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The built environment and physical activity: What is the relationship?

See companion Policy Brief available at *www.policysynthesis.org*

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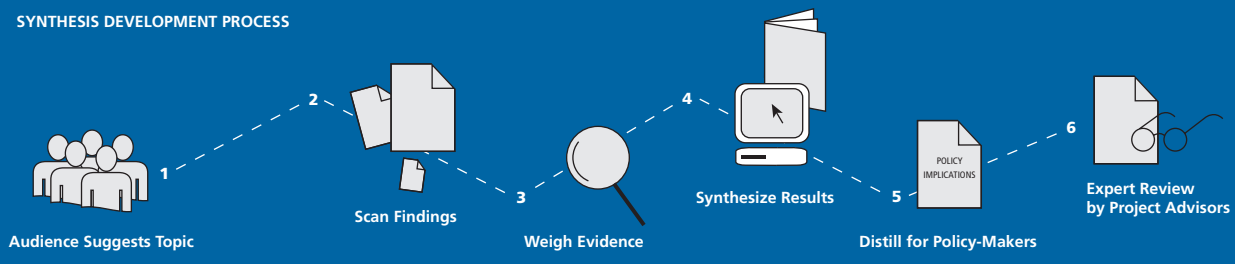
THE SYNTHESIS PROJECT (Synthesis) is an initiative of the Robert Wood Johnson Foundation to produce relevant, concise, and thought-provoking briefs and reports on today's important health policy issues. By synthesizing what is known, while weighing the strength of findings and exposing gaps in knowledge, Synthesis products give decision-makers reliable information and new insights to inform complex policy decisions. For more information about the Synthesis Project, visit the Synthesis Project's Web site at *www.policysynthesis.org*. For additional copies of Synthesis products, please go to the Project's Web site or send an e-mail request to *pubsrequest@rwjf.org*.

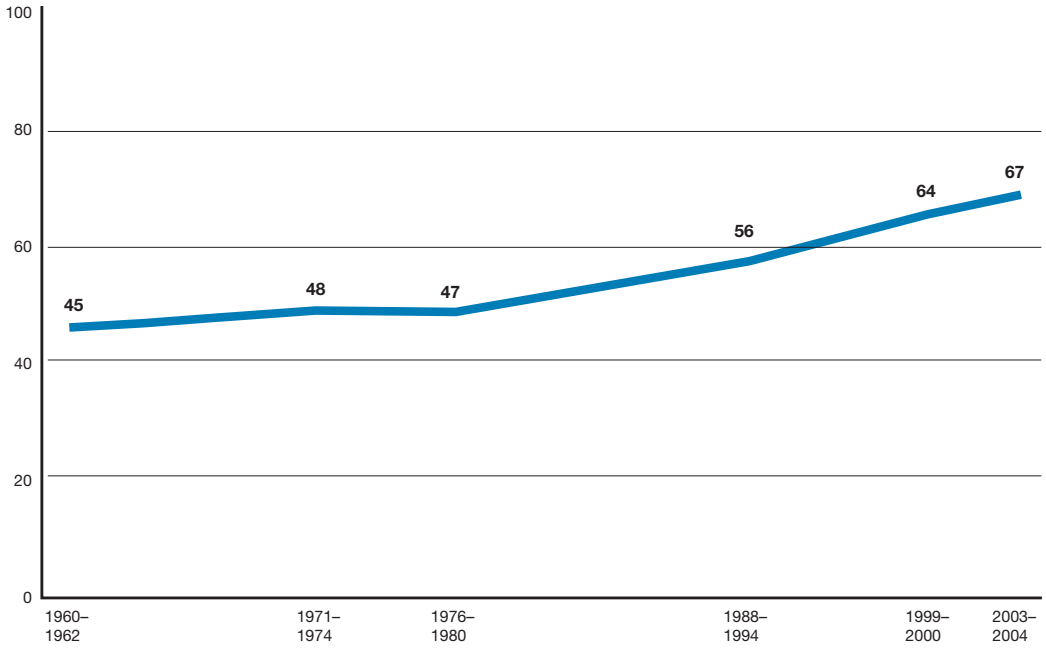


Introduction

Why is this issue important to policy-makers?

Obesity is the second leading cause of preventable death in the U.S., contributing to more than 100,000 deaths annually and a growing burden of chronic disease. Rates of obesity have increased rapidly since the 1980s (Figure 1), prompting health experts and policy-makers to explore its causes and potential solutions.

Figure 1. Trend in adult obesity (age-adjusted percent of U.S. adults aged 20–74 who are overweight or obese), 1960–2004



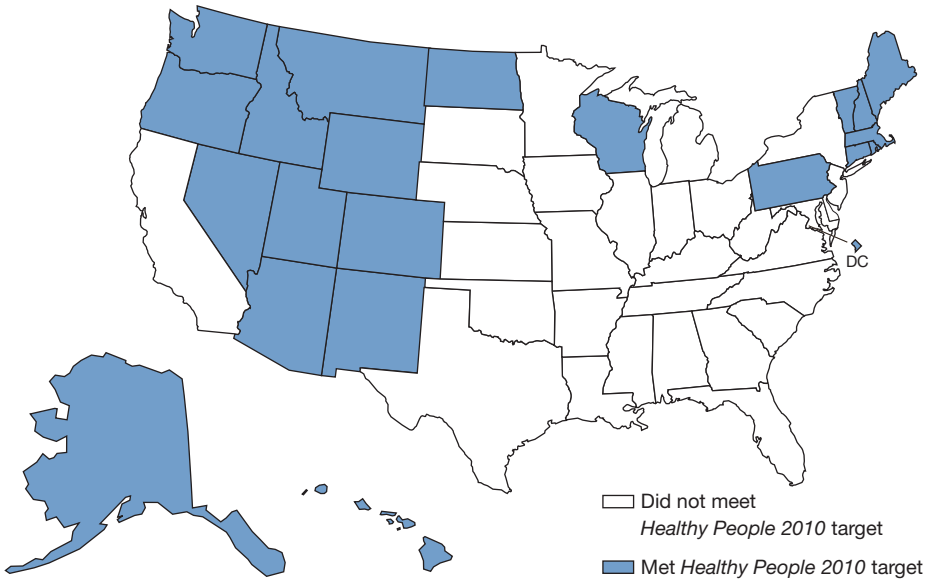
Source: CDC, NCHS: National Health Examination Survey and National Health and Nutrition Examination Survey.

