THE UNIVERSITY of EDINBURGH

Edinburgh Research Explorer

Associations between neighborhood opportunity and Indicators of physical fitness for New York City public school youth

Citation for published version:
D'Agostino, EM, Zhao, AY, Zewdie, HY, Ogletree, SS, Messiah, SE, Armstrong, SC, Skinner, AC, Hipp, JA, Day, SE, Konty, KJ & Neshteruk, CD 2023, 'Associations between neighborhood opportunity and Indicators of physical fitness for New York City public school youth', *Childhood Obesity*.
https://doi.org/10.1089/chi.2023.0079

Digital Object Identifier (DOI):
10.1089/chi.2023.0079

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Childhood Obesity

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 03. Oct. 2024

Associations Between Neighborhood Opportunity and Indicators of Physical Fitness for New York City Public School Youth

Emily M. D'Agostino, DPH[1,2,3], Amy Y. Zhao, BSc[4*], Hiwot Y. Zewdie, MSc[5*], S. Scott Ogletree, PhD[6,7], Sarah E. Messiah, PhD[8,9], Sarah C. Armstrong, MD[2,3,5,10], Asheley C. Skinner, PhD[2,3], J. Aaron Hipp, PhD[6,7],Sophia E. Day, MA[11], Kevin J. Konty, PhD[11], Cody D. Neshteruk, PhD[2]

[1] Department of Orthopaedic Surgery, Duke University School of Medicine, Durham, NC
[2] Department of Population Health Sciences, Duke University School of Medicine, Durham, NC
[3] Duke Clinical Research Institute, Durham, NC
[4] Trinity College of Arts & Sciences, Duke University, Durham, NC
[5] Duke Global Health Institute, Duke University, Durham, NC
[6] Center for Geospatial Analytics, NC State University, Raleigh, NC
[7] Department of Parks, Recreation, and Tourism Management, NC State University, Raleigh, NC
[8] Department of Epidemiology, Human Genetics and Environmental Sciences, University of Texas Health Science Center School of Public Health, Houston, TX
[9] Center for Pediatric Population Health, Children's Health System of Texas and UTHealth School of Public Health, Dallas, TX
[10] Department of Pediatrics, Duke University School of Medicine, Durham, NC
[11] NYC Department of Health and Mental Hygiene, Office of School Health, New York, NY

*Co-second Authors

Corresponding Author

Emily M. D'Agostino, DPH, MS, MEd, MA
Department of Orthopaedic Surgery, Occupational Therapy Doctorate Division
Department of Population Health Sciences
Duke University School of Medicine
311 Trent Drive, 5244
Durham, NC 27710
Cell: (646) 853-1223
Email: emily.m.dagostino@duke.edu

Author Contributions

Emily D'Agostino, Amy Zhao and Hiwot Zewdie conceptualized the study. Emily D'Agostino performed the formal analysis. Amy Zhao, Hiwot Zewdie, and Emily D'Agostino wrote the original draft. Sophia Day and Kevin Konty curated the data and managed the dataset. Sophia Day, Kevin Konty, S. Scott Ogletree, Sarah Messiah, Sarah Armstrong, Asheley Skinner, Cody Neshteruk, and J. Aaron Hipp reviewed and edited the manuscript for important intellectual content.

Abstract

Background: Fewer than 1/4th of US children and adolescents meet physical activity guidelines, leading to health disparities that track into adulthood. Neighborhood opportunity may serve as a critical modifiable factor to improve fitness attainment and reduce these disparities. We drew data from the Child Opportunity Index to examine associations between neighborhood indicators of opportunity for physical activity and multiple fitness indicators among New York City public school youth.

Methods: Multilevel generalized linear mixed models were used to estimate overall and sex-stratified associations between neighborhood indicators (greenspace, healthy food, walkability, commute time) and indicators for physical fitness (curl-ups, push-ups, PACER, sit-and-reach) using the NYC FITNESSGRAM dataset.

Results: The analytic sample (n=299,839; median [IQR] age=16 [12-17]) was 50.1% female, 37.5% Hispanic, 26.2% non-Hispanic Black, and most (69.5%) qualified for free/reduced price school meals. Neighborhood indicators were positively associated with higher values of indicators for physical fitness. The strongest associations were observed between walkability and both BMI and PACER, and commute time with BMI, push-ups and PACER. For example, walkability had the greatest magnitude of effects for BMI and muscular strength and endurance (BMI: β: -0.75, 95% CI:-1.01,-0.49; PACER: β: 1.98, 95% CI:1.59,2.37), and particularly for girls compared to boys (BMI, girls: β: -0.91, 95% CI:-1.22,-0.66); BMI, boys: β: -0.56, 95% CI:-0.86,-0.25); PACER, girls: β: 2.11, 95% CI:1.68,2.54; push-ups, boys: β: 1.71, 95% CI:1.31,2.12).

