate and useable estimates of PA than the self-report measures alone. Estimated school-related MVPA combined the estimated minutes/week from the ATS and school-time PA subscales because the ATS subscale was comprised of only two items, which can introduce measurement error, and the sample prevalence of ATS was low. Estimated non-school time and weekend MVPA were based on their respective YAP subscales. Estimated total MVPA combined the estimated minutes/week from all four YAP subscales. To provide a comprehensive analysis of the correlates of adolescent PA, we also analyzed estimated total MVPA, non-school time MVPA, and weekend MVPA. We reported results for non-school time and weekend MVPA in the Appendix.

The NCI's Classification of Laws Associated with School Students (CLASS) resource (https://class.cancer.gov) provided data on state law measures for the 2014 calendar year. All respondents received a score (ranging from 0 to 4) for the degree to which their state of residence's law addressed the amount of PE or PA in school (Table 1). Based on the median split of the PE state law scores, we categorized the PE time requirement scores as 'weak' or 'strong', consistent with a previous publication (Perna et al., 2012). We recoded the PA state law scores as 'none' or 'any' as half the respondents had scores of zero.

A FLASHE report describes the methods for creating the neighborhood environment variables (Westat, 2018). A 1200-meter street network buffer around each respondent's geocoded school address included scores for a set of neighborhood factors derived from a principal component analysis of 13 measures from the 2010 Census and the 2010–14 American Community Survey (ACS): population/residential density, neighborhood age, and commute times (Table 1) (National

Table 1
FLASHE (2014) measures for adolescent physical activity, state laws, school neighborhood, and psychosocial factors.

Measures	Description	Response options	Scoring
Physical activity			
Self-reported active transport to/from school (ATS)	[2 items] Number of days walked or biked (a) to or (b) from school in the last 7 days.	0 = '0 days' 1 = '1 day' 2 = '2 days' 3 = '3 days' 4 = '4–5 days'	Dichotomized variable due to low prevalence of ATS. None = 0 on both items Any = 1 or higher on either item
Self-reported school-time PA	[3 items] Frequency of PA (e.g., running/moving/playing) during (a) PE, (b) breaks/study hall, or (c) lunch break in the last 7 days.	0 = 'I didn't have PE, breaks/study hall, or lunch breaks' 1 = 'Almost none of the time' 2 = 'A little bit of the time' 3 = 'A moderate amount of the time' 4 = 'A lot of the time' 5 = 'Almost all of the time'	Mean score
Estimated school-related MVPA	Raw scores on the self-report ATS and school-time PA items above converted to estimated MVPA minutes using a calibrated model.	N/A	Estimated minutes/week
Estimated non-school time MVPA	Raw scores on 3 self-report items on PA (a) before school (6–8 am), (b) after school (3–6 pm), and (c) school evenings (6–10 pm) in the last 7 days, converted to estimated MVPA minutes using a calibrated model. Excludes ATS.	For the self-report items: 0 = '0 days' 1 = '1 day' 2 = '2 days' 3 = '3 days' 4 = '4–5 days'	Estimated minutes/week
Estimated weekend MVPA	Raw scores on 2 self-report items on PA (a) last Saturday and (b) last Sunday converted to estimated MVPA minutes using a calibrated model.	For the self-report items: 1 = 'No activity' 2 = 'Small amount (1–30 min)' 3 = 'Small to moderate amount (31–60 min)' 4 = 'Moderate to large amount (1 − 2h)' 5 = 'Large amount (> 2 h)'	Estimated minutes/week
Estimated total MVPA	Raw scores on the above self-report ATS, school-time, non-school, and weekend PA items converted to estimated MVPA minutes using a calibrated model.	N/A	Sum of estimated MVPA minutes/week
State laws			
PE time requirement	Degree to which state law addresses the amount of PE instruction per the NASPE recommended standard at the middle/high school levels.	0 = 'No PE time requirement/recommendation' 1 = 'State only recommends a PE time requirement for public school districts or state requirement for PA includes an option for PE' 2 = 'State requires public school districts to provide PE for < 90 min/wk. or state requires PE without a specified time requirement' 3 = 'State requires public school districts to provide PE for 90–150 min/wk' 4 = 'State requires public school districts to provide PE for 150–225 min/wk' 5 = 'State requires school districts to provide PE for ≥ 225 min/wk'	None had a score of 0, thus scores were dichotomized as: Weak = scores of 1–2 Strong = scores of 3–5
PA time requirement	Degree to which state law addresses the amount of PA occurring in schools and may/may not include time allocated for PE and other activities during the school day at the middle/high school levels.	0 = 'No PA time requirement/recommendation' 1 = 'State only recommends a PA time requirement' 2 = 'State requires school districts provide PA for < 90 min/wk. or state requires PA without a specified time requirement' 3 = 'State requires school districts provide PA for 90–150 min/wk' 4 = 'State requires school districts provide PA for 150–225 min/wk' 5 = 'State requires school districts provide PA for ≥ 225 min/wk'	Half of the sample had no PA time requirement/recommendation in their state, thus their scores were dichotomized as: None = scores of 0 Any = scores of 1–5
School neighborhood			
Urban-rural location	Urban-rural environment of the school neighborhood using the 2010 NCES categories.	1 = City 2 = Suburb 3 = Town 4 = Rural	Raw scores
Density	Population/residential density within 1200-m street network buffer around school address. Estimated from principal component analysis of 13 Census measures.[a] Scores ranged from − 1.57 to 3.51, with higher scores indicating higher density.	N/A	Tertiles
Neighborhood age	Age of buildings/units within 1200-m street-network buffer around school address. Estimated from principal component analysis of 13 Census measures.[a] Scores ranged from − 1.77	N/A	Tertiles