The alarming increase in overweight and obesity has likely resulted from a confluence of changes in U.S. food and activity norms over the last several decades. Consumption of sugar sweetened beverages and of food purchased away from home–served in larger portions and of lower nutritional quality than home-cooked food–has increased dramatically, while the share of trips made on foot or bicycle has declined. Children spend more time watching television–during which time they are exposed to advertisements for candy, sweetened cereal and sodas–yet the proportion of children with daily physical education at school has declined.

Efforts to address obesity have focused on both eating patterns and physical activity, the two sides of the energy balance equation. Regular physical activity helps prevent obesity, heart disease, hypertension, diabetes, colon cancer and premature mortality. Despite its benefits, many Americans are not sufficiently active, and only 21 states and the District of Columbia meet the *Healthy People 2010* goal for adult physical activity (Figure 2).

Introduction

Figure 2. States meeting Healthy People 2010 *target: at least 50 percent of adults have achieved recommended levels of physical activity, 2003*



Source: CDC, BRFSS.

Traditionally, interventions to increase physical activity and combat obesity have targeted individual behavior change through education and promotion. There is increasing recognition by researchers and public health leaders, however, of the need to expand the focus of interventions to the environments and contexts in which poor nutrition and lack of activity occurs; whether in lunchrooms with poor food choices or in communities whose design promotes car-reliance. This focus has spawned a relatively new body of research examining the role of the community "built environment" in promoting or discouraging physical activity.

Characteristics of the built environment have the potential to influence both recreational and travel-related physical activity. For instance, certain features of the neighborhood environment–sidewalks, streetlights and terrain–might make recreational activity more appealing or safe. Meanwhile, other characteristics such as residential density, proximity to destinations and grid-like street patterns might make it easier or more pleasant to walk or bicycle for transportation.

This synthesis divides the built environment features that are hypothesized to be associated with either travel-related or recreational activity into four categories: recreational resources, land use characteristics, neighborhood form and community environment (Figure 3).

Introduction

Figure 3. Community features included in four built environment categories

Recreational resources include walking trails, biking trails, parks and open spaces. This analysis focuses on recreational resources that are part of the outdoor community environment and not private and public indoor facilities (gyms, pools, etc.).

Land use characteristics include residential and employment density, land use mix (what types of buildings, services and businesses are in the community), street connectivity (are the streets designed in a grid pattern or broken up by cul-de-sacs and loops) and proximity of destinations (shops, employment and services) to residences.

Neighborhood form characteristics include availability of sidewalks and streetlights.

Community environment characteristics include mostly contextual features of the environment such as aesthetics, cleanliness, traffic and crime safety and community support or cohesion.

While the research to date explores the associations between environmental characteristics and activity, the ultimate interest in this area of research is to determine if changes to the built environment could promote greater activity in America's communities. By affecting whole communities, not just individuals enrolled in a particular intervention or educational effort, these changes have the potential to create broad-based and lasting population impact.

This research synthesis examines what we know about how the physical or built environment affects activity and outlines the potential policy implications of these findings. After discussing methodological issues in the literature, the synthesis is organized by the following key questions:

- What is the association between the built environment and physical activity?
- Does the association between the built environment and activity vary across subgroups?
- What is the impact of the built environment on health?

What methodological issues do researchers face?

This synthesis reviews two distinct bodies of evidence; studies produced by physical activity (public health) researchers and those conducted by transportation researchers. The two groups use different explanatory models and measures of activity and of the environment in their research (Figure 4). Physical activity researchers rely on the social ecological model to examine and explain physical activity behavior, but do not typically examine travel-related activity. The social ecological model assumes there are multiple influences on a person's behavior including individual characteristics and preferences as well as the social, cultural and physical environment. By contrast, transportation researchers use demand theory to explain travel behavior, examining the feasibility, costs and benefits of different transportation choices. This model and its variations were mainly developed to forecast travel choices by car or transit, although transportation studies increasingly incorporate measures of active travel by foot or bicycle. The two different approaches can have an important effect on the types of findings and conclusions drawn by researchers.

Figure 4. Examples of outcome and explanatory measures used in physical activity and transportation research

	Physical activity research	Transportation research
Outcome measures	**Walking measures** include: • Total minutes walked • Steps walked • Walking "as recommended" Some studies distinguish walking for recreation from walking for transportation, while others do not. **Overall activity measures** include minutes spent in any, moderate or vigorous activity. These data are sometimes used to assign an activity level to survey respondents (e.g., "active," "inactive" and "insufficiently active").	**Transportation choice measures** include the number or share of trips made by car, foot or bicycle.
Explanatory measures	• Availability of parks • Presence of sidewalks, streetlights and hills • Proximity of destinations • Social support and cohesion	• Residential or commercial density • Street connectivity • Land use mix • Proximity of destinations • Presence of sidewalks and transit

The overwhelming majority of evidence on the association of the built environment and activity is from cross-sectional studies. The better studies use multivariate analyses to examine the association of explanatory variables (community and individual characteristics) and outcome variables (measures of activity or travel mode) at a single point in time. While useful to explore associations, the cross-sectional design does not allow determinations about causality–e.g., does the presence of sidewalks in a community lead to more walking–as would findings of more rigorous randomized or longitudinal studies.

In addition to the problem of establishing causality, we face several other challenges when analyzing the relationship of the built environment and physical activity (see Appendix II for a more detailed discussion of the methodological challenges in the literature).

