The Relationship Between Built Environments and Physical Activity: A Systematic Review

Alva O. Ferdinand, JD, MPH, Bisakha Sen, PhD, Saurabh Rahurkar, BDS, MPH, Sally Engler, BA, and Nir Menachemi, PhD, MPH

Objectives. We conducted a systematic review of the literature examining the relationship between built environments (e.g., parks, trails, sidewalks) and physical activity (PA) or obesity rates.

Methods. We performed a 2-step inclusion protocol to identify empirical articles examining any form of built environment and any form of PA (or obesity rate) as the outcome. We extracted data from included abstracts for analysis by using a standard code sheet developed for this study.

Results. Of 169 included articles, 89.2% reported beneficial relationships—but virtually all articles utilized simple observational study designs not suited for determining causality. Studies utilizing objective PA measures (e.g., pedometer) were 18% less likely to identify a beneficial relationship. Articles focusing on children in community settings (–14.2%), those examining direct measures of obesity (–6.2%), or those with an academic first author (–3.4%) were less likely to find a beneficial relationship.

Conclusions. Policymakers at federal and local levels should encourage more rigorous scientific research to determine whether altered built environments will result in increased PA and decreased obesity rates. (*Am J Public Health.* 2012;102:e7–e13. doi:10.2105/AJPH.2012.300740)

Obesity rates have risen dramatically in the United States over the past few decades among both adults[1] and children.[2] Although obesity prevalence has increased in all parts of the country and for all demographic groups, the prevalence of obesity is higher in the US South[3–7] and among African Americans, Hispanics, and the educationally and economically disadvantaged.[2,3,8,9] Obesity and sedentary lifestyles are estimated to result in more than 300 000 premature deaths per year in the United States.[10,11] The obesity epidemic is regarded as one of the leading health problems facing the country and several federal initiatives such as the Centers for Disease Control and Prevention's "Communities Putting Prevention to Work" or the First Lady's "Let's Move" campaign aim to reverse childhood obesity.

Ultimately, obesity is a result of imbalance between energy intake and energy expenditure.[12] Physical activity (PA) provides one of the main sources of energy expenditure.[13] In fact, the rising prevalence of obesity in the United States has occurred concurrently with general declines in the rates of PA associated with a decrease in such factors as active transportation (e.g., walking to work or school) and an increase in sedentary leisure-time activities such as television watching[6] and video game playing,[14,15] and a decrease in physical activity in schools.[16] Overall, it is estimated that more than 50% of US adults fail to meet the recommended levels of overall PA, with higher prevalence of inadequate PA in the South.[7] Evidence of inadequacy in PA among children is also well documented.[17–20]

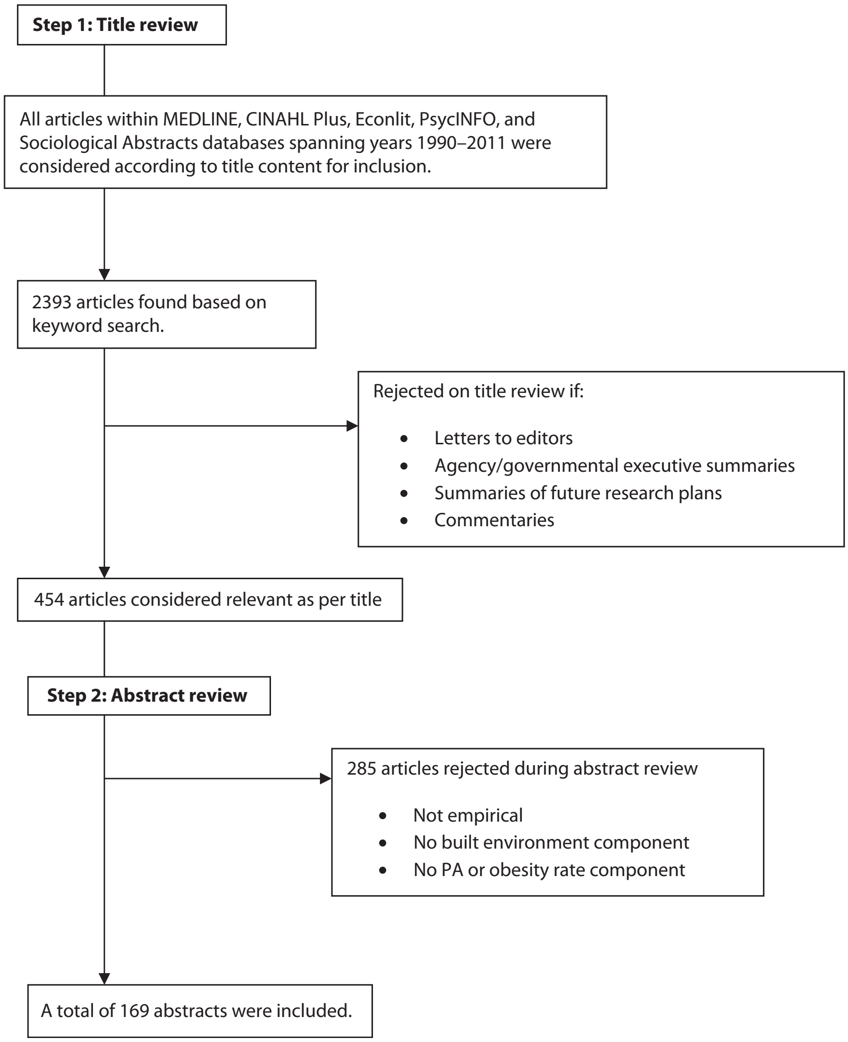
It is generally believed that PA is not just a matter of personal choice, but also a function of the built environment[21–23]—which refers broadly to the collective availability of sidewalks, parks, trails, recreational facilities, traffic safety, and other neighborhood characteristics that promote recreational PA as well as active transport to work, school, or errands.[24–29] There is also evidence that low-income neighborhoods and minority communities have less access to recreational facilities[30] and the existing facilities available to them are of a poorer quality.[31] Thus, modifying built environments to make them more PA-friendly is widely advocated as a way to create healthier and less obese communities.[32] Concurrently there has been a growing body of scientific research on how various facets of the built environment are associated with changes in PA or obesity rates.[33–39] However, because of the wide range of scientific journals in which such studies are published, the heterogeneity in types of built environments considered, the different ways in which PA is defined or measured, and the varying study populations examined, it is increasingly difficult for policymakers and other stakeholders to keep abreast of current findings.