(*continued on next page*)

Table 1 (*continued*)

Measures	Description	Response options	Scoring
	to 2.74, with higher scores indicating older neighborhoods.		
Commute time	Within 1200-m street-network buffer around school address, percent of workers aged 16 or older (excluding those who worked at home) who commuted to work in < 20 min by any transportation mode. Estimated from principal component analysis of 13 Census measures.[a] Scores ranged from −5.03 to 1.84, with higher scores indicating higher percentage of workers with short commutes to work.	N/A	Tertiles
SES	Yost socioeconomic status (SES) index within 1200-m street-network buffer around school address. Based on Census data for income, poverty, education, employment, occupation, and housing (median house value and median house rent). Scores ranged from −1.71 to 1.84, with higher scores indicating higher SES.	N/A	Tertiles
Psychosocial			
Social support	[1 item] "My friends play sports or are physically active with me."	1 = 'strongly disagree' to 5 = 'strongly agree'	Raw score
Social norms	[1 item] "My friends exercise most days of the week."	1 = 'strongly disagree' to 5 = 'strongly agree'	Raw score
Self-efficacy	[1 item] "I feel confident in my ability to exercise regularly."	1 = 'strongly disagree' to 5 = 'strongly agree'	Raw score
Barriers	[5 items] (a) "I don't like to sweat," (b) "I don't like to exercise," (c) "I don't want to mess up my hair," (d) "My family doesn't like to exercise," and (e) "I'm not athletic."	1 = 'strongly disagree' to 5 = 'strongly agree'	Mean score
Attitudes	[5 items] "If I were to be physically active most days of the week it would…" (a) "Be fun," (b) "Help me cope with stress," (c) "Help me make new friends," (d) "Make me more good looking," and (e) "Make me better in sports, dance or other activities."	1 = 'strongly disagree' to 5 = 'strongly agree'	Mean score
Autonomous motivation	[2 items] "I would exercise most days of the week because…" (a) "I have thought about it and decided that I want to exercise" and (b) "It is an important thing for me to do."	1 = 'strongly disagree' to 5 = 'strongly agree'	Mean score
Controlled motivation	[2 items] "I would exercise most days of the week because…" (a) "I would feel bad about myself if I didn't" and (b) "Others would be upset with me if I didn't."	1 = 'strongly disagree' to 5 = 'strongly agree'	Mean score

Notes: FLASHE = Family Life, Activity, Sun, Health, and Eating; MVPA = moderate- to vigorous-physical activity; NASPE = National Association for Sport and Physical Education; NCES = National Center for Education Statistics; PA = physical activity; PE = physical education.

[a] Census measures: population density; median year structure built; percentage of units built before 1950; percentage of units built in 1970 or later; percentage of commutes < 20 min; percentage of commutes ≥ 35 min; percentage of units that are 1, detached; percentage of units ≥ 5 attached; percentage of units owner occupied; median number of rooms; percentage of commutes by car, truck or van; percentage of commutes by public transit; and percentage of commutes by walking or bicycling.