- Because of the clustering of community characteristics, reaching conclusions about the relative importance or independent contribution of different factors is difficult.
- Studies do not use consistent measures of activity and this outcome is usually self-reported.
- Community characteristics are best measured at the neighborhood level, yet because of data limitations several studies have examined much larger geographical units such as counties or MSAs, potentially diluting results.
- Including both subjective and objective measurement of some community characteristics–especially proximity of destinations, safety and aesthetics–is important given evidence of differences between objective and perceived assessments, yet most studies report only one or the other.

Introduction

How does this synthesis weigh the evidence?

Confidence in results from cross-sectional studies can be greatly increased–and plausibility of alternative explanations of findings decreased–by reliance on stronger evidence:

- From studies with strong methodologies and approaches (e.g., studies using appropriate sample selection and adequate sample size, multivariate analysis, high response rates and valid and reliable measures).
- Drawn from research with good controls for individual characteristics that might also influence activity, including personal preferences and values.
- That is consistent with findings from other strong studies.

To ensure reliance on the strongest findings, this synthesis used a structured approach to evaluate the evidence base. First, we identified a set of studies published since 2000 that examined the association of built environment and physical activity among adults. We then used several established criteria of study quality to evaluate the evidence and rank the relevant studies on a three-tiered scale by the strength of their methodologies (see Appendix II in this document and Attachment I available at *www.policysynthesis.org*). Studies with scores in the lowest tier (Tier I) are not generally used in this synthesis to evaluate evidence and reach conclusions. Those with scores in the middle (Tier II) and highest (Tier III) tiers are used to evaluate evidence and reach conclusions, with greater weight given to studies in the highest tier.

Findings of Previous Reviews

Previous literature reviews have tended to reach similar conclusions about the relationship of physical activity and the built environment (see Appendix II for a more detailed discussion):

- Several built environment characteristics are associated with activity.
- While causality cannot be proved, there is evidence that the environment plays at least a facilitative role in promoting activity.
- There is insufficient evidence to make specific recommendations on changes to the built environment.
- While reviews decline to make specific policy recommendations because of the weakness in the evidence base, they generally support the development and study of more walkable and activity-friendly communities.

As discussed above, this Synthesis adopts a structured approach to analyzing and weighing the evidence and distills the results of the many recently published studies in both the physical activity and transportation literatures.

Findings

What is the association between the built environment and physical activity?

Recreational Resources

Parks and open spaces are associated with walking for transportation but not with recreational walking.

Researchers hypothesize that the availability, proximity and quality of public open space, parks and walking and biking trails are associated with recreational, and possibly transportation, activity. Three studies do find an association between access to parks and open spaces and walking for transportation, but none finds an association with walking for recreation (Figure 5). These results are not intuitive, as it would seem reasonable that parks would be used primarily for recreational walking. But as Zlot (83) hypothesizes, parks might provide safe and accessible routes to shops or other locations, facilitating walking for transportation. The evidence is mixed or too limited to reach conclusions for all other relationships.

Figure 5. Study findings on association between recreational resources and activity

Measures	Studies	Findings
Overall physical activity*		
Access to/availability of parks, and open spaces	**Brownson** (13) Giles-Corti (38) Gordon-Larson (39) Sharpe (78) **Wilcox (82)**	- + + None None
Walking/biking routes	De Bourdeaudhuij (22) Huston (52) Sharpe (78)	None + +
Overall walking		
Access to parks, etc.	Giles-Corti (35)	+
Walking/biking routes	De Bourdeaudhuij (22) King (56)	None None
Walking for transportation		
Access to parks, etc.	Giles-Corti (38) Zlot (83)	+ +
Walking/biking routes	Craig (18)	+
Walking for recreation		
Access to parks, etc.	Giles-Corti (38) Li (63) Zlot (83)	None None None

**Different measures are employed but many use the CDC physical activity categories (moderate, insufficient, inactive).*

Strongest studies shown in **bold**.

Findings

Land Use Characteristics

Living close to desirable destinations—jobs, services, stores—is associated with walking.

Researchers hypothesize that older and more traditional community designs characterized by shops within walking distance of residences, higher residential density and a grid street structure are more conducive to activity–and specifically walking–than newer suburban communities with cul-de-sac street formation, lower residential and employment density and longer distances between residences and shopping and service destinations.

Some previous reviews of the literature have relied on studies that do not meet our evidence thresholds (2, 15) to conclude that there is a strong and consistent association between traditional community designs and activity. Our analysis only partly confirms these findings (Figure 6). Studies find a positive relationship between proximity to destinations such as shops and services and overall walking and walking for transportation. The evidence on the association of walking and density, land use mix and street connectivity is limited or mixed and does not allow any firm conclusions.

Figure 6. Study findings on association between land use characteristics and walking

Measures	Studies	Findings
Overall walking		
Proximity to destinations/ number and variety of destinations	De Bourdeaudhuij (22) Handy (41) King (36)	+ + +
Residential density	De Bourdeaudhuij (22)	None
Employment density	Li (63)	+
Street connectivity	De Bourdeaudhuij (21) De Bourdeaudhuij (22) Li (63)	None None +
Composite "walkability" measure	**Berrigan (7)** **Doyle (23)** **Ewing (28)**	+ + +
Walking for transportation		
Proximity to destinations/ number and variety of destinations	Craig (18) Giles-Corti (38) Handy (41) **Hoehner (46)** Lee (62)	- + + + +
Residential density	Besser (8) Lee (62)	+ +
Greater land use mix	De Bourdeaudhuij (21)	+
Walking for recreation		
Proximity to destinations/ number and variety of destinations	Lee (62)	None
Residential density	Lee (62) Li (63)	None None
Greater land use mix	De Bourdeaudhuij (21)	+
Street connectivity	Lee (62)	None

Strongest studies shown in **bold**.

Findings

Despite the lack of findings on specific measures, there is an association between the overall "walkability" of communities and walking.

Despite the lack of findings on several individual land use variables, three of the strongest studies have found an association between composite "walkability" indices and walking (Figure 6). Either through a proxy variable (e.g., age of house) or by combining several land use variables into an index measuring land use mix, residential density and connectivity (Figure 7), these studies examine the relationship of the built environment and walking. Interestingly, none of the indices directly measures proximity to destinations, the only measure with a strong and consistent association with walking in the analysis of individual variables.