The purpose of this study was to systematically review the literature examining the relationship between built environments and PA or obesity rates. We were interested in any articles that focused on any aspect of the built environment that also examined any form of PA or direct measures of obesity. Our work supplements previous reviews of the literature that focused narrowly on body weight only,[39] a limited population (e.g., African Americans)[37] or other disadvantaged groups,[38] or literature (e.g., epidemiology only[33]), and those that were concerned entirely with how to best measure built environments.[35] In addition, previous authors have examined how PA and obesity are related to macro, political, economic, and micro environments[36] or the concept of "smart growth" in the context of urban planning.[34] In our study, we were interested broadly in determining whether built environment characteristics are associated with decreases in obesity or increases in various types of PA. Moreover, we were interested in quantifying the proportion of existing studies that focus on Southern states, on children, or other vulnerable populations, and determining whether such studies differ with respect to identifying a benefit from built environments. Lastly, we were interested in identifying any specific study characteristics that are associated with finding results that show improvements in PA or obesity rates. Overall, our study helps identify gaps in the literature and provides a useful synthesis for policymakers, urban planners, public health professionals, and other stakeholders concerned with maximizing the benefits of built environments for the health of their communities.

METHODS

We used a systematic review methodology to identify and then extract information from articles for further quantitative analysis. To systematically review the literature examining the relationship between built environment and obesity rates or PA, we included articles published from 1990 through April 2011. To be as comprehensive as possible we enlisted the help of a professionally trained library science expert. We searched all the major databases including MEDLINE, CINAHL Plus, Econlit, PsycINFO, and Sociological Abstracts with such search terms as “built environment,” “environment design,” “residence characteristics,” “open spaces,” “neighborhoods or neighbourhoods,” and “public lands” to capture articles that addressed the built environment. Moreover, we used terms such as “physical activity,” “motor activity,” “physical fitness,” “walking,” “running,” “biking,” “recreation,” and “exercise” to capture articles that addressed PA. We also searched for terms such as “BMI” and “obesity” to identify articles that examined direct measures of body mass index (BMI; defined as weight in kilograms divided by the square of height in meters). We only considered English-language, empirical publications that appeared in peer-reviewed journals. Because of our focus on evidence-based literature contributions, we excluded letters to the editor, policy briefs, executive summaries of governmental reports, and summaries of future research plans.

Our keyword search identified 2393 articles. We used a 2-step inclusion process outlined in Figure 1. In the first step, 2 independent reviewers examined article titles and each marked articles for elimination that did not reveal a focus on some type of built environment and some measure of PA or obesity. The broad nature of our search terms picked up articles that were not intended because of different uses of terminology in different disciplines, (e.g., articles that looked at the impact of sports arenas on land values,[40] the impact of the environment on aging,[41] and the activity of animals[42]). In this first step we sought a high level of sensitivity (erring on the side of inclusion). Thus, if either reviewer chose to include an article on the basis of the title, it was selected for abstract review in step 2. We included a total of 454 titles (19%) once this step was completed.



Note. PA = physical activity

FIGURE 1—Steps to identify articles for the systematic review of literature examining the relationship between built environments and physical activity or obesity rate.