Cancer Institute, 2014). A previous study from Texas identified these measures (Hoehner et al., 2011). Higher values on the neighborhood factors (higher density, older neighborhood, and shorter commute times) represent greater mixed land-use (Frank et al., 2005) and pedestrian friendliness (Berrigan and Troiano, 2002; Smith et al., 2008; Craig et al., 2002) and are indicative of favorable neighborhood characteristics for health (Hoehner et al., 2011; Christian, 2012).

Each school buffer also included an SES index score based on 2010–14 ACS data (Table 1) (Yost et al., 2001). Higher scores indicated higher school neighborhood SES. We converted the school neighborhood factors and SES index to tertiles for ease of interpretation in the interaction models. Preliminary analyses revealed no differences in the interpretation of the results using the continuous neighborhood variables, so we report only the analyses with the tertile variables.

Covariates included individual and psychosocial factors related to the PA outcomes as well as school urban-rural location. Urban-rural location was based on Census 2010 data and categorized using the National Center for Education Statistics classifications (Table 1) (Geverdt, 2015). Individual factors included age, gender, race/ethnicity, and parent education, as well as distance between home and school (the shortest distance between respondents' home and school addresses following the street network in miles). Psychosocial factors specific to PA included social support, self-efficacy, perceived barriers, attitudes, autonomous motivation, and controlled motivation (Biddle et al., 2011) (17 items; Table 1).

2.3. Weighting

Given FLASHE is a non-probability sample, the FLASHE dataset includes weights intended to help reduce under-coverage, nonresponse, and selection biases inherent of opt-in panels (National Cancer Institute, 2014). Such biases make it difficult to draw inferences from

the sample statistics to the general population. The survey weights used four raking variables from the 2014 Current Population Survey Annual Social and Economic Supplement: age, gender, race/ethnicity, and Census region. Because statistical inferences for variables other than the raking variables are still subject to selection bias, caution is advised in generalizing estimates for those variables to the general US adolescent population (National Cancer Institute, 2014).

2.4. Analysis

To examine the associations of the state laws and school neighborhood factors with each PA outcome, we used SAS PROC SURVEY procedures to conduct weighted logistic and linear regressions. We conducted separate analyses for the middle and high school respondents, stratifying by self-report school level. Models controlled for socio-demographics, the seven psychosocial factors, distance to school, and school urban-rural location. We performed tests for multicollinearity prior to finalizing the models. We did not apply mixed effects models given that respondents were not recruited in clusters (at the school or state level), we had small sample sizes in some states for the state law variables, and we did not find issues of autocorrelation among our variables.

To examine the moderating effects of school neighborhood SES on the associations between the school contextual factors and each PA outcome, we tested two-way interaction terms between school neighborhood SES and each state law as well as each school neighborhood factor (5 interactions total). To the best of our knowledge, such interactions have not been reported in previous studies, and as such, statistical significance was maintained at $p < 0.05$ (we did not make any adjustments). We performed all statistical procedures using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

3. Results

About half the sample lived within 3 miles of their school and most attended a school in a suburb (Table 2). A higher proportion of middle school respondents had strong PE or any PA state laws compared to those in high school (Table 2). The scores for the school neighborhood factors and SES were normally distributed and similar between the middle and high school respondents (Table 2).

ATS was low (about 30%) for both school levels (Table 2) and among high school respondents there was a gender difference, with a higher prevalence of ATS in males (17%) than females (12%) (data not shown). School-time PA was significantly higher among middle school respondents (Table 2) and among males compared to females in middle school (mean in males: 2.3; females: 2.0) or high school (mean in males: 1.9; females: 1.5) (data not shown). According to the estimated MVPA min/week, all respondents met the minimum recommended 60 min/day of MVPA (*Physical Activity Guidelines for Americans*, 2018). However, MVPA was significantly higher among middle school respondents than those in high school during school-related, non-school, and weekend times, as well as overall; there were no gender differences (Fig. 1).

