Neighborhood Food Environment and Physical Activity Among U.S. Adolescents

Ashleigh M. Johnson, MPH,[1] Erin E. Dooley, MS,[1] Leigh Ann Ganzar, MPH,[1]
Christine E. Jovanovic, MPH,[1] Kathryn M. Janda, MPH,[1] Deborah Salvo, PhD[2]

Introduction: Few U.S. adolescents meet physical activity guidelines. Although several neighborhood characteristics influence physical activity, the role of food-related features as potential drivers of adolescent physical activity remains understudied. Using representative U.S. data, authors examined the effect of the neighborhood food environment on adolescents' out-of-school physical activity.

Methods: The Family Life, Activity, Sun, Health, and Eating (FLASHE) study was conducted in 2014. Secondary data analysis occurred in 2018. Multinomial logistic regression models examined associations between neighborhood availability of (1) convenience store; (2) supermarket; (3) farmer's market; (4) fast food; (5) non−fast food restaurant and adolescent out-of-school physical activity (tertile-based, low as referent). An additional association between a total aggregate neighborhood food environment score was assessed.

Results: Final analytic sample was 1,384 adolescents (mean age=14.5 years, SD=1.6). Controlling for free/reduced-price lunch, age, sex, race/ethnicity, and neighborhood physical activity and social environments, the aggregate food environment score was significantly associated with high physical activity (versus low tertile; OR=1.2, 95% CI=1.1, 1.3). Most individual categories of food retail outlets were significantly and directly associated with out-of-school moderate- to vigorous-intensity physical activity in the single food environment variable models. However, when fully adjusting for all food retail outlet categories plus confounders, they were no longer significant.

Conclusions: The availability of a diverse combination of retail food destinations within walking distance from home may provide opportunities for adolescents to achieve more physical activity, likely because of transport-based physical activity. Pending future research, these findings suggest that the role of the food environment on health extends beyond its influence on dietary behaviors to other health behaviors like physical activity.
Am J Prev Med 2019;57(1):24−31. © 2019 American Journal of Preventive Medicine. Published by Elsevier Inc. All rights reserved.

INTRODUCTION

Physical activity has numerous health benefits for adolescents, including improved cardiovascular fitness and reduced risk of anxiety, depression, high blood pressure, type 2 diabetes, cancer, and heart disease.[1] The U.S. Physical Activity Guidelines recommend at least 60 daily minutes of moderate- to vigorous-intensity aerobic physical activity (MVPA) for adolescents.[1] Nearly 73% of U.S. adolescents do not meet guidelines, and 14.3% of students report no physical activity participation of any kind during the week.[2]

Several factors at multiple levels, ranging from the individual, interpersonal, social, environmental, and

24   Am J Prev Med 2019;57(1):24−31

policy-based, have been identified as correlates or determinants of physical activity. In terms of the built environment, walkability and nonresidential land use concentrations are directly associated with physical activity.[3−5] However, most built environment and physical activity research to date has focused on adults, with less evidence for adolescents.[6] Among the few adolescent studies, the predominant focus has been on the role of neighborhood infrastructure for leisure-time physical activity (e.g., recreational/fitness opportunities).[7] The studies that have examined the role of neighborhood destinations on adolescent physical activity have used overall destination measures, assuming that all destinations matter equally for physical activity.[7−9] A critical destination, however, to achieve livable, walkable, and vibrant communities with high foot traffic are food retail outlets.[10]

Adolescence is a life stage in which leisure-time physical activity decreases and autonomy increases.[11−13] Therefore, transport-related physical activity, like walking to destinations, may represent a good strategy for promoting activity among adolescents. Food retail outlet availability is known to promote walking among adults,[10] and given adolescents' limited access to motorized mobility options (driving), there is potential for an effect on adolescent physical activity as well. Most studies to date have only examined the effect of the food neighborhood environment on dietary behaviors.[14−16]

The goal of this study is to examine the effect of the home neighborhood food environment on U.S. adolescents' out-of-school physical activity using nationally representative data. Given the known differences of the role of other built environment features on physical activity by sex,[17] effect modification by sex is also examined.[18]

