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The Role of Built Environments in Physical Activity, Obesity, and CVD

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Abstract

In industrialized nations like the United States and Sweden, the vast majority of adults do not meet the physical activity guidelines of 150 minutes per week.¹ Inactive lifestyles put most adults at risk of cardiovascular diseases (CVD), diabetes, obesity, some cancers, osteoporosis, and psychological disorders.² Physical activity can be effective at all phases of chronic disease management, from primordial prevention (prevention of risk factors) through treatment and rehabilitation.² There is particular interest in the potential for physical activity to prevent chronic diseases, thereby improving quality of life and reducing health care costs.³ In the past decade, limitations of prevention approaches that target mainly individuals with educational and motivational programs have been recognized, triggering a trend to consider influences on behavior

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that are outside the person, such as the built environment.^{4,5} The purposes of the present paper are to describe multilevel ecological models of behavior as they apply to physical activity, describe key concepts, summarize evidence on the relation of built environment attributes to physical activity and obesity, and provide recommendations for built environment changes that could increase physical activity. The intent of this non-systematic review is to present conclusions from previous reviews then illustrate results by highlighting selected studies.

Keywords

exercise; ecological model; recreation; transportation

An Ecological Model of Physical Activity

Ecological models specify multiple levels of influence on behavior, from individual and social factors, to institutional, community, built environment, and policy factors. A key principle is that interventions should be most effective when they change the person, the social environment, as well as built environments and policies.⁶ Motivating a person to change in an environment that poses many barriers is not expected to be very effective, nor is providing a supportive environment in the absence of educational interventions to promote use of those environments.

Built environments are the totality of places built or designed by humans, including buildings, grounds around buildings, layout of communities, transportation infrastructure, and parks and trails.⁷ Policies can be laws and regulations at any level of government, corporate practices, and rules at institutions like schools. Changing built environments and policies is expected to have long-term impact on most or all of the people in those places. Characteristics of built environments, from neighborhoods to cities, have been related to rates of chronic disease and mental health^{8–10} and risk factors such as obesity^{11,12} and hypertension.¹¹ Physical activity is believed to be a critical mechanism by which built environments can affect chronic disease.^{8,9}

Societal changes over decades have dramatically reduced the need for physical activity in daily life while creating ubiquitous barriers to physical activity. Mechanization and computerization have reduced physical activity at work, labor saving devices have reduced activity required for household chores, and investments and policies that favored travel by automobiles have reduced walking and bicycling for transportation. Although these societal changes have had some desirable effects, they have also led to a decrease in daily physical activity.

Physical activity can be classified into four domains of life that describe how people spend their time: leisure/recreation/exercise, occupation (school for youth), transportation, and household.¹³ The four domains are relevant to and driven by different built environment features and policies. Figure 1 is a simple ecological model of physical activity that identifies institutional and community built environment settings and features, as well as policies, that are relevant to each physical activity domain.

A commonality across all of the environmental settings identified in Figure 1 (i.e., recreation facilities, community design, transportation facilities, workplaces, schools, homes) is that none is controlled by health professionals. Yet these places can affect health. Thus, for both research and practical applications, it is necessary for health professionals to develop partnerships with professionals from diverse and often unfamiliar disciplines and sectors of society.¹⁴

The need for a multi-level, multi-sector approach to physical activity promotion, obesity and CVD prevention has been recognized by numerous health organizations.^{4,15-18} These recommendations justify a vigorous research program to identify modifiable environmental attributes and policies that have the strongest or most widespread effects/associations to guide intervention efforts. The Active Living Research program of The Robert Wood Johnson Foundation has been funding such studies since 2003,¹⁹ and the US National Institutes of Health includes environment and policy research in the Strategic Plan for NIH Obesity Research.²⁰ Environmental research on physical activity has grown rapidly since 2000, has been reviewed numerous times,²¹⁻²⁴ and is informing policy debates at all levels of government.

Because investigators do not have control over the policy or environment "intervention", it is rarely possible to randomly assign people or places to experimental conditions. Thus, most of the studies are observational, though quasi-experimental studies have become more common. In the present non-systematic review, overviews of the literature are provided and illustrative results are described as related to active transportation and active recreation, because these physical activity domains appear most amenable to environment and policy intervention. Because there is limited evidence about how built environments are related to occupational and household physical activity, these domains were not addressed.