Adjusted models showed significant associations between the state laws and school-time PA only among high school respondents: Strong PE time requirement B (SE) = 0.27 (0.11), $p = 0.02$; any PA time requirement B (SE) = 0.34 (0.10), $p = 0.0003$ (Table 3; full model in Appendix Table A). Further, the adjusted models for estimated MVPA min/week showed that high school respondents with any PA time requirement had about 7.5 min/wk. more of school-related MVPA than those with no such requirement (Table 4; full model in Appendix Table D). Neither state law was associated with estimated total MVPA or any of the middle school respondent's PA outcomes (Tables 3 and 4).

For the school neighborhood factors, one association was statistically significant (i.e., between neighborhood commuting time and ATS) among the high school respondents and no associations were significant for those in middle school (Tables 3 and 4). Adjusted models showed that compared to high school respondents who attended schools in neighborhoods with longer commutes (lowest tertile), those who attended schools in neighborhoods with shorter commutes (highest tertile) were less likely to report ATS (OR = 0.37, 95% CI: 0.18–0.73) (Table 3; full model in Appendix Table B). They also had about 8 min/wk. fewer of school-related MVPA (Table 4; full models in Appendix

Table 2
Weighted characteristics of FLASHE (2014) public middle and high school adolescent sample.

	Middle school (n = 387)	High school (n = 591)	All (N = 978)
Socio-demographics			
Age, years, %*			
12–13	75.3	3.1	30.7
14–15	23.8	37.5	32.3
16–17	0.9	59.4	37.1
Female, %	49.6	49.3	49.4
Race/ethnicity, %			
Non-Hispanic white	52.4	55.3	54.2
Non-Hispanic black	14.3	13.5	13.8
Hispanic	16.2	18.9	17.9
Other	17.2	12.3	14.2
Parent highest education, %			
College degree or higher	44.1	47.7	46.3
Some college, no degree	35.2	37.6	36.7
High school/GED or less	20.8	14.7	17.0
Home to school distance, miles, %*			
< 1	20.7	13.1	16.0
1 to <2	19.4	23.1	21.7
2 to <3	18.1	15.2	16.3
≥ 3	41.8	48.6	46.0
Self-report physical activity			
Active transport to/from school, % yes	29.1	28.7	28.9
School-time PA, mean (SE) (range: 0–5)*	2.2 (0.1)	1.7 (0.1)	1.9 (0.04)
State laws			
PE time requirement, %*			
Strong (score: 3–5)	35.4	26.5	29.9
Weak (score: 1–2)	64.6	73.5	70.1
PA time requirement, %*			
Any (score: 1–5)	59.1	48.9	52.8
None (score: 0)	40.9	51.1	47.2
School neighborhood			
Urban-rural location, %			
City	26.2	32.7	30.2
Suburb	46.4	41.0	43.0
Town	10.9	11.4	11.2
Rural	16.5	14.9	15.5
Density, mean (SE)	−0.2 (0.0)	−0.1 (0.0)	−0.1 (0.0)
Neighborhood age, mean (SE)	−0.2 (0.1)	−0.1 (0.0)	−0.1 (0.0)
Commute time, mean (SE)	−0.1 (0.1)	0.03 (0.0)	−0.01 (0.0)
Socioeconomic status, mean (SE)	0.2 (0.1)	0.2 (0.0)	0.2 (0.0)
Psychosocial scores, mean (SE) (range: 1–5)[a]			
Social support*	3.9 (0.1)	3.7 (0.1)	3.8 (0.0)
Social norms*	3.6 (0.1)	3.5 (0.1)	3.5 (0.0)
Self-efficacy	3.9 (0.1)	3.8 (0.1)	3.9 (0.0)
Barriers	2.3 (0.1)	2.4 (0.0)	2.3 (0.0)
Attitudes	3.9 (0.0)	3.9 (0.0)	3.9 (0.0)
Autonomous motivation	3.9 (0.1)	3.9 (0.0)	3.9 (0.0)
Controlled motivation	2.8 (0.1)	2.7 (0.0)	2.8 (0.0)

Notes: FLASHE = Family Life, Activity, Sun, Health, and Eating Study; GED = General Educational Development; MVPA = moderate to vigorous physical activity; PA = physical activity; PE = physical education.

* Significant differences between middle and high school respondents ($p < 0.05$).

[a] Responses ranged from 1 = 'strongly disagree' to 5 = 'strongly agree'.