METHODS

Study Population

This study used secondary data from the Family Life, Activity, Sun, Health, and Eating (FLASHE) Study, a 2014 (April−October) cross-sectional national survey developed by the National Cancer Institute to examine correlates of physical activity, diet, and other cancer preventive behaviors among parent−adolescent dyads.[19] The FLASHE sample was selected to be similar to the U.S. population in terms of parent sex, household income, household size, race/ethnicity, age, and Census division. Parental participants were eligible if they were aged >18 years, lived with at least one child between the ages of 12 and 17 years for >50% of the time, and agreed to be contacted for participation. Parents were recruited through the Ipsos Consumer Opinion panel. Adolescents were eligible if they were between ages 12 and 17 years, and lived in that household for >50% of the time. If more than one adolescent was eligible within a household, one was randomly selected. Of 5,027 dyads invited, 1,945 accepted participation

(38.7% response rate). More information on the FLASHE study is available elsewhere.[20] Approval of data collection materials and procedures was provided by the U.S. Government's Office of Management and Budget, National Cancer Institute's Special Studies IRB, and Westat's IRB.

Measures

The primary outcome variable for this secondary analysis was adolescent weekly minutes of out-of-school MVPA, a measure of total self-reported minutes accrued out of school and on the weekend. The variable was derived via the validated Youth Activity Profile.[21] For this analysis, weekly minutes of MVPA were categorized as tertiles of low, medium, and high physical activity.

The primary exposure was the presence of food retail within walking distance of the home (i.e. neighborhood food environment; parental self-report). Parents were asked, *Think about your neighborhood, which is the local area around your home, within a 10-15 minute walk in any direction. Which of the following do you have in your neighborhood?* Five food retail items were measured: (1) convenience/corner store/small grocery store/bodega; (2) supermarket (or midsize grocery store); (3) fruit/vegetable market/farmer's market/co-op/community-supported agriculture; (4) fast-food restaurant; and (5) non−fast-food restaurant. For this analysis, answers were dichotomized as *yes/no* response options and an aggregate neighborhood food environment score was calculated as the total number of categories indicated (range, 0−5). All neighborhood food environment questions were sourced from the Neighborhood Environment Walkability Scale for Youth (NEWS-Y), which are valid and reliable measures for these constructs.[9]

The following available self-report variables were included in the analysis as they may act as confounders: receiving free or reduced-price lunch; adolescent age (years); race/ethnicity (Hispanic, non-Hispanic black/African American, non-Hispanic white, and other); neighborhood physical activity environment; and neighborhood social environment. Free or reduced-price school lunch, neighborhood physical activity environment, and neighborhood social environment were assessed via parent self-report. For free or reduced-price school lunch, parents were asked, *Does {TEEN} currently receive free or reduced price lunch at school?* This variable is used as a proxy for SES, as eligibility is for those with an annual household income ≤185% of the federal poverty level, equating to a yearly household income of $44,123 in 2014.[22] For this analysis, the neighborhood physical activity environment and neighborhood social environment variables were constructed as aggregate scores of NEWS-Y[9] and National Survey of Children's Health[23] items, respectively, each based on a 4-point Likert-type scale of agreement. Neighborhood physical activity environment included four items on the availability of shops and transit stops within walking distance, sidewalk coverage in the neighborhood, and the availability of free or low-cost recreation facilities in the neighborhood. The neighborhood social environment variable included three items on community trust, social support, and social disorder in the neighborhood.

Statistical Analysis

Analyses were conducted in May 2018. Descriptive statistics including prevalences and means with SDs were calculated for sociodemographic variables. Differences between sexes on sociodemographic

characteristics were assessed using *t*-test for continuous variables and chi-square test for categorical variables.

Multinomial logistic regression models were run to examine the association between the neighborhood food environment and out-of-school physical activity, using the lowest tertile of weekly minutes of MVPA as reference. The unadjusted relation between individual categories of food retail outlets and the aggregate neighborhood food environment score with out-of-school physical activity were assessed with bivariate models. Next, a series of multivariate models were run to test the association between the individual categories of food retail outlets and out-of-school MVPA, and between the aggregate neighborhood food environment score and the outcome. Partially adjusted models (single neighborhood food environment variable models) included single categories of food retail establishments as the independent variable, plus confounders. Also, a model testing the effect of the aggregate food environment variable, while adjusting for confounders, was run. After performing several collinearity diagnostics, including examination of the correlation coefficient matrix, variance inflation factors (<10), conditional indices, and associated proportions of variance, it was determined that a final fully adjusted model (i.e., mutually adjusted for all individual food retail outlet variables, plus confounders) could be run. This final model was used to determine if one or more single types of food retail establishments were significantly associated with out-of-school physical activity after adjusting for all other food retail sources and, thus, were acting as the main drivers of any association observed between the aggregate neighborhood food environment score and the physical activity outcome measure. Effect modification (interaction) by sex was assessed using the likelihood ratio test. Main effects and interaction significance was set at *p*<0.05. Analyses were performed using Stata, version 14.2.