Figure 7. Variables included in composite "walkability" measures

Author	Variable included
Berrigan (7)	Living in an urban or suburban home built before 1974
Doyle (23)	Average block length/size and number of intersections per road mile
Ewing (28)	Residential density, land use mix, degree of centering[1] and street accessibility
Frank (31)	Land use mix, residential density, intersection density

The positive association between these composite measures and walking contrasted with limited or mixed findings for individual built environment variables likely reflects at least two issues. First, few stronger studies have examined the association between individual land use variables and activity. Second, neighborhood features such as connectivity, mixed use, density and proximity of destinations often co-occur, so that the variables are highly correlated.[2] Their individual explanatory power is reduced by inclusion of several of these variables in a model. To address this issue, some authors have constructed indices combining several variables while others only include the variables with the most explanatory power in regression models.

Two studies (28, 31) examined the association of the "walkability" indices and overall activity levels, rather than walking, with mixed findings. Only one (31) found a positive relationship.

Neighborhood Form

Sidewalks are associated with walking.

Eleven studies meeting our evidence thresholds examine the association of sidewalks and activity (overall activity or walking) and six investigate the association of streetlights and activity (Figure 8). The authors' hypothesize that these community features will be positively associated with activity because they make neighborhood-based activity safer and more enjoyable. Consistent with this hypothesis, five studies find that sidewalks are positively associated with *walking*, while the majority of studies fine no association between sidewalks and measures of *overall activity* (e.g., meeting recommendations for activity or being moderately and vigorously active).

1 Development is focused on core and regional subcenters.

2 De Bourdeaudhuij (21) found intercorrelations of above .50 among the variables of land use mix, residential density, availability of sidewalks, ease of walking to public transport and street connectivity. Frank also found high correlation between residential density, connectivity and land use mix.

Findings

What explains the finding that sidewalks–like proximity to destinations and parks and open spaces–are associated with walking but not necessarily with overall activity? It may be that while sidewalks facilitate walking, walking substitutes for other forms of activity. Alternatively, it could be that any additional walking associated with sidewalks or other features is not sufficient to achieve the thresholds used for measuring overall activity (e.g., "active" versus "inactive"). Additional research is needed to address more nuanced questions about how features of the built environment are associated with discrete measures of activity and with meeting physical activity guidelines.

The evidence fairly consistently indicates no association between streetlights and overall activity, but there are too few studies to reach any conclusions on the relationship between streetlights and walking.

Figure 8. Study findings on association between neighborhood form characteristics and activity

Measures	Studies	Findings
Overall physical activity*		
Sidewalks	**Brownson (13)** De Bourdeaudhuij (22) Giles-Corti (38) **Hoehner (46)** Huston (52) **King (55)** Sharpe (78) **Wilcox (82)**	+ None None None None None + None
Streetlights	Addy (1) **Brownson (13)** Huston (52) **King (55)** Sharpe (78)	+ None None None None
Overall walking		
Sidewalks	Addy (1) De Bourdeaudhuij (22)	+ +
Walking for transportation		
Sidewalks	Giles-Corti (38) Lee (62) Troped (81)	+ None +
Streetlights	Troped (81)	+
Walking for recreation		
Sidewalks	De Bourdeaudhuij (21) Giles-Corti (38) Lee (62)	+ None +

**Different measures are employed but many use the CDC physical activity categories (moderate, insufficient, inactive).*

Strongest studies shown in **bold.**

Findings

Community Environment

Attractiveness of the neighborhood environment is associated with overall activity and with recreational walking.

Four studies (including three of the strongest) find a positive relationship between attractive neighborhood aesthetics (enjoyable scenery, neighborhood pleasant, attractive appearance of neighborhood) and measures of overall physical activity (Figure 9). Little is known about the precise attributes of an "aesthetically pleasing" environment that are associated with activity, and how this evaluation might vary from person to person. There is also evidence that recreational walking and walking in general are associated with aesthetics, and a mix of findings on the association of walking for transportation and aesthetics.

Social and community support are also predictors of activity.

Four studies, including two of the strongest, find that residents of neighborhoods where many people are seen exercising or where they perceive social support for activity are more likely to be active. Similarly, two studies find that community support and cohesion are related to measures of walking.[1] An important topic for future research is how social support features might interact with features of the built environment to promote or deter activity.

While crime and heavy traffic might be expected to deter activity, several studies find the opposite: the presence of heavy traffic and crime are positively or not associated with activity.

Recent studies find that four variables thought to be barriers to neighborhood-based activity–high crime, high traffic, hills and unattended dogs–are not associated or are positively associated with activity (Figure 9). Perhaps the most surprising finding is the consistent lack of an association between crime and measures of activity found in eight separate studies. Also unexpectedly, seven studies find no association between traffic and activity (walking or overall activity) while three find a positive relationship (more traffic is associated with more activity). Only one study finds the expected inverse relationship (more traffic is associated with less activity).

1 Three out of five of the studies with positive findings included control variables for community safety, which might be correlated with social support and cohesion measures.

Findings

Figure 9. Study findings on association between community environment characteristics and activity