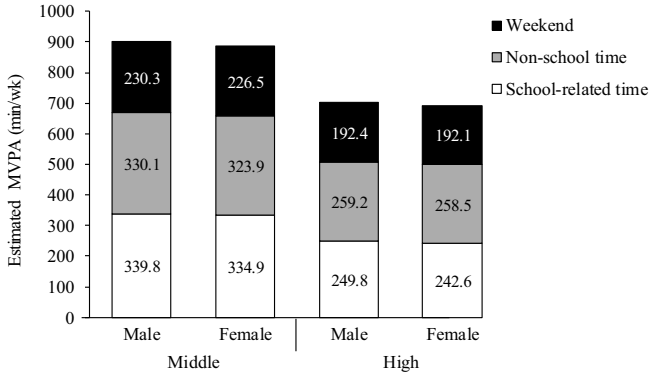

Fig. 1. Estimated minutes per week of moderate-to-vigorous physical activity (MVPA) during weekends, non-school time, and school-related time (active travel to/from school and school-time PA combined) among middle (n = 387) and high school (n = 591) FLASHE (2014) respondents. Differences between middle and high school respondents for each time context are significant ($p < 0.0001$).

Table D). There were no significant school neighborhood correlates of estimated total MVPA for either middle or high school respondents (Table 4; full models in Appendix Tables C and D).

Finally, the interaction analyses found no significant moderating effects of school neighborhood SES on the associations between the school contextual factors and any of the PA outcomes (all interaction terms $p > 0.05$) (data not shown).

4. Discussion

This is one of the first studies to examine the contributions of school contextual factors (state laws and neighborhood environment) on multiple PA outcomes among a national adolescent sample. Findings showed that among high school respondents, strong PE and any PA state laws were related to higher self-report school-time PA, and short commute time in the school neighborhood was related to lower self-report ATS. These effects were independent of individual and psychosocial factors, as well as school urban-rural location. The results were similar with the high school respondents' estimated school-related MVPA, thereby validating the results of the self-report PA measures. School neighborhood SES did not moderate any of the associations between the school contextual factors and PA outcomes. Further, none of the school contextual factors were related to estimated total MVPA, potentially due to the lack of specificity of total MVPA, which included PA during and beyond school hours.

Past studies have reported positive associations between state laws and youth PA (e.g., higher PA in PE class and higher total MVPA) (Cawley et al., 2007a; Hood et al., 2014; Cawley et al., 2007b). In the present study, state laws for PA and PE were weaker for high school respondents than those in middle school, consistent with past research (Perna et al., 2012). Yet, these laws were significantly related to higher school-time PA and estimated school-related MVPA only among those in high school. This finding contrasts those of a different study that found a significant association among the middle but not high school group (Perna et al., 2012). However, our findings are not directly comparable to that study given analyses were performed at different levels (school-level vs. individual-level) and focused on different outcomes (PE time vs. school-time PA).

One possible reason that the state laws were related to PA only among the high school respondents is that the addition of PA state laws augmented the effect of PE state laws on high school respondents' school-time PA. This finding may also be explained by other policies or practices at the district-level not measured in our study. That is, despite having state laws, school districts can make decisions regarding allocation of resources or use of alternatives to PE (e.g., waivers or exemptions) that can alter PA/PE opportunities during school. In the 2014 CLASS dataset, state laws that allowed substitutions of other activities (e.g., sports) for PE were more common for high schools than middle schools (https://class.cancer.gov). However, middle schools are more likely than high schools to have policies that allow excused absences from PE for instructional or test preparation (*Results from the School*

Table 3
Multivariate associations[a] of state laws and school neighborhood factors with self-reported active transport to/from school[b] and self-reported school-time physical activity[c], stratified by school level (FLASHE, 2014).