RESULTS

The final analytic sample included 1,384 dyads. The adolescent sample had a mean age of 14.5 years (SD=1.6), was 51.2% female, and 65.0% were non-Hispanic white (Table 1). Thirty percent participated in free and

reduced-price lunch. Adolescents were similarly distributed across males and females in age, race/ethnicity, and free and reduced-price lunch status (*p*>0.05).

The sample had an average aggregate neighborhood food environment score of 2.62 (SD=1.77, range, 0−5), with 40.1% reporting the presence of four to five food environment categories within walking distance (Table 2). The most reported food outlet category was convenience stores, with 69.5% reporting at least one convenience store within walking distance from home. This was followed by the presence of fast-food restaurants (58.2%); non−fast-food restaurants (50.1%); supermarkets (48.3%); and farmer's markets (17.2%). There were no significant differences by sex.

Adolescents reported an average of 498.6 (SD=85.6) weekly minutes of out-of-school MVPA. The lowest tertile of physical activity ranged from 249.1 to 468.2 minutes/week, the medium tertile ranged from 468.7 to 541.9 minutes/week, and the highest tertile ranged from 550.4 to 642.1 minutes/week (Table 3). There were no differences by sex.

The results of the partially and fully adjusted associations between the neighborhood food environment and adolescent out-of-school MVPA are shown in Figure 1 (unadjusted estimates are in Appendix Table 1, available online). There was no evidence of effect modification by sex (likelihood ratio test: chi-square=1.52, *p*=0.22); thus, reported findings are of the overall sample. In the adjusted models, sex was included as a covariate.

When assessing the effect of the five individual categories of food retail outlets on adolescent out-of-school physical activity using single independent variable models (i.e., adjusted for covariates, but not mutually adjusted for the other studied single types of food retail outlets), all but farmer's markets (OR=1.38, 95% CI=0.87, 2.19) were

Table 1. FLASHE Study Teen Participant Characteristics

Characteristics	Total sample, % (*n*) (N=1,384)	Male, % (*n*) (*n*=676)	Female, % (*n*) (*n*=708)	*p*-value for difference by sex
Age, years				0.44
12−13	33.31 (461)	32.54 (220)	34.04 (241)	
14−15	34.03 (471)	33.14 (224)	34.89 (247)	
16−17	32.66 (452)	34.32 (232)	31.07 (220)	
Race/ethnicity				0.55
Hispanic	9.83 (136)	9.76 (66)	9.89 (70)	
Non-Hispanic black or African American	16.26 (225)	17.46 (118)	15.11 (107)	
Non-Hispanic white	64.96 (899)	63.31 (428)	66.53 (471)	
Non-Hispanic other	8.96 (124)	9.47 (64)	8.47 (60)	
Free and reduced-price lunch status				0.13
Yes	30.20 (418)	32.10 (217)	28.39 (201)	

FLASHE, Family Life, Activity, Sun, Health, and Eating.

Table 2. FLASHE Study Frequency of Neighborhood Food Environment

Home neighborhood food environment variable	Total sample, % (*n*) (N=1,384)	Male, % (*n*) (n=676)	Female, % (*n*) (n=708)	*p*-value for difference by sex
Aggregate neighborhood food environment score[a]				0.67
0−1 food aggregate score	31.07 (430)	29.73 (201)	32.34 (229)	
2−3 food aggregate score	28.83 (399)	28.40 (192)	29.24 (207)	
4−5 food aggregate score	40.10 (555)	41.86 (283)	38.42 (272)	
Presence of[b]				
Supermarket	48.30 (667)	49.48 (334)	47.17 (333)	0.39
Non−fast food restaurant	50.07 (692)	50.37 (340)	49.79 (352)	0.83
Fast food restaurant	58.21 (805)	57.69 (390)	58.70 (415)	0.70
Farmer's market[c]	17.20 (237)	16.15 (109)	18.21 (128)	0.31
Convenience stores	69.49 (961)	69.97 (473)	69.02 (488)	0.70