Measures	Studies	Findings
Overall activity*		
Positive aesthetics	**Brownson (13)**	+
	De Bourdeaudhuij (22)	None
	Giles-Corti (38)	None
	Hoehner (46)	+
	King (55)	+
	Wilcox (82)	+
Community support or cohesion	**Brownson (13)**	+
	De Bourdeaudhuij (22)	None
	Giles-Corti (38)	+
People active in neighborhood	Addy (1)	+
	Brownson (13)	+
	King (55)	+
Hills	**Brownson (13)**	+
	King (55)	+
	Wilcox (82)	None
Heavy traffic	**Brownson (13)**	+
	De Bourdeaudhuij (22)	None
	Hoehner (46)	None
	Huston (52)	+
	King (55)	None
	Sharpe (78)	None
	Wilcox (82)	None
High crime	**Brownson (13)**	None
	De Bourdeaudhuij (22)	None
	Hoehner (46)	None
	Huston (52)	None
	King (55)	None
	Wilcox (82)	None
Unattended dogs	**Brownson (13)**	None
	Huston (52)	None
	Wilcox (82)	None
Overall walking		
Positive aesthetics	Handy (41)	+
	Handy (42)	+
People active in neighborhood	Troped (81)	None
Hills	Troped (81)	None
Heavy traffic	Troped (81)	None
High crime	De Bourdeaudhuij (22)	None
	Troped(81)	None
Walking for transportation		
Positive aesthetics	Craig (18)	None
	De Bourdeaudhuij (22)	None
	Handy (41)	+
	Lee (62)	None
	Troped (81)	+
Community support or cohesion	De Bourdeaudhuij (21)	+
People active in neighborhood	Craig (18)	-
Hills	Lee (62)	-
Heavy traffic	Craig (18)	-
	Giles-Corti (38)	+
	Lee (62)	None
Walking for recreation		
Positive aesthetics	Giles-Corti (38)	+
	Humpel (48)	+
	Humpel (49)	+
	Humpel (50)	+
	Lee (62)	+
Community support or cohesion	Giles-Corti (38)	+
Hills	Lee (62)	+
Heavy traffic	Lee (62)	None
High crime	Li (63)**	None

** Different measures are employed but many use the CDC physical activity categories (moderate, insufficient, inactive).*

*** The measure used is "safe to walk," which is distinguished from "safe from traffic."*

Strongest studies shown in **bold.**

The unexpected positive association between traffic and activity is perhaps due to unmeasured differences among communities. As Brownson (13) and other authors indicate, more walkable urban communities are often also areas with more traffic. Residents of these neighborhoods are also more likely to have low incomes and not own cars–two variables associated with walking for transportation (8, 30, 38). Other possible explanations for the positive association between traffic and activity are that variables are poorly defined, that there is little variability among communities studied or that people active in the community are more likely to be aware of safety features of the community.

Activity-promoting features vary for recreational and transportational walking.

The evidence above indicates that some characteristics of the built environment are associated with walking, but not with overall activity measures, and some are associated with recreational walking but not with walking for transportation. A subset of studies (38, 62, 81) have examined the environmental features associated with each type of walking, permitting an investigation of these divergent patterns (Figure 10). A flaw of these studies, however, is that they typically do not include many of the land use and some of the urban form measures (connectivity, density, proximity of destinations, mixed development) that might be associated with activity and, especially, with walking for transportation.

The studies show that some environmental features are associated with both walking for transport and recreation, while others are associated with one and not the other.

- Studies find that neighborhood aesthetics, social support, sidewalks and streetlights are associated with both recreational and transportation activity, but no single study finds both associations for any variable.
- One study finds that hills are negatively associated with transportation activity but positively associated with recreational activity. A possible explanation is that while hills may increase the interest and pleasure in recreational walking, they are experienced as a barrier to getting to a destination for transportational walking.
- As might be expected, proximity to destinations is associated with transportational but not with recreational walking.

Figure 10. Association of community characteristics and recreational and transportational walking in studies examining both types of activity

Measures	Studies	Association with recreational walking*	Association with walking for transportation*
Scenery aesthetics	Giles-Corti (38) Lee (62) Troped (81)	+ +	 +
Social environment	Giles-Corti (38) Lee (62)	+	 +
Sidewalks/streetlights	Giles-Corti (38) Lee (62) Troped (81)	 +	+ +
Hills	Lee (62)	+	-
Proximity to stores, other destinations	Giles-Corti (38) Lee (62) Troped (81)		+ + +**

*Null findings are not shown. **Proximity to rail/trail.

Does the association between the built environment and activity vary across subgroups?

This section of the Synthesis examines whether built-environment/activity relationships and exposure to built environment features are consistent or vary among groups.

Racial and ethnic minorities are more likely to walk for transportation, but overall activity is lower than for whites.

Racial and ethnic minorities are more likely to live in walkable communities and walk for transportation (8) than are whites. Socioeconomics may largely drive these findings. Minority groups are more likely to be poor and live in poor neighborhoods, and people in these neighborhoods–regardless of race–are more likely to walk for transportation (62) than those in other areas. Three factors may contribute to higher walking in poorer areas; lower car ownership, design features associated with walkability typically found in urban neighborhoods and the "contagion" effect of seeing others exercising.

Despite a higher level of walking and transportational activity, minority groups including Latinos and African Americans are less likely than whites to be active overall, primarily because of much lower recreational and vigorous activity levels. Survey data from the Behavioral Risk Factors Sample Survey and the National Health Interview Survey show that physical activity levels are lower for women, racial minorities and people with lower income or less education.

Findings

There are important differences in the community characteristics and perceptions of safety across racial and ethnic groups.

Differences in the attractiveness and social support of the neighborhood may partially explain lower levels of recreational activity among some groups. Giles-Corti (38) found that respondents in low socioeconomic areas ranked their neighborhoods as being less attractive and having less social support than people living in higher socioeconomic areas. Once the analysis controlled for these variables, the socioeconomic status of the neighborhood did not have a significant influence on activity.

There may also be differences in how different groups perceive their environments. One study found that African Americans are more likely to give a lower safety rating to the same community than whites, regardless of the racial composition of the neighborhood (11). The importance of social context also varies by community and group. King (55) found that seeing others exercising was associated with activity for African Americans, but not for other groups.

Some evidence suggests that community features are more strongly associated with women's than with men's activity.

Several studies have examined differences between men and women in their response to the built environment. Two authors (13, 23) find that community characteristics are more highly associated with activity for women than for men, although another finds that after controlling for personal preferences men's activity but not women's is associated with built environment characteristics (6). There is also evidence that men and women have different perceptions of their neighborhoods (6) and that men are more active, but women not necessarily so, in areas with greater proximity to destinations (6, 22).

Children and adults may respond to the built environment in different ways.