	Active transport to/from school				School-time physical activity					
	Middle school (n = 387)		High school (n = 591)		Middle school (n = 387)			High school (n = 591)		
	OR	95% CI	OR	95% CI	B	SE	*p*	B	SE	*p*
State laws										
Strong PE time requirement (ref = weak)	1.12	0.55–2.30	1.23	0.70–2.16	0.15	0.14	0.28	**0.27**	**0.11**	**0.02**
Any PA time requirement (ref = none)	1.07	0.55–2.11	0.99	0.61–1.59	0.14	0.14	0.31	**0.34**	**0.10**	**0.0003**
School neighborhood										
Density (ref = lowest tertile)										
Medium	0.97	0.43–2.19	0.90	0.47–1.69	−0.06	0.16	0.70	0.02	0.12	0.88
High (most dense)	1.55	0.67–3.60	1.44	0.67–3.09	0.32	0.18	0.07	0.02	0.15	0.88
Neighborhood age (ref = lowest tertile)										
Medium	1.30	0.60–2.82	0.68	0.37–1.25	−0.003	0.15	0.98	−0.17	0.12	0.16
High (oldest)	1.20	0.52–2.75	1.49	0.82–2.73	0.11	0.14	0.45	0.05	0.12	0.67
Commute time (ref = lowest tertile)										
Medium	1.49	0.71–3.11	0.95	0.55–1.65	−0.001	0.15	0.99	0.02	0.12	0.88
High (shorter commutes)	1.32	0.56–3.07	**0.37**	**0.18–0.73**	−0.09	0.17	0.58	−0.11	0.14	0.43
SES (ref = lowest tertile)										
Medium	1.28	0.60–2.72	1.51	0.81–2.82	−0.01	0.15	0.94	0.06	0.13	0.65
High	1.46	0.60–3.56	1.12	0.53–2.37	0.02	0.17	0.91	−0.09	0.13	0.49

Notes: **Bold** values are statistically significant. FLASHE = Family Life, Activity, Sun, Health, and Eating; GED = General Educational Development; MVPA = moderate to vigorous physical activity; PA = physical activity; PE = physical education; SES = socioeconomic status.

[a] Models were weighted and adjusted for adolescent age, gender, race/ethnicity, parent education, distance between home and school, school urban-rural location, social support, social norms, self-efficacy, barriers, attitudes, autonomous motivation, and controlled motivation.

[b] Walked or bicycled to/from school at least 1 day in the past week.

[c] Average frequency of PA during PE, breaks/study hall, or lunch break in the past week.

Table 4
Multivariate associations[a] of state laws and school neighborhood factors with estimated MVPA min/week, stratified by school level (FLASHE, 2014).

	School-related MVPA[b]						Total MVPA					
	Middle school (n = 387)			High school (n = 591)			Middle school (n = 387)			High school (n = 591)		
	B	SE	*p*	B	SE	*p*	B	SE	*p*	B	SE	*p*
State laws												
Strong PE time requirement (ref = weak)	4.49	5.64	0.43	4.52	3.28	0.17	7.34	8.80	0.41	4.36	8.19	0.60
Any PA time requirement (ref = none)	5.01	5.13	0.33	**7.53**	**2.76**	**0.01**	−2.02	7.92	0.80	4.31	6.97	0.54
School neighborhood												
Density (ref = lowest tertile)												
Medium	−0.97	6.06	0.87	3.74	3.58	0.30	−9.03	9.45	0.34	0.61	9.53	0.95
High (most dense)	12.43	7.35	0.09	4.43	4.41	0.32	−0.08	12.80	0.99	5.48	12.03	0.65
Neighborhood age (ref = lowest tertile)												
Medium	4.95	6.16	0.42	−1.81	3.41	0.60	9.40	9.76	0.34	1.22	8.95	0.89
High (oldest)	2.90	6.16	0.64	6.99	3.80	0.07	3.99	9.87	0.69	10.93	9.57	0.25
Commute time (ref = lowest tertile)												
Medium	2.81	6.12	0.65	−1.23	3.32	0.71	10.50	10.01	0.30	1.86	8.58	0.83
High (shorter commutes)	−0.06	6.89	0.99	**−8.13**	**3.91**	**0.04**	3.17	12.03	0.79	−4.96	10.59	0.64
SES (ref = low tertile)												
Medium	−2.60	6.19	0.67	4.64	3.55	0.19	−4.30	10.74	0.69	−2.75	9.09	0.76
High	2.40	6.72	0.72	−0.14	4.44	0.98	−4.21	10.73	0.70	−9.06	11.33	0.42

Notes: **Bold** values are statistically significant. FLASHE = Family Life, Activity, Sun, Health, and Eating; MVPA = moderate to vigorous physical activity; PA = physical activity; PE = physical education; SES = socioeconomic status.

[a] Models were weighted and adjusted for adolescent age, gender, race/ethnicity, parent education, distance between home and school, school urban-rural location, social support, social norms, self-efficacy, barriers, attitudes, autonomous motivation, and controlled motivation.