Conclusion: Neighborhood indicators were associated with multiple measures of youth fitness. Continued research on neighborhood opportunity and youth fitness may better inform place-based public health interventions to reduce disparities.

Impact Statement

Neighborhood opportunity may serve as a critical modifiable factor to improve youth fitness attainment and reduce obesity and fitness disparities. We observed multiple positive associations between neighborhood indicators of opportunity for physical activity and indicators for physical fitness. Continued research on neighborhood opportunity and youth fitness can inform place-based public health interventions to reduce disparities.

Introduction

Less than 25% of children 6 to 17 years of age meet the national guidelines of at least 60 minutes of moderate-to-vigorous physical activity (PA) every day.[1] Low youth PA corresponds to low health-related physical fitness (a state reflecting one's ability to perform physical activity or exercise that is related to both present and future health), which strongly predicts cardiovascular disease risk in childhood, as well as cardiometabolic disease, some cancers, and all-cause mortality in adulthood.[2,3] Similar to PA, the percentage of youth who meet performance guidelines on health-related physical fitness tests (cardiorespiratory endurance, muscular strength, muscular endurance, flexibility and body composition) remains low, both in the United States and worldwide.[2-,4] For instance, in a study of New York City (NYC) youth, only 23% of public school youth meet performance standards.[4] Furthermore, disparities persist in youth physical fitness attainment by sex, with boys demonstrating stronger performance across fitness tests.[5,6] Youth fitness disparities predict persistent cardiovascular health inequities across the lifespan, indicating a need to identify factors that can improve youth fitness.[2-4] In NYC in particular, less than 1 in 4 public school youth in grades 4-12 meet the criteria for health-related fitness based on standardized fitness tests of aerobic capacity, muscular strength and endurance. Moreover, significant widening in sociodemographic disparities in fitness across student grade, sex, race and poverty has been observed over the last 10-15 years, particularly for girls, non-Hispanic black and Hispanic youth, youth living in high household and neighborhood poverty.[4]

Neighborhood contextual factors are strongly associated with youth PA and related cardiovascular health disparities. For instance, neighborhood walkability, traffic speed/volume, access/proximity to parks and recreation centers, land-use mix, and residential density have been associated with youth and adolescent PA.[7,8] Associations have also been found between

neighborhood walkability, sidewalk access, greenspace, mixed land-use, fast food proximity, and safety/crime and youth body mass index (BMI).[9,10,11,12] In NYC, neighborhood crime has been associated with lower PA duration among boys, while park access has been associated with higher frequency of PA among girls.[13] Additionally, land use mix, pedestrian-friendly streets, and quality of environment have been positively associated with PA among NYC minority youth.[14] Finally, low density of street trees and low neighborhood safety have been associated with higher prevalence of obesity among low-income NYC youth.[15]

Although this literature has largely focused on PA, BMI, or obesity as outcome measures, physical fitness is a more accurate proxy for youth cardiovascular health.[2] Studies examining neighborhood-youth fitness associations are limited, despite the importance of youth physical fitness as a key indicator of health and documented low achievement levels.[16] Limited work has examined neighborhood-youth fitness associations in primarily underserved (minority/low-income), and urban settings at a population level.[9-15] Furthermore, few neighborhood-health studies have examined multiple area-level features of the neighborhood environment. Considering the associations between multiple neighborhood factors and health can provide a more comprehensive assessment of this relationship.

The present analysis uses the Child Opportunity Index (COI), a measure of children's neighborhood opportunity, to examine associations between neighborhood indicators of opportunity for physical activity and multiple indicators of youth physical fitness. NYC represents a diverse, urban setting in which distinct neighborhood factors may impact youth fitness. We also draw from a large sample, and use a standardized, evidence-based measure of youth health-related fitness and multiple neighborhood indicators of opportunity for physical activity, and taking into account individual student home residence to estimate the

neighborhood-fitness relationship within largely minoritized populations. We aim to assess whether specific COI indictors are related to youth physical fitness, and if these associations vary across sex. These insights can ultimately inform the development of population-level strategies and built environment initiatives to reduce youth cardiovascular health disparities.

Methods

This cross-sectional analysis used data from two sources: (1) the COI, and (2) the NYC FITNESSGRAM. The COI is managed by the Heller School of Brandeis University and offers a measure of neighborhood-based conditions conducive to healthy child development.[18] The NYC FITNESSGRAM is managed by the NYC Department of Education and Department of Health and Mental Hygiene (DOHMH) and comprises individual-level annual fitness test and demographic data from approximately 860,000 youth (grades 4 – 12) enrolled in NYC public schools.[16] This study was classified as public health surveillance by the DOHMH Institutional Review Board and thus exempt from written informed consent.