[a]Aggregate score is total continuous score of Convenience store + Supermarket + Fruit/vegetable market/Farmer's market/co-op/community-supported agriculture + Fast food restaurant + Non−fast food restaurant, range 0−5.
[b]Dichotomous (reported/not reported).
[c]Includes fruit/vegetable market, farmer's market, co-op, and community-supported agriculture.
FLASHE, Family Life, Activity, Sun, Health, and Eating.

significantly associated with being in the highest tertile of out-of-school MVPA. Convenience stores showed the strongest association with out-of-school MVPA (OR=1.76, 95% CI=1.13, 2.73). No significant associations were observed between any of the individual food retail outlet categories and the medium tertile of out-of-school physical activity (versus lower tertile), suggesting a non-linear relationship. In the final fully adjusted model (including all the individual categories of food retail outlets plus potential confounders), the associations between all specific food retail outlet categories and adolescent out-of-school MVPA were no longer statistically significant at the *p*<0.05 level. However, the same pattern observed in the single food environment variable models emerged, with convenience stores having the strongest association with out-of-school MVPA relative to the other studied independent variables (OR=1.46, 95% CI=0.90, 2.38).

The aggregate neighborhood food environment score, a measure of the total presence of convenience stores, supermarkets, farmer's markets, fast-food restaurants, and non−fast-food restaurants, was significantly associated with adolescents being in the highest tertile of out-of-school physical activity after adjusting for all confounders (versus lower tertile; OR=1.20, 95% CI=1.06, 1.33).
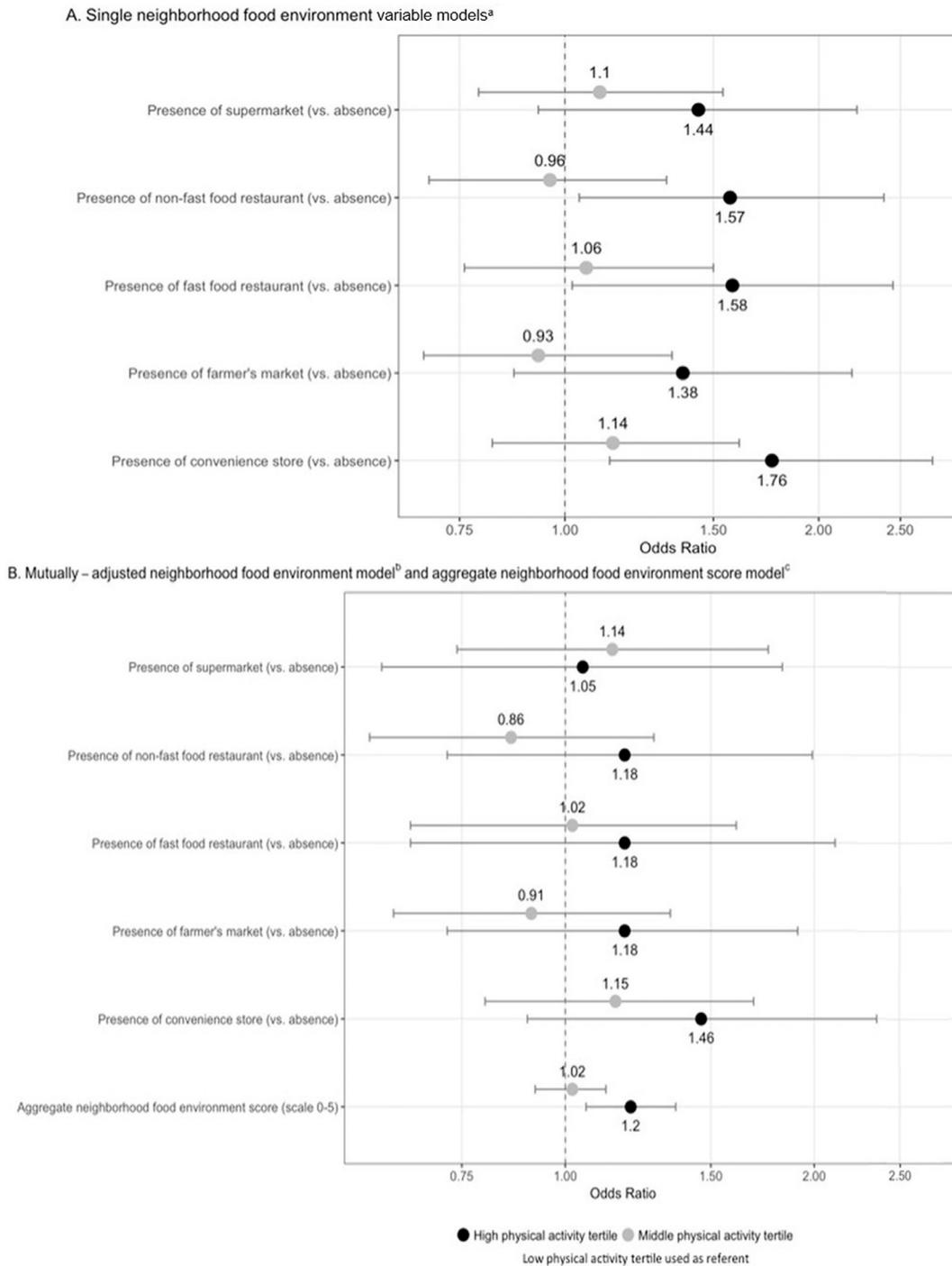
DISCUSSION