[b] Sum of estimated min/wk. of active transport to/from school and school-time PA.

Health Policies and Practices Study 2014, 2015), suggesting an interplay between local school policy and state law.

Further, contrary to our expectation that policies may be related to PA beyond school hours, we found no associations between the state laws and ATS or estimated total MVPA. However, CLASS does not capture laws related to safe routes to school, which may affect ATS more so than laws related to school PA.

Overall, this is one of the first studies to test and find an association between school neighborhood commute times and adolescent PA. Shorter commute times in the neighborhood may represent mixed land-use and level of urbanization (Craig et al., 2002) and are related to higher cardiorespiratory fitness (Hoehner et al., 2011) and more time for PA among adults (Christian, 2012). Contrary to this evidence, our results showed short commute times in the school neighborhood were related to lower ATS among high school adolescents. However, our finding is in line with two other studies (Hobin et al., 2012; Van Dyck et al., 2009) showing school neighborhood factors such as land use mix and walkability are related to lower adolescent PA. This suggests that evidence of neighborhood effects on PA may vary across age groups and settings (school vs. home). To better understand the unexpected inverse association between short commute times and ATS, we need additional information about the school environment (e.g., traffic speeds, street connectivity, and parent perceptions of safety (Wong et al., 2011; Christian, 2012; *Commuting Departure Time and Trip Time*, 2013; Kerr et al., 2006)) and other individual- or family-level variables that may be confounding this relationship.

Finally, although previous work (Institute of Medicine, 2013; Hood et al., 2014; Kerr et al., 2006) suggests possible interactions between neighborhood SES and state laws/built environment factors, we found no evidence of such interactions. School neighborhood SES also did not have any main effects with any of our PA outcomes. It is possible that unmeasured SES variables at a different level (individual, family, or school) are stronger predictors. SES at various levels are distinct constructs that can have independent effects on adolescent health (Janssen et al., 2006; Diez Roux et al., 2002).

4.1. Strengths and limitations

A key strength of this study is that it used a range of variables across levels of the ecologic framework that are often limited in most datasets, especially school neighborhood and policy variables. The large sample size allowed us to conduct stratified analyses by school level. We examined associations at the national level, which provided greater heterogeneity in population, policy, and geographic characteristics than would be obtained from a study from a single community.

One of the limitations of this study is the potential for neighborhood self-selection. Parents supportive of ATS may select to live in neighborhoods within walking distance of their child's school and those supportive of school PA may select schools that provide sports, PE, etc. Although studies with adults show the built environment is related to PA even after controlling for resident travel attitudes and neighborhood preferences (Handy et al., 2006), the effects of parent neighborhood self-selection on their child's PA are not known. In addition, the overall sample had high parent education levels and thus, the sample may not be socioeconomically representative of the national population.

Despite using a similar method to identify and compute the neighborhood factors as described in a study from Texas (Hoehner et al., 2011), the factors that emerged in FLASHE differed from that study. The Texas study identified a “traditional core” factor that included both older neighborhoods and short commute times, whereas these two characteristics emerged as separate factors in FLASHE. This difference is due in part to variations in environmental characteristics at different geographic levels (e.g., single state vs. national). As such, our findings cannot be directly compared to those of the Texas study.

Further, the commuting time variable was based on duration of the commute and did not specify mode. Adolescents may use passive commuting modes such as driving or public transit. The lack of data on alternative commuting modes to school limited our ability to control for these variables.

To better understand the effects of the state laws, we need additional information on policies and practices (e.g., PE exemptions) at the district- and school-levels. Finally, due to the cross-sectional nature of the analyses, our results cannot infer causality.

5. Conclusions

Our results showed evidence for domain- (school-time/transport) and population- (high school) specific school contextual correlates of

adolescent PA, accounting for individual and psychosocial factors. Although the magnitude of the associations of the state laws and school neighborhood variables with PA were modest, this was expected. More distal (contextual) variables often have weaker associations with PA compared to more proximal variables such as individual or psychosocial factors (Giles-Corti and Donovan, 2002). As such, having policies and school environments that support PA are necessary but insufficient to promote adolescent school-related PA. Our sample was highly active per their estimated total MVPA minutes, thus additional variables outside the school context may have a greater influence on PA. Multilevel approaches that target individual, psychosocial, and contextual factors can contribute to promoting adolescent PA and health.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2019.100835.

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