Population

Data were collected during the 2016-2017 academic school year. For analytic efficiency, a random subset of 300,000 eligible youth served as the study sample for this analysis, representative of NYC FITNESSGRAM youth. Youth were randomly selected using PROC SURVEYSELECT in SAS 9.4. Inclusion criteria were those youth enrolled in a general education NYC public school in grades 4-12 during the 2016-2017 academic school year and with complete residential addresses in NYC and complete covariate and biologically plausible fitness data. Youth without matching census tracts for NYC were dropped from the analysis (n=161).

Exposure

The exposures of interest were youth neighborhood indicators of opportunity for physical activity, as measured by the COI. The COI comprises 29 census-tract level indicators across three domains: educational, health and environmental, and social and economic. Z-scores for each indicator were derived and averaged across each domain, then standardized across the surrounding metropolitan area to facilitate within-region comparisons.[18] COI data were linked with NYC FITNESSGRAM data based on individual student home address census tract.

Four indicators including greenspace, walkability, access to healthy foods, and commute duration were included in our analyses as neighborhood indicators of opportunity for physical activity based on existing literature demonstrating relevance to youth fitness-related outcomes.[19,20] Greenspace was measured as the inverse percent of impervious surface areas, such as roads or parking lots, defined using satellite imagery from the 2011 National Land Cover Database. Walkability was measured using 2010-2012 Environmental Protection walkability index, a weighted average of area-level features that predict walking trips: street intersection density, population center distance to nearest transit stop, and mix of employment types and occupied housing across an area. Access to healthy foods was measured as the percent of households in 2015 without a car located further than a half-mile from the nearest supermarket, derived from the USDA Food Access Research Atlas. Commute duration was measured as the percentage of workers older than 16 with a one-way commute time of greater than one hour, derived using 5-year estimates from the American Community Survey (2012-2017). Commute duration was considered a proxy for transportation vulnerability based on commute time used as an indicator for transportation access[21] and the documented association between transportation vulnerability and youth cardiovascular health.[22]

Outcomes

Indicators for youth physical fitness included BMI and fitness tests derived from the NYC FITNESSGRAM dataset.[15] Youth BMI was based on height and weight collected annually and converted to age- and sex-specific BMI percentiles in accordance with growth charts from the US Centers for Disease Control and Prevention (CDC).[23] Age in months was calculated from the measurement date and students' date of birth was drawn from school enrollment records. Extreme or biologically implausible values were identified for height, weight, weight-for-height, and BMI using CDC's age- and sex-specific criteria.

Fitness performance was based on the Cooper Institute's FitnessGram™, an evidence-based measure for youth physical fitness metrics demonstrating strong reliability and validity.[2] Fitness tests included muscular strength and endurance as measured by performance on push-up and curl-up assessments, aerobic capacity measured using the Progressive Aerobic Cardiovascular Endurance Run (PACER), and flexibility as measured by the sit-and-reach test. Push-ups are performed at a 90° elbow angle, and curl-ups are conducted with knees flexed and feet free; both are scored as the number completed. Both are completed without rest and set to a specified pace. The PACER is a multistage shuttle run where participants run back and forth (i.e., lap) in groups across a 20-meter course to a pace that increases incrementally after each minute. It was scored as the number of laps completed. PACER, push-ups and curl-ups were converted to age- and sex-specific percentiles.[24,25] Sit-and-reach was measured by recording the maximum reach of participants instructed to bend forward with their arms extended, while sitting with one leg bent and the other extended against a sit-and-reach box.

Covariates

Covariates included youth age in years (continuous), sex for unstratified models (binary: male/female), youth race/ethnicity (categorical: Hispanic, non-Hispanic Black, non-Hispanic white, Asian/Pacific Islander, and other/multiple races), household poverty status based on eligibility for free/reduced price school meals (binary: yes/no), and neighborhood poverty based on census tract level area poverty drawn from the American Community Survey and categorized as 0-<5%, 5-<10%, 10-<20%, 20-<30%, 30-<40%, and 40-100%.

Statistical Analysis

Descriptive statistics were derived for demographic and socioeconomic characteristics of the overall analytic population and by sex. Medians (interquartile ranges [IQR]) were derived for neighborhood indicators of opportunity for physical activity and youth indicators for physical fitness overall, and by sex.

To account for the level at which our exposures were aggregated (census tract), two-level generalized linear mixed models (GLMM), nested by census tract, were fit to estimate the association between continuous fitness-related neighborhood exposures and youth indicators for physical fitness. A variance covariance structure was specified with random intercepts for census tracts, and the identity link function was used in the GLMM. Unstratified models were adjusted for age, sex, race/ethnicity, and poverty. Next, models including an interaction term between sex and the opportunity indicator were run. If interaction terms were statistically significant, we examined effect modification by sex. Sex-stratified models were run adjusting for age, race/ethnicity, and both individual-level and neighborhood-level poverty. Alpha levels were set at 0.05.

All statistical analyses were conducted in SAS 9.4 (SAS Institute, Inc., Cary, NC).