The next step was to screen the article abstracts of the 454 studies identified in step 1. For this step, we focused on a high level of specificity by excluding articles that did not clearly have a focus on both a built environment component and a PA component. Disagreements or uncertainty about inclusion or exclusion was reconciled by group discussion among the authors. We included a total of 169 abstracts in the systematic review and these are listed in Appendix A (available as a supplement to this article at http://www.ajph.org). These 169 articles represented 194 individual analyses because several papers presented 2 or more separate analyses that fit our inclusion criteria.

We systematically classified all included abstracts by using a standard coding sheet specifically developed for this study (Appendix B, available as a supplement to this article at http://www.ajph.org). For each abstract, we collected information on journal type (e.g., public health, medicine, physical fitness), study design, and study location. Because of our interest in factors influencing PA and obesity rates in the South, we noted whether a study was conducted in 1 of the 17 states classified by the US Census as southern (AL, AR, DC, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, or WV). In addition, we collected information on each study's sample size, main outcome variable, and main findings. Moreover, we collected information about study participants including their gender, race/ethnicity, age, geographic location (rural vs urban), and study setting (school, home or community, hospitals). We also collected information about the method in which PA was measured (e.g., self-reported, technologically measured, or investigator observed) and the types of PA examined (e.g., walking, running, biking). We identified whether the studies focused on physical activity, physical inactivity (e.g., screen time), or directly measured the association of built environment with some measure of body weight (e.g., BMI). Lastly, we determined whether the article findings showed a beneficial relationship between the built environment characteristic and the outcome variable. A beneficial relationship included statistically significant findings that were positive for positive outcomes (e.g., PA) or negative for negative outcomes (e.g., inactivity, weight gain, obesity risk).

We used descriptive analyses to examine the distributions of each variable. We tabulated frequencies for variables of interest and cross-tabulated the variables measuring main outcomes (e.g., PA, BMI) and various variables representing study characteristics (e.g., a focus on a Southern, pediatric, or minority population). Next, we examined the relationship between various study characteristics and whether the conclusions of the study suggested that there was a beneficial relationship between the built environment and the outcome variable. To do so, we developed a logistic regression model where the dependent variable was "finding a beneficial relationship." In this model, covariates included whether the study included a Southern population, sample size, whether PA data were objectively measured, whether the study focused on a specific population, and other characteristics such as journal type, outcome type, and location of first author. We report adjusted odds ratios (ORs) and marginal effects to assist in the interpretation of our findings. In the case of categorical variables, a marginal effect represents the difference in the probability of an outcome occurring between a given category and the reference group. All analyses were conducted in Stata version 11 (StataCorp LP, College Station, TX) and controlled for the nested nature of analyses within papers. Statistical significance was flagged at the $P<.10$; $P<.05$; and $P<.01$ levels.

RESULTS

The number of included articles increased steadily by year with a low of 1 article in 2001 to a high of 43 articles in 2010. Of the 169 articles reviewed, the majority were authored by individuals at academic institutions (86.4%), had an observational study design (100%), were published in a public health or preventive medicine journal (73.4%), and utilized self-reported PA data (85.2%; Table 1). Overall, 24 articles (14.2%) containing 27 analyses were conducted in a Southern state. Lastly, the vast majority of analyses (n = 173 of 194; 89.2%) found a beneficial relationship between the built environment and PA or obesity.

The distribution of how various outcome variables and differing study populations were distributed among the included articles is presented in Table 2. The most common outcome variable was general PA (125 out of 194 studies; 64.4%); and many of these studies focused on a vulnerable population such as children (68 of 194; 35.1%) or the elderly (21 of 194; 10.8%). Direct measures of obesity (e.g., BMI) were the main outcome variable in 47 studies (24.2%) and 7 of these analyses focused on a Southern population (Table 2). Despite the many articles that focused on other vulnerable populations, very few studies focused on a minority race (n = 10; 5.2%) or rural population (n = 8; 4.1%).

In bivariate analysis (data not shown), if PA was measured objectively (defined as measured technologically including by the use of pedometers, or investigator observations) articles were less likely to find a beneficial relationship (69% vs 93%; $P<.001$). In addition, articles that focused on elderly populations were marginally more likely to find a beneficial relationship (100% vs 88%; $P=.09$).

When we controlled for all the various article characteristics in a logistic regression, studies that focused on a Southern state did not differ from their counterparts with respect to finding a beneficial relationship (Table 3). However, in multivariable analysis, when an article focused on children younger than 19 years (OR = 0.09; 95% confidence interval [CI] = 0.02, 0.38; marginal effect −14.2%) or had an academic lead author (OR = 0.23; 95% CI = 0.08, 0.70; marginal effect −3.4%), there was a reduced likelihood of observing a beneficial relationship. Compared with studies that recruited community participants, those that recruited participants from either schools (OR = 16.8; 95% CI =1.78, 159.6; marginal effect +5.5%) or "other" settings including hospitals and clinics (OR = 12.9; 95% CI = 3.22, 52.5; marginal effect +6.7%) were more likely to find beneficial relationships between the built environment and obesity or PA.