This study examined the association between the neighborhood food environment and out-of-school MVPA among a nationally representative sample of U.S. adolescents. The presence of a variety of neighborhood food retail options within walking distance from home (captured by the aggregate neighborhood food environment score) was significantly associated with higher out-of-school physical activity among adolescents. Out-of-school MVPA is likely reflective of active transportation (walking or cycling), supporting the availability of food retail destinations within walking distance as an opportunity to promote physical activity among adolescents. Sex did not modify the association between the neighborhood food environment and physical activity. This is a positive result, suggesting that supportive changes in the built environment to increase

Table 3. FLASHE Study Participant Self-Reported Out-of-School Physical Activity Levels in Minutes per Week

Physical activity levels (minutes/per week)	Total sample physical activity range (*n*) (N=1,384)	Male, physical activity range (*n*) (n=676)	Female, physical activity range (*n*) (n=708)	*p*-value for difference by sex
Category				0.74
Lowest tertile	249.09−468.17 (460)	249.09−468.17 (221)	249.09−468.17 (239)	
Medium tertile	468.73−541.91 (459)	468.73−541.91 (221)	468.73−541.91 (238)	
Highest tertile	550.43−642.06 (465)	550.43−642.06 (234)	550.43−642.06 (231)	

FLASHE, Family Life, Activity, Sun, Health, and Eating.

A. Single neighborhood food environment variable models[a]

B. Mutually – adjusted neighborhood food environment model[b] and aggregate neighborhood food environment score model[c]

● High physical activity tertile   ● Middle physical activity tertile
Low physical activity tertile used as referent

Figure 1. FLASHE Study: association between neighborhood food environment and adolescent out-of-school time physical activity levels.

[a]Single neighborhood food environment variable models (partially adjusted). Models include single neighborhood food environment exposure variable plus covariates (age, sex, race, SES, neighborhood physical activity environment, and neighborhood social environment).

[b]Mutually adjusted neighborhood food environment variables model. All store-specific neighborhood food environment exposure variables are mutually adjusted for each other as well as for covariates (age, sex, race, SES, neighborhood physical activity environment, and neighborhood social environments).

[c]Aggregate score is total continuous score of Supermarket + Non−fast food restaurant + Fast food restaurant + Fruit/vegetable market/Farmer's market/co-op/community-supported agriculture + Non−fast food restaurant + Convenience store, range 0−5. Adjusted for covariates (age, sex, race, SES, neighborhood physical activity environment, and neighborhood social environments).

FLASHE, Family Life, Activity, Sun, Health, and Eating.

access to key destinations, such as food outlets, are likely to positively impact both boys and girls.