Results

Descriptive Results

Youth resided across 2,131 census tracts in NYC (median youth per census tract: 119; IQR: 71-193). **Table 1** displays sociodemographic and fitness-related neighborhood COI characteristics of the analytic population, and stratified by sex. The median age was 16 years (IQR: 12-17), 50.1% of the sample was female, 37.5% identified as Hispanic, and 26.2% identified as non-Hispanic Black. Approximately 70% of the sample was eligible for free/reduced price school meals, and 28.7% and 23.6% were living in neighborhoods with 10-<20% and 20-<30% area poverty. The median (IQR) for each fitness-related neighborhood factor z-score were as follows: greenspace= -2.37 ([-2.56, -1.89), healthy food= 0.85 (0.85, 0.85), walkability= 1.17 (0.76, 1.54), and commute time=-3.38 (-4.18, -2.19). The median (IQR) for youth indicators for physical fitness included: BMI percentile= 79.20 (70.31, 92.45), curl-ups percentile= 52.44 (27.87, 76.65), push-ups percentile= 50.54 (29.05, 78.53), PACER percentile (54.65 (29.05, 78.53), and sit-and-reach (mm)= 10 (8, 12).

Multilevel mixed model:

Table 2 displays results from unstratified and stratified mixed models used to estimate the association between neighborhood indicators of opportunity for physical activity and youth indicators for physical fitness. Greenspace was associated with higher values of indicators of physical fitness except BMI. Greenspace-fitness indicators associations had the greatest magnitude of effects for muscular strength and endurance (push-ups: β: 0.92, 95% CI: 0.62, 1.22; curl-ups: β: 0.46, 95% CI: 0.20, 0.71; PACER: β: 0.47, 95% CI: 0.05, 0.88). Higher walkability

scores were associated with lower BMI (β: -0.75, 95% CI: -1.01, -0.49) and higher values of indicators of physical fitness, particularly for PACER (β: 1.98, 95% CI: 1.59, 2.37) and curl-ups (β: 1.27, 95% CI: 0.93,1.62). Access to healthy foods was associated with lower push-ups performance (β: -0.34, 95% CI: -0.60, -0.07), and lower BMI (β: -0.39, 95% CI: -0.63, -0.16). Those living in areas with a greater percentage of long-commuters showed higher values for indicators of fitness. This association was most pronounced for BMI (β: -0.85, -0.96, -0.73), PACER (β: 2.03, 95% CI: 1.87, 2.18), and push-ups (β: 0.75, 95% CI: 0.62, 0.88).

The direction of neighborhood factors-youth fitness indicator associations was preserved when stratifying across sex; however, magnitude varied, particularly for greenspace. Higher greenspace was more strongly associated with significant positive values of indicators of muscular strength and endurance for girls (curl-ups, girls: β: 0.72, 95% CI: 0.31, 1.14) and a null association for boys. We also observed differences across walkability-fitness indicator associations, with higher walkability more strongly associated with higher values for indicators of fitness for girls compared to boys for both BMI and PACER (BMI, girls: β: -0.91, 95% CI: -1.22, -0.60); BMI, boys: β: -0.56, 95% CI: -0.86, -0.25; PACER, girls: β: 2.11, 95% CI: 1.68, 2.54; PACER, boys: β: 1.71, 95% CI: 1.31, 2.12). For commute time, girls also showed higher magnitudes of associations with fitness indicators for push-ups and PACER (push-ups, girls: β: 0.87, 95% CI: -0.71, 1.03); pushups, boys: β: 0.55, 95% CI: 0.40, 0.70; PACER, girls: β: 2.09, 95% CI: 1.91, 2.27; PACER, boys: β: 1.87, 95% CI: 1.69,2.04).

Discussion

This study examined the association between multiple measures of neighborhood indicators of opportunity for physical activity, and youth indicators for physical fitness among a racially diverse population of NYC public school youth. Multilevel models showed positive associations between neighborhood indicators of opportunity for physical activity (greenspace, walkability, healthy foods, commute time) and fitness outcomes, with the strongest positive associations between greenspace and muscular endurance (curl-ups, push-ups), walkability with BMI and PACER, healthy foods with BMI and push-ups, and commute time with BMI and aerobic capacity (push-ups and PACER) performance. Additionally, sex-stratified models showed strengthened associations for girls versus boys. Study findings warrant more research on the neighborhood-youth fitness relationship, which can ultimately inform geographically tailored population-level initiatives targeting select components of the neighborhood environment to reduce youth fitness-related disparities.

Previous cross-sectional studies have reported associations between COI and health-related outcomes, including pediatric acute care visits and asthma-related hospitalizations.[26] Our study indicates that COI indicators of neighborhood opportunity also are related to youth indicators for physical fitness, further highlighting the importance of a comprehensive understanding of neighborhood context in shaping youth health.