There was no relationship between year of publication and likelihood of finding a beneficial outcome. However, the use of direct measures of body weight (e.g., BMI) as the main outcome variable in a study was associated with a reduced likelihood in finding a beneficial relationship (OR = 0.29; 95% CI = 0.08, 1.09; marginal effect −6.2%). Furthermore, studies whose main outcome variable was active transport (OR = 0.14; 95% CI = 0.03, 0.66; marginal effect −16.4%) or "inactivity" (OR = 0.05; 95% CI = 0.01, 0.37; marginal effect −39.9%) were less likely to observe a beneficial relationship. Moreover, the use of objectively measured PA data as opposed to self-reported data was associated with a reduced likelihood in finding a beneficial relationship between the built environment and PA or obesity rates (OR = 0.10; 95% CI = 0.03, 0.35; marginal effect −18.0%). Lastly, compared with articles published in a public health or preventive medicine journal, those published in a physical fitness academic journal were more likely to have a beneficial relationship (OR = 26.4; 95% CI = 6.37, 109.8; marginal effect +5.3%).

TABLE 1—Descriptive Statistics of Articles Reviewed (n = 169) on the Relationship Between Built Environments and Physical Activity or Obesity Rate: 2000–2011

Variables	No. (%)
First author from academia	146 (86.4)
Journal type	
Public health or preventive medicine	124 (73.4)
Medicine or clinical	23 (13.6)
Physical fitness	21 (12.4)
Transportation or urban planning	1 (0.6)
Study location	
Southern state	24 (14.2)
Non-Southern state	25 (14.8)
Nationwide	20 (11.8)
Non-US	60 (35.5)
Unknown	40 (23.7)
Study design	
Experimental	0 (0)
Observational—quantitative	164 (97.1)
Observational—qualitative	5 (2.9)
Sample origination	
School	28 (16.3)
Home or community	94 (55.6)
Other or unknown	44 (28.1)
Mode of PA data collection:	
PA objectively measured (e.g., pedometer or investigator observed)	25 (14.8)
PA self-reported or other	144 (85.2)
Dependent variable	
General physical activity	104 (61.5)
Park or trail use	5 (3.0)
BMI or obesity	45 (26.6)
Active transport	12 (7.1)
Inactivity	3 (1.8)
Study reported a statistically significant beneficial relationship between the built environment and the outcome variable	
Yes	173 (89.2)
No	21 (10.8)
Types of built environment	
Parks	30 (15.5)
Sidewalks	21 (10.8)
Trails	13 (6.7)
Recreational facilities	47 (24.2)
School playgrounds	5 (2.6)
Traffic safety	27 (13.9)
Other or unknown	51 (26.3)

Note. BMI = body mass index (defined as weight in kilograms divided by the square of height in meters); PA = physical activity. Sample size in each study: mean = 12 598; median = 1318; SD = 65 187; range (min–max) = 10–616 007.

DISCUSSION

The literature examining the association between the built environment and PA or obesity has grown in recent years. This expansion has corresponded to widespread community initiatives aimed at increasing people's access to recreational centers, parks, trails, and other green spaces in an effort to increase PA and reduce obesity. In light of the large recent growth in the literature, we sought to systematically review the current state of scientific work on this important topic. We were particularly interested in identifying whether existing studies are generalizable to the US South where both poverty and obesity are a major public health challenge.

The main finding of our review is that a high percentage of studies have identified a beneficial relationship between the built environment and PA or obesity. Furthermore, studies that included populations from the South had similar positive findings. Despite these promising results, we also found that virtually all studies in the existing literature employed observational study designs that severely limit researchers' ability to determine if the relationship between the built environment and desirable outcomes are indeed causal. Among these observational studies was one that used a match–control design (at the neighborhood level) and objectively examined PA as well as self-reported screen time.[43] Given its study design, it is perhaps better able to suggest causality. It is encouraging that this study, although it focused on a unique inner-city pediatric population,[43] found positive findings including increased PA and decreased reported TV and video watching following the opening of a new schoolyard.