Among the individual measures of neighborhood food environment, convenience stores had the highest prevalence in the neighborhood and were shown to have the strongest association with out-of-school physical activity. As nearly half of U.S. adolescents report visiting convenience stores weekly,[24] these findings suggest this is an important destination for active transportation in adolescents. Although this relationship implies that locating convenience stores within neighborhoods may increase physical activity among adolescents, the high availability of unhealthy options found in these stores may have a mitigating effect on the overall health benefit of physical activity.[25] Future research jointly examining the effects of convenience stores on dietary behaviors, physical activity, and weight-related outcomes is warranted. It is also worth noting that in the final, mutually adjusted model, no single category of food outlets (including convenience stores) retained statistical significance. This, together with the significant association observed between the aggregate neighborhood food environment score and out-of-school physical activity, suggests that having access to a variety of sources of food retail within walkable range may be more important for promoting physical activity among U.S. adolescents than focusing on increasing access to any single type of food retail store.

Although this study shows that convenience stores were most strongly associated with being in the highest tertile of physical activity for adolescents in the FLASHE study, there were additional associations of similar magnitude between other types of retail outlets and out-of-school MVPA among adolescents. These include supermarkets, fast-food restaurants, and non−fast-food restaurants. The similarity of effect sizes suggests that different food retail destinations (healthy versus unhealthy) may have a similar influence on out-of-school physical activity. This finding is corroborated by studies that found perceived length of time to walk to convenience stores, supermarkets, non−fast-food restaurants, and fast-food restaurants to be significantly associated with food and beverage purchasing, with those that perceive the shortest time duration having the highest purchasing.[26] Thus, it is plausible that adolescents with more food establishments within a 10−15-minute walk from home have increased physical activity due to active travel to these destinations. The results suggest that promoting the placement of a variety of retail food destinations that offer healthy options could support physical activity among adolescents while avoiding the disadvantage of increasing exposure to unhealthy foods. Future research should investigate food and beverage purchasing and transport-based physical activity in tandem to explore the potential health cost benefit within these two behaviors. Ideally, healthy behaviors can cluster such that adolescents would increase their physical activity, through active transportation, to destinations for healthy eating rather than to unhealthy food retail destinations.

This study has a number of strengths. It expands current knowledge by providing evidence on the importance of the neighborhood food environment for adolescent physical activity. The ability to examine out-of-school time separately from overall physical activity is a strength, as the use of these locations must generally occur during non-school hours. Using a measure of overall physical activity instead would have added noise to the results, as this would include in-school activity, more likely influenced by structured school days and state physical education mandates than by the neighborhood food environment.[27] Additionally, although there have been studies showing that type of commercial destinations that encourage walking and physical activity differ between adults and older adults,[28] this study is unique as it provides additional evidence on the types of destinations associated with adolescent physical activity. The use of a large, representative sample of U.S. adolescents provides external validity and the power to detect differences between the various retail establishments. These findings add evidence on the need to provide a variety of convenient places within walking distance from home as opportunities beyond the school setting for adolescent participation in physical activity.

Limitations

The limitations of this study must be noted. FLASHE was a cross-sectional study, limiting the ability to make causal inferences. There is also the possibility that other built environment features that are often associated with the presence of food establishments, like population density and connectivity, could be fully or partially responsible for higher physical activity levels in these types of neighborhoods.[3] The food environment represents only one aspect of the overall neighborhood context, which altogether influences physical activity and health behaviors at large.[29,30] The authors attempted to control for this by including both a measure of the neighborhood physical activity environment and one of the neighborhood social environment as covariates in the adjusted models. Additionally, the measure for physical activity is based on self-report. Although more prone to recall bias, it allows for distinguishing between types/domains of physical activity, which is impossible with device-based measures that provide minutes per week of overall physical activity. The authors were able to specifically use out-of-school MVPA as the outcome, thus focusing the

analysis on the portion of MVPA most likely to be related with the neighborhood food environment. However, this analysis was limited by the survey items available. A better outcome measure would have been out-of-school (i.e., excluding trips to and from school) transport-based physical activity. The current outcome measure includes leisure-time physical activity (i.e., sports and exercise) occurring out of school, which is unlikely to be influenced by the neighborhood food environment. Another limitation is that the neighborhood environment variables were reported by the parents and not the adolescents. Further, the use of self-report provides a perceived, rather than objective, measure of the neighborhood environment. However, FLASHE food and physical activity neighborhood items were derived from the NEWS-Y,[9] which is a reliable and valid measure of the built environment when compared with objective GIS measures.[31]