Previous studies also help to support the associations observed between neighborhood factors and higher values of indicators of physical fitness. Prior research has demonstrated negative associations between neighborhood walkability and youth BMI or adolescent overweight/obesity.[9] Additionally, higher neighborhood greenspace has been associated with decreased risk of overweight/obesity in youth.[11] We observed that greenspace, walkability and commute time were most strongly associated with muscular strength/endurance, aerobic

capacity, and BMI. Higher walkability and longer commute times may indicate the presence of more sidewalk density and connectivity, as well as more opportunities and/or reflecting greater need to use active and mixed (active and public) transportation increasing total time to reach recreational spaces like parks and playgrounds and other open spaces that promote structured exercise and greater fitness.[27,28] The finding that commute time was negatively associated with BMI and positively associated with all other fitness outcomes contradicts prior literature showing longer neighborhood commuting time corresponding to increased obesity risk in adults, which may predict youth outcomes.[29,30] However, the associations we observed are less surprising given the urban setting for this study, density of active and mixed transit, and potential for longer parental commute time which may lead to youth having less adult supervision, and subsequent increased participation in after-school programs and recreational activities.[31] Additionally, youth in urban settings may be more independently mobile, which may promote participation in active transportation or usage of public transportation, which has been shown to increase youth PA.[32]

Studies on the contribution of food environments to youth BMI and overweight/obesity have been equivocal. For instance, limited access to supermarkets has been shown to be associated with higher BMI in boys;[33] however, other studies have shown null associations between grocery store availability and youth BMI.[34] Although we observed a negative association between access to healthy foods and BMI, other youth fitness outcomes also had an unexpected negative (push-ups) or null (PACER) association, suggests that proximity to healthy food outlets may not be sufficient to influence physical fitness. Even if available, healthy food options may be less affordable than unhealthier foods[35] or may not be the first-choice food option for youth.

We also observed sex differences in the associations between neighborhood factors -and fitness, with more pronounced associations observed among girls. Previous studies demonstrate stronger associations between neighborhood factors and indicators of physical fitness among girls, including obesity and overweight risk, supporting this finding. [8,36] This suggests that neighborhood walkability, active transportation opportunities, and greenspace may be particularly important for girls' cardiovascular health. Girls may be more likely to engage in PA and other health-promoting activities in outdoor spaces such as parks and playgrounds and participating in active transportation.[32,37] Utilizing strategies that incorporate these aspects of the neighborhood environment may help to reduce sex disparities in youth fitness attainment.

Strengths and Limitations

Strengths of this study include using a large and diverse sample, estimates based on a standardized, evidence-based measure of youth health-related fitness and multiple indicators of neighborhood opportunity to derive a comprehensive understanding of the association between neighborhood context and youth fitness. Additionally, multilevel analyses took into account clustering of observations by census tract, providing a more robust estimate of the neighborhood-fitness relationship. Finally, our analytic population was comprised of largely minoritized populations with low or very low COI scores, indicating the importance of modifiable neighborhood environment features for youth fitness attainment in historically marginalized and underserved populations.

This study has several limitations. First, the COI is derived from data obtained from several sources across multiple years and ultimately combined into a "2015 index" that is meant to characterize a child's neighborhood opportunity exposure for 2015. Differential timing in

these exposure measurements may have introduced measurement error to our estimates by neglecting the time-varying nature of some of the variables included in the index. Also, certain neighborhood factors specifically relevant to NYC, such as land use mix, bus and subway stop density, cleanliness, and safety/violence, were not included in the analysis because the COI was limited to nationally representative data.[38] In addition, we clustered youth within home residence census tracts, although neighborhood of residence may not be the most appropriate context for measuring a child's exposure to opportunity. Additionally, youth commute time to school would more accurately measure youth transportation vulnerability compared to adult commuting time and should be investigated further in future studies.

Conclusion

Our findings suggest that more favorable NYC neighborhood opportunity is positively associated with youth indicators for physical fitness and may be sex-specific. Future studies should examine the mechanisms accounting for relationships between neighborhood factors and youth indicators for physical fitness, such as physical activity, healthy eating, or psychosocial factors. Further research on the impact of neighborhood factors on youth BMI and fitness outcomes has potential to better inform public health efforts to reduce health disparities modifiable through tailored place-based interventions.

Financial Disclosure: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. CDC. CDC | Physical Activity | Facts | Healthy Schools. CDC. Published April 21, 2020. Accessed April 27, 2022. https://www.cdc.gov/healthyschools/physicalactivity/facts.htm

2. Plowman SA, Meredith MD. F*ITNESSGRAM/ACTIVITYGRAM Reference Guide* (4th Edition). Dallas, TX: The Cooper Institute; 2013.