The focus of this synthesis is to weigh the evidence on the relationship of physical activity and the built environment for adults, but exploring how this relationship might differ for children is also worthwhile. Handy has hypothesized that typical suburban community design–with cul-de-sacs available for street play–may promote young children's activity, but not adults'. Suburban communities have many attributes–low street connectivity, long distance to destinations and low density and land use mix–that decrease walkability. But if the perceived safety of suburbs and suburban design promotes outside play, children in these areas are likely to be more active (playing outside is one of the strongest predictors of young children's activity) (75). This possible difference should be tested with focused research examining children and adults' responses to the built environment.

But similar to adults, children may be more likely to walk for transportation if an area is more "walkable." Results from Frank (30) indicate that older children in communities with higher street connectivity, mixed land use and density are more likely to walk at least half a mile a day for transportation. Such walking is most responsive to community design features among young adolescents, possibly because they have more opportunities to walk than younger children who are not yet walking independently and than older adolescents who can drive.

Findings

How does research handle self-selection?

The choice of where to live might be closely tied to the likelihood of engaging in activity, confounding results.

Studies suggest that both preferences and built environment features affect travel choices, but the same has not yet been shown for physical activity.

People with a high motivation to exercise or walk for transportation might select neighborhoods with built environment features facilitating these activities. That they are more active than people in other areas may then be primarily due to the personal preferences that drove their selection of residence location, and only secondarily due to the activity-enhancing features of the community they chose. Researchers employ several strategies to address this problem of self-selection (see Appendix II).

Several studies in the transportation literature (see Appendix II) use strategies to control for personal preferences and self-selection that are not yet in common use in physical activity research. The studies generally find that both preferences and community attributes influence *travel mode*–with preferences generally shown to be more important than the built environment. Evidence is inconclusive on whether the built environment is associated with *activity* after controlling for personal choices. Findings underscore that caution should be used in interpreting the results of weaker cross-sectional studies.

What is the impact of the built environment on health?

Research evidence is inconclusive on the association of sprawl and overweight.

There are six strong studies (5, 23, 24, 26, 28, 65) examining the relationship of sprawl and overweight (Figure 11). The best of these use longitudinal analyses to control for self-selection and do not find an association between sprawl and overweight (24, 26). The four other studies (23, 28, 35, 65) finding an association between measures of the built environment and overweight use cross-sectional analyses and do not control for self-selection (Figure 11). Similarly, the evidence base is inconclusive for the relationship between built environment measures and chronic health problems.

Figure 11. Findings on association between built environment characteristics and overweight, obesity and chronic health problems

Author/measures	Obese	Overweight/ higher BMI	Chronic health problems
Balfour (5) Heavy traffic, inadequate lighting, access to transportation			+*
Doyle (23) Low walkability		+	None
Eid (24) Sprawl index Mixed use *Controlled for self-selection*	None		
Ewing (26) Sprawl index *Controlled for self-selection*	None	None	
Ewing (28) Sprawl index	+	+	Mixed**
Giles-Corti, 2005 (35) No proximity to shops No paths/ sidewalks	+	+	
Lopez (65) Sprawl index	+	+	

** Function loss.*

*** Positive association for hypertension, but not for diabetes and coronary artery disease.*

Strongest studies shown in **bold.**

Few studies of interventions exist and their results are inconclusive.

Most of the intervention studies to date are small and local, examining the effect of a limited set of community level changes on activity. Neither the interventions nor the methodologies are sufficiently developed to permit any firm conclusions about the impact of community level changes, and the majority of studies do not meet the thresholds for evidence quality established in this review.

Implications for Policy-Makers

Conclusions

Results from cross-sectional studies with weaker designs should be interpreted very cautiously. Despite weaknesses in many of the studies, several characteristics of the built environment are consistently associated with activity in cross-sectional analyses:

- Access to parks and open spaces.
- Proximity to destinations.
- "Walkability" of the community (density, land use mix, street connectivity).
- Availability of sidewalks.
- Aesthetics of the community.

For many other community design measures the findings are inconclusive. A mix of findings (some null and some positive) could be due to sampling error.

Personal and demographic factors are stronger determinants of activity than are environmental measures. Built environment variables typically explain only a small percentage of the variability in activity across groups.

Several studies indicate that both preferences and environment features contribute to travel choices, but the same has not yet been shown for physical activity. The study designs and methods used in the majority of studies limit our ability to either establish causality or rule out personal preferences as an explanation for differences in activity across communities.

Even if preferences and personal factors are the dominant drivers of activity, the built environment might facilitate (or inhibit) activity motivated by these preferences. The environment helps give opportunities for activity, but is unlikely to motivate activity on its own.

Community design features are more strongly associated with walking for transportation than with overall activity levels and walking for recreation. As might be expected, community design features are not strong predictors of vigorous activity.

Different community features are linked to different types of activity. Some features are associated with travel-related but not recreational activity. Others are associated with walking but not with measures of overall activity. Why certain variables are associated with walking but not with overall activity is unclear. Possibly these features promote walking but walking substitutes for other activity. Alternatively, the dominant measures of overall activity (active, inactive and insufficiently active) may not be sufficiently sensitive to register modest changes in walking.

Contrary to expectation, several variables thought to be barriers to activity, including traffic and crime, suggest no or a positive relationship with activity. This pattern possibly reflects the influence of unmeasured community features; high traffic and crime are often also found in areas with compact and walkable designs.

Implications for Policy-Makers

Policy Implications

There is a pressing need for rigorous research to examine the effectiveness of current efforts to make communities more walkable and bikable. This research can provide the basis for future policy-making.

Local policy-makers, developers and community leaders are spearheading efforts to make communities more walkable and bikable through promotion of mixed use development and building of sidewalks and bicycle paths and dense residential areas close to transit locations. These efforts provide important opportunities to examine the effectiveness of built environment interventions and the causal relationship between built environment features and activity, controlling for personal preferences. This research agenda is of critical importance to the development of effective and targeted interventions.

Careful analysis of these natural experiments is needed. This research should track populations longitudinally as changes occur and include outcomes of interest for both transportation and physical activity researchers.