Future research should evaluate the best mix of retail food establishments to encourage physical activity in adolescents. There may be a minimum density of food retail outlets needed for adolescents to be more likely to engage in physical activity, as suggested by the apparently non-linear relations identified in the analysis. Additional research is also needed to understand the impact of proximity; total density; and diversity (entropy) of the retail food environment on physical activity, which may be important for overall health at the population level. Future studies should also incorporate GIS methods to better capture the geospatial neighborhood exposures of interest.

CONCLUSIONS

Significant declines in physical activity from childhood to adolescence support the investigation of various factors of influence for physical activity engagement among adolescents. This study suggests that the presence of food retail destinations within walking distance from home may provide opportunities for adolescents to achieve higher levels of physical activity. Future work using longitudinal research designs should further investigate the relation between the neighborhood food environment and adolescent physical activity by examining the roles of proximity, outlet density, and diversity, as well as the relative health cost benefit of food and beverage purchasing at and active transportation to neighborhood food retail outlets.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2019.01.008.

REFERENCES

1. HHS. 2008 physical activity guidelines for Americans: Be active, healthy, and happy! www.health.gov/paguidelines. Updated 2008. Accessed January 2018.
2. Centers for Disease Control and Prevention (CDC). Youth Risk Behavior Survey data. www.cdc.gov/yrbs. Updated 2018. Accessed January 16, 2019.
3. Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med*. 2003;25(2):80–91. https://doi.org/10.1207/S15324796ABM2502_03.
4. Sallis JF, Glanz K. The role of built environments in physical activity, eating, and obesity in childhood. *Future Child*. 2006;16(1):89–108. https://doi.org/10.1353/foc.2006.0009.
5. Sallis JF, Bowles HR, Bauman A, et al. Neighborhood environments and physical activity among adults in 11 countries. *Am J Prev Med*. 2009;36(6):484–490. https://doi.org/10.1016/j.amepre.2009.01.031.
6. Ferdinand AO, Sen B, Rahurkar S, Engler S, Menachemi N. The relationship between built environments and physical activity: a systematic review. *Am J Public Health*. 2012;102(10):e7–e13. https://doi.org/10.2105/AJPH.2012.300740.
7. Nicosia N, Datar A. Neighborhood environments and physical activity: a longitudinal study of adolescents in a natural experiment. *Am J Prev Med*. 2018;54(5):671–678. https://doi.org/10.1016/j.amepre.2018.01.030.
8. Panter JR, Jones AP, van Sluijs EM. Environmental determinants of active travel in youth: a review and framework for future research. *Int J Behav Nutr Phys Act*. 2008;5:34. https://doi.org/10.1186/1479-5868-5-34.
9. Rosenberg D, Ding D, Sallis JF, et al. Neighborhood Environment Walkability Scale for Youth (NEWS-Y): reliability and relationship with physical activity. *Prev Med*. 2009;49(2−3):213–218. https://doi.org/10.1016/j.ypmed.2009.07.011.
10. Sevtsuk A. Location and agglomeration: the distribution of retail and food businesses in dense urban environments. *J Plan Educ Res*. 2014;34(4):374–393. https://doi.org/10.1177/0739456X14550401.
11. Sprengeler O, Wirsik N, Hebestreit A, Herrmann D, Ahrens W. Domain-specific self-reported and objectively measured physical

activity in children. *Int J Environ Res Public Health*. 2017;14(3):242. https://doi.org/10.3390/ijerph14030242.

12. Carlson JA, Schipperijn J, Kerr J, et al. Locations of physical activity as assessed by GPS in young adolescents. *Pediatrics*. 2016;137(1): e20152430. https://doi.org/10.1542/peds.2015-2430.

13. Centers for Disease Control and Prevention (CDC). Physical activity levels among children aged 9−13 years—United States, 2002. *MMWR Morb Mortal Wkly Rep*. 2003;52(33):785−788.