3. Raghuveer Geetha, Hartz Jacob, Lubans David R., et al. Cardiorespiratory Fitness in Youth: An Important Marker of Health: A Scientific Statement From the American Heart Association. *Circulation*. 2020;142(7):e101-e118. doi:10.1161/CIR.0000000000000866

4. Konty KJ, Day SE, Larkin M, et al. Physical fitness disparities among New York City public school youth using standardized methods, 2006-2017. *PLOS ONE*. 2020;15(4):e0227185. doi:10.1371/journal.pone.0227185

5. Marta CC, Marinho DA, Barbosa TM, et al. Physical Fitness Differences Between Prepubescent Boys and Girls. *J Strength Cond Res*. 2012;26(7):1756-1766. doi:10.1519/JSC.0b013e31825bb4aa

6. Flanagan SD, Dunn-Lewis C, Hatfield DL, et al. Developmental differences between boys and girls result in gender-specific physical fitness changes from fourth to fifth grade. *J Strength Cond Res*. 2015;29(1):175-180. doi:10.1519/JSC.0000000000000623

7. Ding D, Sallis JF, Kerr J, et al. Neighborhood environment and physical activity among youth a review. *Am J Prev Med*. 2011;41(4):442-455. doi:10.1016/j.amepre.2011.06.036

8. Kowaleski-Jones L, Fan JX, Wen M, et al. Neighborhood Context and Youth Physical Activity: Differential Associations by Gender and Age. *Am J Health Promot AJHP*. 2017;31(5):426-434. doi:10.1177/0890117116667353

9. Yang S, Chen X, Wang L, et al. Walkability indices and childhood obesity: A review of epidemiologic evidence. *Obes Rev*. 2020; 22(S1):e13096. doi:10.1111/obr.13096

10. Wei J, Wu Y, Zheng J, et al. Neighborhood sidewalk access and childhood obesity. *Obes Rev*. 2021;22(S1):e13057. doi:10.1111/obr.13057

11. Jia P, Cao X, Yang H, et al. Green space access in the neighbourhood and childhood obesity. *Obes Rev*. 2021; 22(S1):e13100. doi:10.1111/obr.13100

12. Jia P, Pan X, Liu F, et al. Land use mix in the neighbourhood and childhood obesity. *Obes Rev*. 2021;22(S1):e13098. doi:10.1111/obr.13098

13. Graziose MM. Association Between the Built Environment in School Neighborhoods With Physical Activity Among New York City Children, 2012. *Prev Chronic Dis*. 2016;13. doi:10.5888/pcd13.150581

14. Huang JH, Hipp JA, Marquet O, et al. Neighborhood characteristics associated with park use and park-based physical activity among children in low-income diverse neighborhoods in New York City. *Prev Med*. 2020;131:105948. doi:10.1016/j.ypmed.2019.105948

15. Lovasi GS, Schwartz-Soicher O, Quinn JW, et al. Neighborhood safety and green space as predictors of obesity among preschool children from low-income families in New York City. *Prev Med*. 2013;57(3):189-193. doi:10.1016/j.ypmed.2013.05.012

16. Day SE, Konty KJ, Napier MD, et al. NYC FITNESSGRAM: Population-Level Physical Fitness Surveillance for New York City Youth. *Am J Epidemiol*. 2023 Feb 24;192(3):334-341. doi: 10.1093/aje/kwac204.

17. Neckerman KM, Lovasi GS, Davies S, et al. Disparities in Urban Neighborhood Conditions: Evidence from GIS Measures and Field Observation in New York City. *J Public Health Policy*. 2009;30(1):S264-S285. doi:10.1057/jphp.2008.47

18. Noelke C, McArdle N, Baek M, et al. Child Opportunity Index 2.0 Technical Documentation. 2020. Retrieved from diversitydatakids.org/research-library/research-brief/how-we-built-it.

19. McGrath LJ, Hopkins WG, Hinckson EA. Associations of objectively measured built-environment attributes with youth moderate-vigorous physical activity: a systematic review and meta-analysis. *Sports Med Auckl NZ*. 2015;45(6):841-865. doi:10.1007/s40279-015-0301-3

20. Bader MDM, Schwartz-Soicher O, Jack D, et al. More neighborhood retail associated with lower obesity among New York City public high school students. *Health Place*. 2013;23:104-110. doi:10.1016/j.healthplace.2013.05.005

21. Litman T, Nixon H, Simons C. Commute Duration Dashboard Guide: Mapping Commute Travel Times to Evaluate Accessibility. Mineta Transportation Institute; 2021

22. D'Agostino EM, Patel HH, Hansen E, et al. Does transportation vulnerability explain the relationship between changes in exposure to segregation and youth cardiovascular health? *Health Place*. 2019;57:265-276. doi:10.1016/j.healthplace.2019.04.002

23. CD*C. 2000 CDC Growth Charts for the United States: Methods and Development. Public Health Serv*ice, CDC, National Center for Health Statistics; 2002.

24. Day SE, Konty KJ, Napier MD, Irvin E, Thompson HR, D'Agostino EM. NYC FITNESSGRAM: Population-Level Physical Fitness Surveillance for New York City Youth. Am J Epidemiol. 2023 Feb 24;192(3):334-341. doi: 10.1093/aje/kwac204.