The current body of evidence is relatively weak and associational, relying on cross-sectional analyses and not studies of the impact of community level changes or moves from one environment to another.

While many studies have found an association between aspects of the built environment and activity, few have explored the causal relationship between the two. Without greater certainty about this causal relationship or the specific variables that might be most strongly associated with activity, there is insufficient evidence to conclude that built environment changes will produce changes in activity.

A multi-faceted approach may be needed to increase activity in US communities.

Many intersecting factors influence physical activity. As with tobacco control, changes to physical activity will likely result from a multi-faceted approach including individually-focused health promotion interventions, greater social support for activity, changes to community environments and policy interventions.

The Need for Additional Information

Future research efforts should focus on addressing key issues of causality and impact of built environment changes, and not on further exploration of built environment/activity associations using simple cross-sectional analyses:

- There is a need for research that explores causal relationships, addresses methodological issues and investigates the relative contribution of different factors.
- Ongoing initiatives by developers and communities to build more compact and walkable communities provide critical opportunities for research on the impact of built environment changes on activity. These studies should include careful controls for sociodemographic characteristics and for personal preferences as well as efforts to ensure that the research examines the same population before and after interventions.
- Funders should make efforts to spearhead collaborative research bringing together transportation, urban planning and physical activity researchers to develop shared frameworks, better data sets and models and outcome variables that can more fully address questions of interest.
- Exploring the interactions and relationships among variables and differential responses to the built environment by different groups are critical areas for future research. Important questions include:
  - How do social and personal characteristics interact with the built environment to determine activity?
  - Do children and adults respond similarly or differently to built environment characteristics?
  - Why are some built environment measures associated with walking but not with overall activity? Why are some community attributes associated with walking for transportation but not with walking for recreation?
  - What are the relationships among travel activity, recreational activity and overall activity?

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Appendix II Methodological Discussion

Evidence Used in Synthesis

While the vast majority of studies on the relationship of the built environment and physical activity are cross-sectional, there have been many studies, most are quite recent, and several draw on large data sets and control for potential confounders.

Almost all of the evidence is on adults, although an emerging body of studies examines the experience of children, racial and ethnic minorities and the elderly. Several studies also examine the divergent results for men and women.

There are two main bodies of evidence: studies produced by transportation researchers and studies conducted by physical activity researchers. They tend to use different measures of activity and of the environment. The transportation research often examines the association between the number or share of trips made on foot or by bicycle and land use and urban form characteristics including density, street connectivity, land use mix and sidewalks. The public health research typically examines walking or total activity and includes measures of urban form and community environment, but not land use mix. Measures used include sidewalks, streetlights, crime, traffic, presence of dogs and aesthetics. The lack of studies that capture both types of activity and include a comprehensive set of measures (or indices combining them) is problematic.

Models typically account for only a small percentage (2–15 percent) of the variation in activity among communities (22, 27, 31).

Measurement Challenges

Challenges arise in synthesizing the research literature in this field due to the variation in approaches to measuring both the environment and activity.

- Because studies differ in the variables they include and how they define them, and because these variables tend to be correlated at the community level, reaching conclusions about the relative importance and independent contribution of different factors is difficult.
- Studies do not use consistent measures of activity. Measures include total activity, meeting physical activity recommendations, walking a mile in the last month, total minutes walked, and walking and bicycling for transportation. Many studies include measures of moderate, but not vigorous, activity and use self-reported activity measures. In addition, many studies fail to explicitly capture both recreational and transportational activity, or measure only walking and not bicycling or other forms of activity that might be linked to the built environment.
- Community characteristics are best measured at the neighborhood level, yet several studies have examined much larger units, including counties or MSAs, which include several communities with divergent characteristics. This approach tends to dilute the results of the studies, as shown by Addy (1), who found associations between neighborhood built environment characteristics and activity, but not between county measures and activity.
- As with activity, many studies use self-reported measures of the community environment. While geographic information systems (GIS) are increasingly used to measure urban form objectively, the measures and metrics are not yet well developed.
- Including both subjective and objective measurement of some community characteristics–especially convenience, safety and aesthetics–is important given evidence of differences between objective and perceived assessments (46), yet most studies measure only one or the other.

Appendix II Methodological Discussion

Selection Bias

Another significant issue is that causality cannot be established because of the cross-sectional design of studies and the issue of self-selection. That is, people who value walking might be more likely to select a community that is more "walkable" and this preference, and not the built environment characteristics of walkable communities, may promote activity.

Several studies in the transportation literature (see figure below) use approaches to control for personal preferences and self-selection, although these strategies are not yet in common use in physical activity research. The studies generally indicate that both preferences and community attributes influence travel mode and underscore that caution should be used in interpreting the results of weaker cross-sectional studies.

Several of the studies analyze the contribution of land use characteristics and individual preferences in determining driving choice without directly examining active travel (4, 60, 77). These results still have bearing on questions regarding active travel as several studies have found that there is an inverse relationship between auto use and active travel (34).

Transportation studies controlling for personal preferences

	Method for addressing selection bias	Built environment/ activity relationship after controlling for preferences		Built environment/ transportation mode relationship after controlling for preferences		Findings
		Yes	No	Yes	No	
Bagley (4)	Structural equations modeling				√	Preferences (but not residential location) have an impact on travel behavior
Handy (42)	Quasi-experimental Control variables measuring preferences			√		An association exists between driving and the built environment, controlling for attitudes (Cross sectional analysis does not show this)
Schwanen (77)	Control variables measuring preferences			√		Both location and preferences influence driving behavior
Greenwald and Boarnet (40)	Instrumental variables	√				Built environment features are associated with non-work walking
Krizek (60)	Quasi-experimental		√	√		Changes in built environment are not associated with changes in walking but are associated with changes in driving (study examines people who moved)

Handy's study (42) examines the behavior of California residents who moved from one community to another. Assuming that individuals have the same preferences before and after moving, the influence of personal preferences is controlled by the pre-post design. Her results underscore the limits of cross sectional designs in teasing out the contributions of the built environment and personal preferences. The longitudinal analysis finds an association between transit choice and built environment, controlling for preferences, but her cross-sectional analysis does not indicate this.