14. Meyer KA, Boone-Heinonen J, Duffey KJ, et al. Combined measure of neighborhood food and physical activity environments and weight-related outcomes: the CARDIA study. *Health Place*. 2015;33:9−18. https://doi.org/10.1016/j.healthplace.2015.01.004.

15. Mejia N, Lightstone AS, Basurto-Davila R, Morales DM, Sturm R. Neighborhood food environment, diet, and obesity among Los Angeles county adults, 2011. *Prev Chronic Dis*. 2015;12:150078. https://doi.org/10.5888/pcd12.150078.

16. Rundle A, Neckerman KM, Freeman L, et al. Neighborhood food environment and walkability predict obesity in New York City. *Environ Health Perspect*. 2009;117(3):442−447. https://doi.org/10.1289/ehp.11590.

17. Garcia Bengoechea E, Spence JC, McGannon KR. Gender differences in perceived environmental correlates of physical activity. *Int J Behav Nutr Phys Act*. 2005;2:12. https://doi.org/10.1186/1479-5868-2-12.

18. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*. 2006;117(2):417−424. https://doi.org/10.1542/peds.2005-0058.

19. HHS, National Cancer Institute (NCI). 2014 family life, activity, sun, health and eating (FLASHE) survey data. Published 2014.

20. National Cancer Institute. Family life, activity, sun, health, and eating (FLASHE) study. https://cancercontrol.cancer.gov/brp/hbrb/flashe.html. Updated 2017. Accessed December 11, 2018.

21. Welk GJ, Saint-Maurice PF, Kim Y, et al. Understanding and interpreting error in physical activity data: insights from the FLASHE study. *Am J Prev Med*. 2017;52(6):836−838. https://doi.org/10.1016/j.amepre.2017.03.001.

22. U.S. Department of Agriculture. Income eligibility guidelines. *Fed Regist*. 2014;79(43):12647−12649. www.govinfo.gov/content/pkg/FR-2014-03-05/pdf/2014-04788.pdf. Accessed January 23, 2019.

23. Blumberg SJ, Olson L, Frankel MR, Osborn L, Srinath KP, Giambo P. Design and operation of the National Survey of Children's Health, 2003. *Vital Health Stat 1*. 2005(43):1−131.

24. Sanders-Jackson A, Parikh NM, Schleicher NC, Fortmann SP, Henriksen L. Convenience store visits by U.S. adolescents: rationale for healthier retail environments. *Health Place*. 2015;34:63−66. https://doi.org/10.1016/j.healthplace.2015.03.011.

25. Powell LM, Auld MC, Chaloupka FJ, O'Malley PM, Johnston LD. Associations between access to food stores and adolescent body mass index. *Am J Prev Med*. 2007;33(4)(suppl):S301−S307. https://doi.org/10.1016/j.amepre.2007.07.007.

26. Hearst MO, Pasch KE, Laska MN. Urban v. suburban perceptions of the neighbourhood food environment as correlates of adolescent food purchasing. *Public Health Nutr*. 2012;15(2):299−306. https://doi.org/10.1017/S1368980011002114.

27. National Association of Boards of Education. *Preventing Childhood Obesity: A School Health Policy Guide*. Published 2009.

28. Nathan A, Pereira G, Foster S, Hooper P, Saarloos D, Giles-Corti B. Access to commercial destinations within the neighbourhood and walking among Australian older adults. *Int J Behav Nutr Phys Act*. 2012;9:133. https://doi.org/10.1186/1479-5868-9-133.

29. Kwan M. The limits of the neighborhood effect: contextual uncertainties in geographic, environmental health, and social science research. *Ann Am Assoc Geogr*. 2018;108(6):1482−1490. https://doi.org/10.1080/24694452.2018.1453777.

30. Myers CA, Denstel KD, Broyles ST. The context of context: examining the associations between healthy and unhealthy measures of neighborhood food, physical activity, and social environments. *Prev Med*. 2016;93:21−26. https://doi.org/10.1016/j.ypmed.2016.09.009.

31. Adams MA, Ryan S, Kerr J, et al. Validation of the neighborhood environment walkability scale (NEWS) items using geographic information systems. *J Phys Act Health*. 2009;6(suppl 1):S113−S123. https://doi.org/10.1123/jpah.6.s1.s113.