25. Konty KJ, Day SE, Napier MD, Irvin E, Thompson HR, M D'Agostino E. Context, importance, and process for creating a body mass index surveillance system to monitor childhood obesity within the New York City public school setting. Prev Med Rep. 2022 Jan 19;26:101704. doi: 10.1016/j.pmedr.2022.101704.

26. Acevedo-Garcia D, Noelke C, McArdle N, et al. Racial And Ethnic Inequities In Children's Neighborhoods: Evidence From The New Child Opportunity Index 2.0. *Health Aff (Millwood)*. 2020;39(10):1693-1701. doi:10.1377/hlthaff.2020.00735

27. Braubach M, Egorov A, Mudu P, et al. Effects of Urban Green Space on Environmental Health, Equity and Resilience. In: Kabisch N, Korn H, Stadler J, Bonn A, eds. *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*. Springer International Publishing; 2017:187-205. doi:10.1007/978-3-319-56091-5_11

28. Baobeid A, Koç M, Al-Ghamdi SG. Walkability and Its Relationships With Health, Sustainability, and Livability: Elements of Physical Environment and Evaluation Frameworks. *Front Built Environ*. 2021;7. Accessed April 21, 2022. https://www.frontiersin.org/article/10.3389/fbuil.2021.721218

29. Zhang X, Holt JB, Lu H, et al. Neighborhood commuting environment and obesity in the United States: An urban–rural stratified multilevel analysis. *Prev Med*. 2014;59:31-36. doi:10.1016/j.ypmed.2013.11.004

30. McLoone P, Morrison DS. Risk of child obesity from parental obesity: analysis of repeat national cross-sectional surveys. *Eur J Public Health*. 2014;24(2):186-190. doi:10.1093/eurpub/cks175

31. Paleti, R., Copperman, R.B. & Bhat, C.R. An empirical analysis of children's after school out-of-home activity-location engagement patterns and time allocation. *Transportation* **38**, 273–303 (2011). https://doi.org/10.1007/s11116-010-9300-2

32. Granados I, Haderer EL, D'Agostino EM, et al. The Association Between Neighborhood Public Transportation Usage and Youth Physical Activity. *Am J Prev Med*. 2021;61(5):733-737. doi:10.1016/j.amepre.2021.04.035

33. Hsieh S, Klassen AC, Curriero FC, et al. Built Environment Associations with Adiposity Parameters among Overweight and Obese Hispanic Youth. *Prev Med Rep*. 2015;2:406-412. doi:10.1016/j.pmedr.2015.05.005

34. Reis WP, Ghamsary M, Galustian C, et al. Childhood Obesity: Is the Built Environment More Important Than the Food Environment? *Clin Med Insights Pediatr*. 2020;14:1179556520932123. doi:10.1177/1179556520932123

35. Kern DM, Auchnicloss AH, Stehr MF, et al. Neighborhood Prices of Healthier and Unhealthier Foods and Associations with Diet Quality: Evidence from the Multi-Ethnic Study of Atherosclerosis. *Int J Environ Res Public Health*. 2017;14(11). doi:10.3390/ijerph14111394

36. Singh GK, Siahpush M, Kogan MD. Neighborhood Socioeconomic Conditions, Built Environments, And Childhood Obesity. *Health Aff (Millwood)*. 2010;29(3):503-512. doi:10.1377/hlthaff.2009.0730

37. Fan M, Jin Y. Do Neighborhood Parks and Playgrounds Reduce Childhood Obesity? *Am J Agric Econ*. 2014;96(1):26-42. doi:10.1093/ajae/aat047

38. Rundle A, Diez Roux AV, Free LM, et al. The urban built environment and obesity in New York City: a multilevel analysis. *Am J Health Promot*. 2007;21(4 Suppl):326-334. doi:10.4278/0890-1171-21.4s.326

Table 1. Descriptive characteristics of the analytic sample, New York City youth, 2016-17