Our analysis also found that studies that focused on children (compared with adults) that were recruited from the community were less likely to report a "positive" result.[44–46] Although more in-depth analysis is required to explain this discrepancy, it is possible that the relationship between the built environment and child PA may be moderated to a greater extent than for adults by certain intangible characteristics. For example, an extensive number of studies have found that parental perceptions of neighborhood safety and quality

TABLE 2—Number of Studies With Given Outcomes and Populations on the Relationship Between Built Environments and Physical Activity or Obesity Rate: 2000–2011

		Main Outcome Variable, No. of Articles (%)				
Variable	No. of Articles (%)	General PA	Park or Trail Use	Direct Measures of BMI or Obesity	Active Transport	Inactivity
Focus on a Southern state	27 (13.9)	17	1	7	2	0
Focus on a minority race	10 (5.2)	9	0	0	0	1
Focus on a rural location	8 (4.1)	5	0	2	1	0
Focus on children	68 (35.1)	42	0	16	9	1
Focus on elderly	21 (10.8)	14	1	5	0	1
Studies not focusing on above populations	78 (40.2)	51	3	20	3	1
Total analyses	194 (100)	125 (64.4)	5 (2.6)	47 (24.2)	14 (7.2)	3 (1.5)

Note. BMI = body mass index (defined as weight in kilograms divided by the square of height in meters); PA = physical activity. Totals may not add up to 100% because categories of vulnerable populations are not mutually exclusive. The sample contained 169 articles including 195 analyses.

are strong predictors of child PA and obesity risk.[47–50] We speculate that availability of PA facilities may not be as useful to children as to adults as long as there are parental concerns about neighborhood safety. On the other hand, we found that studies that focused on children in school settings were more likely to find a beneficial result associated with the built environment than studies recruiting from other settings. This raises the question of whether school-related built environments have a larger impact on children's PA than community-based built environment. This may be the case because, in a school setting, PA can be mandated as part of the physical education curriculum; furthermore, in a school setting, issues about neighborhood safety are presumably of less concern to parents. Nevertheless, this line of inquiry may be a useful direction of future research.

TABLE 3—Predictors of "Beneficial" Relationships in Studies Examining the Built Environment and Obesity or Physical Activity: 2000–2011

	Article Finds a Statistically Significant Beneficial Relationship	
Variable	Odds Ratio (95% CI)	Marginal Effect, %
Focus on a Southern state	2.35 (0.37, 14.4)	+2.3
Sample size	1.15 (0.78, 1.70)	0
PA data objectively measured[a]	0.10*** (0.03, 0.35)	−18.0
Study focused on children (aged < 19 y)	0.09*** (0.02, 0.38)	−14.2
Study focused on overweight or obese populations only	2.24 (0.36, 14.1)	+2.8
Academic first author	0.23*** (0.08, 0.70)	−3.4
Sample drawn from		
Home or community (Ref)	1.00	
School	16.8** (1.78, 159.6)	+5.5
Other or unknown	12.9*** (3.22, 52.5)	+6.7
Outcomes variable		
General PA (Ref)	1.00	
Park or trail use	1.43 (0.12, 16.8)	+1.1
Direct measures of obesity (BMI)	0.29* (0.08, 1.09)	−6.2
Active transport	0.14** (0.03, 0.66)	−16.4
Inactivity	0.05*** (0.01, 0.39)	−39.9
Journal type		
Public health or preventive medicine (Ref)	1.00	
Medicine or clinical	6.78 (0.69, 66.5)	+4.1
Physical fitness	26.4*** (6.37, 109.8)	+5.3
Transportation or urban planning	1.0 (0.99, 1.01)	0
Year	1.16 (0.87, 1.53)	+0.5

Notes. BMI = body mass index (defined as weight in kilograms divided by the square of height in meters); CI = confidence interval; PA = physical activity. The sample contained 194 analyses clustered within 169 articles.
[a]Technologically measured (e.g., pedometer) or investigator observed.
*$P < .1$; **$P < .05$; ***$P < .01$.

It is also important to note that certain study characteristics, many of which are suggestive of higher scientific rigor, were associated with a decreased likelihood of finding a beneficial relationship between the built environment and PA or obesity. For example, studies that utilized more objective measures of PA (e.g., use of a pedometer rather than respondent recall) were less likely to identify a desirable relationship between the built environment and PA.[51–53] Furthermore, studies that were led by an academic author, as opposed to an author from industry, a special interest group, or a nonprofit entity, were less likely to report a desirable relationship as well.[54–57] Lastly, studies that examined direct measures of body weight as an outcome variable (e.g., BMI) were less likely than studies that focused on PA to find an effect by the built environment being studied. Although it is conceivable that studies examining BMI failed to have long enough time periods for an effect to be realized, it is worrisome that authors that examine the "holy grail" measure are finding beneficial relationships significantly less often. Although outside the scope of our analysis, issues related to the interplay between the food environment and obesity may have influenced this finding.[58] Clearly, there are many psychosocial,[59] economic,[60] and quality of life[61] benefits of establishing greenways in communities; based on the current empirical evidence, it is less clear that reducing obesity is one of them.

Overall, our findings indicate a major opportunity for researchers to pursue studies that employ more scientifically rigorous tools when studying the effect of the built environment and ensuing health outcomes. A need for higher-quality evidence should become a priority. Recognizing that experimental studies are potentially not feasible in many situations, researchers should look for opportunities to employ quasiexperimental designs.[62,63] One example of such designs is the difference-in-difference approach that seems particularly applicable for the study of environmental changes such as the addition of a greenway to a neighborhood. The difference-in-difference approach is frequently used to study the impact of policy changes in situations not amenable to randomized controlled trials and it examines differences in the outcome of interest for an intervention group before and after the intervention and compares this with the difference in the outcome for a comparison or "control group" over the same time period. The current literature is replete with cross-sectional studies and a shift to more natural experiments and longitudinal studies is warranted to more plausibly investigate whether there is actually a causal effect of built environment on PA and BMI.