Findings of Previous Systematic Reviews

Several systematic reviews of the evidence on the association of the built environment and activity have been completed. The approaches for evaluating the literature and reporting conclusions vary, and differ from the approach used here. The Community Guide analysis (45), for instance, restricts findings to studies indicating the effect size of the "intervention" (for cross-sectional studies the authors consider the intervention the differences among communities varying on built environment characteristics). The Handy analysis completed for the Transportation Review Board (43) divided studies into two tiers based on whether they controlled for potential confounders. Despite these differences in approach, the reviews tend to reach similar conclusions about the meaning of the evidence and how to advance research and policy-making in the face of sometimes-inconclusive information. As a group, the reviews reach the following conclusions:

- Several built environment variables are associated with activity.
- While causality cannot be proved, there is evidence that the environment plays at least a facilitative role in promoting activity.
- There is insufficient evidence to make specific recommendations on changes to the built environment.
- Policies should be advanced that promote activity friendly and walkable environments and results of these changes should be studied.

Appendix II Methodological Discussion

Findings from recent reviews on relationship of built environment and activity

Study	Major conclusions	Policy recommendations
Heath, 2006 (Community Guide)	There is sufficient evidence that community and street-scale urban design and land-use policies are effective in promoting physical activity. Variables associated with activity: • Mixed land use, sidewalk quality, connectivity	"The committee did not, however, recommend any specific changes because the causal evidence supporting specific change or changes is not yet available."
Transportation Research Board Special Report #282, 2005	There is an association between urban form and activity but it is not yet possible to sort out which variables are most important. Variables associated with activity: • Density • Land use mix • Proximity to destinations • Sidewalks • Safety from crime and traffic for some groups While causal connections cannot be shown, evidence suggests at least a facilitating role of built environment in promoting activity.	"Many opportunities and potential policies exist for changing the built environment in ways that are more conducive to physical activity, but the available evidence is not sufficient to identify which specific changes would have the most impact on physical activity levels and health outcomes… Research has not yet identified causal relationships to the point that would enable the committee to provide guidance about cost-beneficial investments or state unequivocally that certain changes in the built environment would lead to more physical activity or be the most efficient ways of increasing such activity." "Those responsible for modifications or additions to the built environment should facilitate access to, enhance the attractiveness of, and ensure the safety and security of places where people can be physically active… Local zoning officials, as well as those responsible for the design and construction of residences, developments, and supporting the transportation infrastructure, should be encouraged to provide more activity-friendly environments."
Frank, 2005	Urban form variables (land use mix, density) are associated with walking and biking. There is a mix of findings on whether these variables, or demographic and socioeconomic variables are more important, but the author finds overall that urban form is secondary.	"Amid all of these complexities, this review concludes that some very precise strategies could be articulated in the form of interventions. These interventions would be targeted at retrofitting existing communities and shaping emerging communities in a manner than enables, and even promotes, physical activity."
Handy, 2005	(This document was an input to the TRB report so its main conclusions are similar) There are significant correlations between some aspects of the built environment and some types of physical activity. But there is little evidence on which specific aspects of the environment affect what specific activity. There are still many questions about causality, although even if preferences are important, access to opportunities for activity also play a role.	"In the meantime, does the absence of definitive evidence mean that we should not be adopting policies that create what we believe to be environments more conducive to physical activity? I don't think so. One, the available evidence, despite its limitations, show that a causal link between the built environment and physical activity is a distinct possibility. Two, there are good reasons to build communities that are more walkable, for example, even if we are not sure if it will have the desired impact on the obesity epidemic, Three, there is not necessarily a large cost in doing so, beyond the cost of overcoming inertia and in making changes to existing codes, something that many communities are already doing anyway, And four, there seems to be little risk that building walkable communities will do anyone any harm…"

Appendix II Methodological Discussion

Approach to Weighing the Literature

We have created a structured approach to evaluating the evidence base relying on several established criteria of study quality and using the results of this structured assessment to rank the relevant studies on a three-tiered scale according to the strength of findings (See Attachment I). Those in the lowest tier are mentioned in the analysis and included in the tables of study results but are not used in this synthesis to reach conclusions. Those in the middle and highest tiers are used to reach conclusions. The results of these strong studies (those in the top and middle tiers) are organized and arrayed in findings tables structured by explanatory and outcome variables. Based on the results of the set of stronger studies we can assess the strength and robustness of the evidence base for the association between built environment characteristics and activity. The evaluation approach for the assessment is described below:

Response Rates: A higher response rate can offer some protection against response bias, although high response rates are difficult to achieve in the more detailed mailed surveys typically used for travel behavior studies. Greater weight is given to studies with higher response rates and for attempts to assess and correct for non-response bias.

Sampling Strategy: Greater weight is given to random sampling of the target population (this can include oversampling of certain groups).

Sociodemographic Controls: Greater weight is given to studies that include a set of sociodemographic control variables that have been shown to be associated with activity and related lifestyle choices. These include race, income or education, gender and age.

Controlling for Self-Selection: Self-selection is a potential threat to the validity of findings on the association of built environment and activity. People may select certain communities because they value exercise and it is this preference, and not the environment itself, that is determining activity. Studies are given greater weight if they include variables–or use other methods–that control for these personal preferences. Control variables used include assessment of respondent attitudes including "transit-friendliness," "car dependence" and "self-efficacy."

Sample Size: We use a minimum sample size of 100 as a threshold to screen out studies with very small samples and overly limited scope.

Measures: We give stronger weight to studies using objective measures (accelerometer, GIS analysis of built environment features) and measures with tested reliability/validity.

Generalizability: We give greater weight to studies examining populations across multiple communities in different locations.

For more information about the Synthesis Project, visit the Synthesis Project Web site at *www.policysynthesis.org*. For additional copies of Synthesis products, please go to the Project's Web site or send an e-mail message to *pubsrequest@rwjf.org.*

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NEW INSIGHTS FROM RESEARCH RESULTS

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