All Students (n=299,839)		Males (n=150,223; 50.10%)	Females (n=149,616; 49.90%)
	N(%)	N(%)	N(%)
Race/Ethnicity			
Asian/Pacific Islander	56,086 (18.71)	28,742 (19.13)	27,344 (18.28)
Non-Hispanic Black	78,402(26.15)	38,212 (25.44)	40,190 (26.86)
Hispanic	112,427(37.50)	56,113 (37.35)	56,314 (37.64)
White	49,171(16.40)	25,317 (16.85)	23,854 (15.94)
Mixed/Other[b]	3,752 (1.25)	1,839 (1.22)	1,914 (1.28)
Eligible for free/reduced price school meals			
Yes	208,287(69.47)	103,104 (68.63)	105,183 (70.30)
No	91,552(30.53)	47,119 (31.37)	44,433 (29.70)
Neighborhood Poverty			
0-<5%	21,883 (7.30)	10,916 (7.27)	10,967 (7.33)
5-<10%	45,136 (15.06)	22,658 (15.09)	22,478 (15.03)
10-<20%	85,981 (28.68)	43,198 (28.77)	42,783 (28.60)
20-<30%	70619 (23.56)	35,320 (23.52)	35,299 (23.60)
30-<40%	45,040 (15.03)	22543 (15.01)	22,497 (15.04)
40-100%	31,087 (10.37)	15,538 (10.35)	15,549 (10.40)
	Median (IQR)	Median (IQR)	Median (IQR)
Neighborhood indicators of opportunity for physical activity			
Greenspace	-2.37 (-2.56, -1.89)	-2.37 (-2.56, -1.89)	-2.37 (-2.56, -1.89)
Healthy Food	0.85 (0.85, 0.85)	0.85 (0.85, 0.85)	0.85 (0.85, 0.85)
Walkability	1.17 (0.76, 1.54)	1.17 (0.76, 1.55)	1.17 0.76, 1.54)
Commute Time	-3.38 (-4.12, -2.19)	-3.38 (-4.12, -2.19)	-3.38 (-4.12, -2.19)
Youth indicators for physical fitness			
BMI percentile	79.20 (70.31, 92.45)	81.07 (72.31, 94.44)	77.16 (68.53, 90.26)
Curl-ups percentile	52.44 (27.87, 76.65)	52.14 (27.87, 76.44)	52.93 (28.69, 77.03)
Push-ups percentile	50.54 (26.74, 76.41)	49.66 (25.79, 75.39)	54.04 (27.68, 76.99)
PACER percentile	54.65 (29.05, 78.53)	54.65 (28.74, 78.19)	54.75 (29.33, 78.85)
Sit and Reach (mm)	10 (8, 12)	9.00 (7,11)	10.00 (8, 12)

IQR=Interquartile Range;

[a]Median age (years)= 16; IQR: 12-17

[b]Mixed/Other race/ethnicity category includes: Parents Refused to Sign / No Data / Multi-Racial / Native American or Alaskan Indian

417

Table 2. Overall and sex-stratified[a] adjusted modeled estimates for the association between metro-normed child opportunity and youth indicators for physical fitness, NYC youth, 2016-2017

	Greenspace			Walkability			Healthy Foods			Commute Time		
	95% CI			95% CI			95% CI			95% CI		
	β[b]	lower	upper	β[b]	lower	upper	β[b]	lower	upper	β[b]	lower	upper
BMI percentile												
Overall	0.06	-0.21	0.33	-0.75‡	-1.01	-0.49	-0.39‡	-0.63	-0.16	-0.85‡	-0.96	-0.73
Girls	-	-	-	-0.91‡	-1.22	-0.60	-	-	-	-0.79‡	-0.94	-0.65
Boys	-	-	-	-0.56‡	-0.86	-0.25	-	-	-	-0.80‡	-0.95	-0.66
Curl-ups percentile												
Overall	0.46‡	0.20	0.71	1.27‡	0.93	1.62	0.02	-0.29	0.34	1.20‡	1.05	1.35
Girls	0.72‡	0.31	1.14	-	-	-	-0.32	-0.69	0.04	-	-	-
Boys	0.36	-0.05	0.77	-	-	-	0.35	-0.01	0.71	-	-	-
Push-ups percentile												
Overall	0.92‡	0.62	1.22	0.10	-0.19	0.39	-0.34*	-0.60	-0.07	0.75‡	0.62	0.88
Girls	-	-	-	0.07	-0.28	0.42	-	-	-	0.87‡	0.71	1.03
Boys	-	-	-	0.01	-0.32	0.34	-	-	-	0.55‡	0.40	0.70
PACER percentile												
Overall	0.47*	0.05	0.88	1.98‡	1.59	2.37	0.28	-0.07	0.64	2.03‡	1.87	2.18
Girls	-	-	-	2.11‡	1.68	2.54	-	-	-	2.09‡	1.91	2.27
Boys	-	-	-	1.71‡	1.31	2.12	-	-	-	1.87‡	1.69	2.04
Sit-and-reach (mm)												
Overall	0.04*	0.00	0.07	0.08‡	0.05	0.10	-0.03	-0.06	-0.00	0.07‡	0.05	0.08
Girls	0.03	-0.00	0.06	-	-	-	-0.03*	-0.06	-0.00	0.08‡	0.06	0.09
Boys	0.04*	0.01	0.08	-	-	-	-0.03*	-0.06	-0.00	0.06‡	0.04	0.07

[a] Models including an interaction term between sex and the opportunity indicator were run. If interaction terms were statistically significant ($p<0.05$), we examined effect modification by sex. Sex-stratified models were run adjusting for age, race/ethnicity, and both individual-level and neighborhood-level poverty.

[b] BMI, body mass index

*$p<0.05$; †$p<0.01$; ‡$p<0.001$