Lastly, despite the need for more rigorous studies, our review of the literature also identified considerable gaps. For example, very little research has been done with a specific focus on minority populations especially with regard to their use of parks, school playgrounds, and active transport. This finding is consistent with Casagrande et al.[37] who specifically reviewed studies of the built environment that focused on African American populations. Studies of rural populations are also lacking, especially on park or trail use, school playgrounds usage, and inactivity. Moreover, very few studies that focused on the elderly examined whether active transportation (e.g., walking instead of driving to nearby stores, medical appointments) is a viable option for facilitating PA. Without a stronger scientific basis, and more rigorous studies on populations and concepts that are currently absent from the literature, we risk allocating scarce public health resources to a potentially worthy pursuit on which we have limited information.

Despite the new information provided by our study, there are several limitations worth mentioning. First, we recognize that our search protocol could have potentially missed some studies that were worthy of inclusion. To minimize this possibility, we enlisted the assistance of a library science expert, experimented with various differing search terms, and calibrated our approach to err on the side of including articles in step 1 of our search. Second, it is possible that some information that our code sheet was intended to measure was not listed in the abstract of some published studies. Although we tried to carefully restrict our extracted variables to items most scientific abstracts would include, we recognize that some information may have been missed. Lastly, our sample size of 169 articles and 194 analyses limited our ability for more complex statistical analysis that includes a larger number of covariates. This is especially true given that so few articles focused on particular populations or were drawn from certain settings. As a result of this limited power, we were limited in our analytical options. As the literature continues to grow, especially with more scientifically rigorous studies, future work will be able to further tease out the relationship between the built environment and PA or obesity among different types of studies. ■

About the Authors

All authors are with the Department of Health Care Organization and Policy, University of Alabama at Birmingham.

Correspondence should be sent to Nir Menachemi, PhD, MPH, UAB School of Public Health, RPHB 320, 1530 3rd Ave S, Birmingham, AL 35294-0022 (e-mail: nmenachemi@uab.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted February 9, 2012.

Contributors

A. O. Ferdinand participated in the analysis and interpretation of data, and drafted and revised the article. B. Sen participated in the conceptualization and design of the study, and the analysis and interpretation of data, and drafted and revised the article. S. Rahurkar and S. Engler participated in the analysis and interpretation of data, and helped revise the article. N. Menachemi conceptualized the study and design, participated in the analysis and interpretation of data, and drafted and revised the article. All authors gave approval of the final version of the article.

Acknowledgments

This study was in part funded by the Centers for Disease Control and Prevention under the "Communities Putting Prevention to Work" program (grant 1 U58DP002609-01).

Note. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of any entity.

Human Participant Protection

Institutional review board approval for this study was not needed because investigators did not interact with any human participants and only reviewed data in published articles.

References

1. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999–2008. *JAMA*. 2010;303(3):235–241.

2. Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in U.S. children and adolescents, 2007–2008. *JAMA*. 2010;91(3):519–527.

3. Wang Y, Beydoun MA. The obesity epidemic in the United States—gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. *Epidemiol Rev*. 2007;29:6–28.

4. Centers for Disease Control and Prevention. Differences in prevalence of obesity among Black, White, and Hispanic adults—United States, 2006–2008. *MMWR Morb Mortal Wkly Rep*. 2009;58(27):740–744.

5. Shields M, Tjepkema M. Regional differences in obesity. *Health Rep*. 2006;17(3):61–67.

6. Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? *Annu Rev Public Health*. 2005;26:421–443.

7. Centers for Disease Control and Prevention. U.S. physical activity statistics. 2007. Available at: http://www.cdc.gov/obesity/data/adult.html. Accessed June 22, 2012.

8. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999–2002. *JAMA*. 2004;291(23):2847–2850.

9. Schoenborn CA, Adams PF, Barnes P. Body weight status of adults: United States, 1997–98. *Adv Data*. 2002;(330):1–15.

10. McGinnis JM, Foege WH. Actual causes of death in the United States. *JAMA*. 1993;270(18):2207–2212.

11. Allison DB, Mentore JL, Heo M, et al. Antipsychotic-induced weight gain: a comprehensive research synthesis. *Am J Psychiatry*. 1999;156(11):1686–1696.

12. Koplan JP, Dietz WH. Caloric imbalance and public health policy. *JAMA*. 1999;282(16):1579–1581.

13. Goran MI, Reynolds KD, Lindquist CH. Role of physical activity in the prevention of obesity in children. *Int J Obes Relat Metab Disord*. 1999;23(Suppl 3):S18–S33.

14. Sisson SB, Church TS, Martin CK, et al. Profiles of sedentary behavior in children and adolescents: the US National Health and Nutrition Examination Survey, 2001–2006. *Int J Pediatr Obes.* 2009;4(4):353–359.

15. Wack E, Tantleff-Dunn S. Relationships between electronic game play, obesity, and psychosocial functioning in young men. *Cyberpsychol Behav.* 2009;12(2):241–244.

16. Agazzi H, Armstrong K, Bradley-Klug K. BMI and physical activity among at-risk sixth- and ninth-grade students, Hillsborough County, Florida, 2005–2006. *Prev Chronic Dis.* 2010;7(3):A48.

17. Sallis JF, McKenzie TL, Alcaraz JE, Kolody B, Hovell MF, Nader PR. Project SPARK. Effects of physical education on adiposity in children. *Ann N Y Acad Sci.* 1993;699:127–136.

18. Kann L, Warren CW, Harris WA, et al. Youth risk behavior surveillance—United States, 1995. *MMWR CDC Surveill Summ.* 1996;45(SS-4):1–84.

19. Pate RR, Ross R, Dowda M, Trost SG, Sirard JR. Validation of a 3-day physical activity recall instrument in female youth. *Pediatr Exerc Sci.* 2003;15:257–265.

20. Centers for Disease Control and Prevention. Youth Risk Behavior Surveillance–United States, 2005. *MMWR Surveill Summ.* 2006;55(5):1–108.

21. Sallis JF, Glanz K. The role of the built environments in physical activity, eating, and obesity in childhood. *Future Child.* 2006;16(1):89–108.

22. Jackson RJ. The impact of the built environment on health: an emerging field. *Am J Public Health.* 2003;93(9):1382–1384.

23. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. *Annu Rev Public Health.* 2006;27:297–322.

24. Aytur SA, Rodriguez DA, Evenson KR, Catellier DJ, Rosamond WD. The sociodemographics of land use planning: relationships to physical activity, accessibility, and equity. *Health Place.* 2008;14(3):367–385.

25. Craig CL, Brownson RC, Cragg SE, Dunn AL. Exploring the effect of the environment on physical activity: a study examining walking to work. *Am J Prev Med.* 2002;23(2 Suppl):36–43.

26. Smith KR, Brown BB, Yamada I, Kowaleski-Jones L, Zick CD, Fan JX. Walkability and body mass index density, design, and new diversity measures. *Am J Prev Med.* 2008;35(3):237–244.

27. Davison KK, Werder JL, Lawson CT. Children's active commuting to school: current knowledge and future directions. *Prev Chronic Dis.* 2008;5(3):A100.

28. Dollman J, Lewis NR. Active transport to school as part of a broader habit of walking and cycling among South Australian youth. *Pediatr Exerc Sci.* 2007;19(4):436–443.

29. De Bourdeaudhuij I, Sallis JF, Saelens BE. Environmental correlates of physical activity in a sample of Belgian adults. *Am J Health Promot.* 2003;18(1):83–92.

30. 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.

31. Sister C, Wolch J, Wilson J. Got green? Addressing environmental injustice in park provision. *GeoJournal.* 2010;75(3):229–248.

32. Active Living Research. *Designing for Active Living Among Adults.* 2008. Available at: http://www.activelivingresearch.org/files/Active_Adults.pdf. Accessed September 15, 2011.

33. Feng J, Glass T, Curriero F, Stewart W, Schwartz B. The built environment and obesity: a systematic review of the epidemiologic evidence. *Health Place.* 2010;16(2):175–190.

34. Durand CP, Andalib M, Dunton GF, Wolch J, Pentz MA. A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. *Obes Rev.* 2011;12(5):e173–e182.

35. Brownson RC, Hoehner CM, Day K, Forsyth A, Sallis JF. Measuring the built environment for physical activity: state of the science. *Am J Prev Med.* 2009;36(4 Suppl):S99–S123.

36. Kirk SF, Penney TL, McHugh TL. Characterizing the obesogenic environment: the state of the evidence with directions for future research. *Obes Rev.* 2010;11(2):109–117.

37. Casagrande SS, Whitt-Glover MC, Lancaster KJ, Odoms-Young AM, Gary TL. Built environment and health behaviors among African Americans: a systematic review. *Am J Prev Med.* 2009;36(2):174–181.

38. Lovasi GS, Hutson MA, Guerra M, Neckerman KM. Built environments and obesity in disadvantaged populations. *Epidemiol Rev.* 2009;31:7–20.

39. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. *Epidemiol Rev.* 2007;29:129–143.

40. Ahlfeldt G, Maennig W. Arenas, arena architecture and the impact on location desirability: the case of "Olympic Arenas" in Prenzlauer Berg, Berlin. *Urban Stud.* 2009;46(7):1343–1362.

41. Ahrentzen S. On their own turf: community design and active aging in a naturally occurring retirement community. *J Hous Elder.* 2010;24(3-4):267–290.

42. Aksenova TI, Chibirova OK, Dryga OA, Tetko IV, Benabid AL, Villa AE. An unsupervised automatic method for sorting neuronal spike waveforms in awake and freely moving animals. *Methods.* 2003;30(2):178–187.

43. Farley TA, Meriwether RA, Baker ET, Watkins LT, Johnson CC, Webber LS. Safe play spaces to promote physical activity in inner-city children: results from a pilot study of an environmental intervention. *Am J Public Health.* 2007;97(9):1625–1631.

44. Burdette HL, Whitaker RC. Neighborhood playgrounds, fast food restaurants, and crime: relationships to overweight in low-income preschool children. *Prev Med.* 2004;38(1):57–63.

45. Grafova IB. Overweight children: assessing the contribution of the built environment. *Prev Med.* 2008;47(3):304–308.

46. Norman GJ, Nutter SK, Ryan S, Sallis JF, Calfas KJ, Patrick K. Community design and access to recreational facilities as correlates of adolescent physical activity and body-mass index. *J Phys Act Health.* 2006;3(suppl 1):S118–S128.

47. Ferreira I, Van der Horst K, Wendel-Vos W, Kremers S, Van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth—a review and update. *Obes Rev.* 2007;8(2):129–154.

48. Kerr J, Rosenberg D, Sallis JF, Saelens BE, Frank LD, Conway TL. Active commuting to school: associations with environment and parental concerns. *Med Sci Sports Exerc.* 2006;38(4):787–794.

49. Lumeng JC, Appugliese D, Cabral HJ, Bradley RH, Zuckerman B. Neighborhood safety and overweight status in children. *Arch Pediatr Adolesc Med.* 2006;160(1):25–31.

50. Sen B, Mennemeyer S, Gary L. The relationship between perceptions of neighborhood characteristics and obesity among children. In: Grossman M, Mocan NH, eds. *Economic Aspects of Obesity.* Chicago, IL: University of Chicago Press; 2011:145–180.

51. Fitzhugh EC, Bassett DR, Evans MF. Urban trails and physical activity: a natural experiment. *Am J Prev Med.* 2010;39(3):259–262.

52. Cohen DA, Golinelli D, Williamson S, Sehgal A, Marsh T, McKenzie TL. Effects of park improvements on park use and physical activity: policy and programming implications. *Am J Prev Med.* 2009;37(6):475–480.

53. Evenson KR, Murray DM, Birnbaum AS, Cohen DA. Examination of perceived neighborhood characteristics and transportation on changes in physical activity and sedentary behavior: The Trial of Activity in Adolescent Girls. *Health Place.* 2010;16(5):977–985.

54. Haerens L, Craeynest M, Deforche B, Maes L, Cardon G, De Bourdeaudhuij I. The contribution of home, neighbourhood and school environmental factors in explaining physical activity among adolescents. *J Environ Public Health.* 2009. Available at: http://www.hindawi.com/journals/jeph/2009/320372/cta. Accessed June 29, 2012.

55. Oakes JM, Forsyth A, Schmitz KH. The effects of neighborhood density and street connectivity on walking behavior: the Twin Cities walking study. *Epidemiol Perspect Innov.* 2007;4:16.

56. Van Dyck D, Cardon G, Deforche B, Owen N, Sallis JF, De Bourdeaudhuij I. Neighborhood walkability and sedentary time in Belgian adults. *Am J Prev Med.* 2010;39(1):25–32.

57. Lovasi GS, Moudon AV, Pearson AL, et al. Using built environment characteristics to predict walking for exercise. *Int J Health Geogr.* 2008;7:10.

58. Cerin E, Frank L, Sallis J, et al. From neighborhood design and food options to residents' weight status. *Appetite.* 2011;56(3):693–703.

59. Abildso CG, Zizzi S, Abildso LC, Steele JC, Gordon PM. Built environment and psychosocial factors associated with trail proximity and use. *Am J Health Behav.* 2007;31(4):374–383.

60. Guo JY, Gandavarapu S. An economic evaluation of health promotive built environment changes. *Prev Med.* 2010;50(suppl 1):S44–S49.

61. Sarmiento OL, Schmid TL, Parra DC, et al. Quality of life, physical activity, and built environment characteristics among Colombian adults. *J Phys Act Health.* 2010;7(suppl 2):S181–S195.

62. Rohrer JE. Quasi-experimental evaluation without regression analysis. *J Public Health Manag Pract.* 2009;15(2):109–111.

63. Currie J, Ray SH, Neidell M. Quasi-experimental studies suggest that lowering air pollution levels benefits infants' and children's health. *Health Aff (Millwood).* 2011;30(12):2391–2399.