Built Environments and Active Recreation

Healthy People 2020²⁵ and the Institute of Medicine¹⁶ identified public parks and recreation facilities as providing settings for diverse recreation activities for children, families, and organizations such as schools and faith-based institutions. Provision of parks and recreation is a function of government in all developed countries. In the United States, parks are administered by municipal, county, state, and federal levels of government as well as special park districts.²⁶ There are more than 9,000 local park and recreation departments with 108,000 public park facilities and 65,000 indoor recreation facilities in the US.²⁷ Because parks and recreation facilities are generally accessible to populations at highest risk of inactivity and are available at low user costs, they are well positioned to play a role in disease prevention. Their provision, design, and quality can be influenced through public policy.^{26,28}

Recreation environments and active recreation

Availability of and proximity to recreation facilities have been associated consistently with greater physical activity among adults,²⁹⁻³² adolescents,³³⁻³⁵ and children,^{33,34,36,37} with some exceptions.³⁸

A national study of US adults found perceived access to parks and trails was positively associated with physical activity.²⁹ Respondents perceiving access to these resources were nearly two times more likely to meet physical activity guidelines than those who did not perceive these resources were available. A 3-city study found that objectively-measured density of parks and recreation facilities was associated with physical activity among adults.³⁰ An observational study³⁹ in Tampa and Chicago assessed energy expenditure associated with different activity zones in 28 neighborhood parks. Courts (basketball and racquet sports), playgrounds, and soccer fields generally were associated with greater energy expenditure than baseball/softball fields, picnic areas, and open spaces (Figure 2).

Trails and greenways can be used for active recreation and active commuting. People who used trails on a weekly basis were twice as likely to meet physical activity recommendations.⁴⁰ A study in Dallas, Chicago, and Los Angeles demonstrated that greater trail usage was associated with trail characteristics such as mixed views (a combination of

urban and natural scenery), lighting, good trail conditions, cafes, and restrooms.⁴¹ Lower usage was associated with litter, noise, and high density of vegetation on the trails.

Similar results were found in studies of adolescents and children. A national study of 17,000 adolescents found that odds of participating in frequent physical activity were greater when there were more recreation facilities nearby (Figure 3).³⁴ A large study³⁶ of Atlanta, GA youth found that the presence of recreation space within 1km of home was related to walk trips among all age groups (ages 5 to 20) and was the strongest predictor of walking among youth in the 15 to 20 age group. Cohen et al.³³ found that parks with playgrounds, basketball courts, walking paths, tracks, swimming areas, and multiple purpose rooms were associated with greater non-school physical activity among adolescent girls. Thus, presence of parks and trails, as well as the design of these facilities have been related to physical activity.

Recreation environments and obesity

There is limited research on the link between access to recreation environments and weight-related outcomes. Findings generally do not support associations between recreation environments and obesity for either adults or youth.¹² This is not surprising because recreation environments are just one component of the built environment. One notable exception was a US national study of adolescents that found odds of being obese were lower among youth in neighborhoods with more recreation facilities (Figure 3).³⁴

Interventions and active recreation

A few studies evaluated impacts of environmental interventions in park and recreation settings using quasi-experimental designs. For instance, a study conducted in ethnically diverse communities in San Francisco compared visitation and physical activity in two renovated parks to a control park.⁴² Renovations included turf replacement, new fencing and lighting, and additional programming. Both "intervention" parks experienced a significant increase in youth and adult visitors. Another study investigated whether expansion of a skate park and improvements to a community center for older adults (e.g., building renovations and adding exercise equipment) were related to facility use and physical activity, with comparisons to two control parks.⁴³ Renovation of the skate park was associated with a six-fold increase in use and more physical activity. Use levels of the renovated senior center actually declined compared to baseline and was not significantly different than control parks. The researchers suggested the decline might be explained by park users not being aware of the renovations. This highlights the importance of coupling informational and environmental interventions, consistent with ecological models.⁴⁴

Built Environments and Active Transportation

Active transportation has declined in recent decades. Between 1977 and 1995, the number of all walking trips decreased by 32 percent for adults, with similar reductions for youth.⁴⁵ Adults walk for only 21.2 percent of trips that are one mile or less, and children walk for only 35.9 percent of trips to school of that distance.⁴⁵ Reversing the recent decline in rates of walking and biking for transportation, especially for short trips, presents a major opportunity for improving health for all ages. Evidence is accumulating about how the built environment can support active transportation, and this evidence can inform policy changes.

Built environment, active transportation, and physical activity

Key characteristics of built environments and community design are land use (residential, commercial, institutional, or park and open space), intensity (population density), location relative to other community destinations, the interconnections available to reach those destinations, and aesthetic qualities. Having a variety of destinations close by has been

positively associated with walking and bicycling for transportation.^{22,23,46–48} Destinations refer to land uses that are frequently accessed in daily life for shopping, education, work, and recreation. Proximity to parks and commercial areas is associated with higher active transportation.^{24,49}

Population density refers to the number of individuals or households living in a particular area and is consistently associated with higher active transportation.^{23,46} In areas of high density, destinations can be closer together because the number of people needed to support shops, services, and schools is found in a smaller area.

Transportation facilities that connect residential areas and destinations also are related to active transportation. When neighborhoods have sidewalks, streets are well-lit, and pedestrians are shielded from traffic, residents are often found to walk more and have higher physical activity, though results are not highly consistent.^{46,47,50,51} Having bicycle paths or trails that separate bicycles from traffic is sometimes associated with increased bicycle use.^{48,52}

Public bus and rail stops nearby have been positively associated with active transportation.^{51,53,54} People who use public transportation tended to be more active and less likely to be overweight and obese than adults who did not use public transportation.⁵⁵ Nationwide, 29 percent of those who used transit were physically active for 30 minutes or more each day, solely by walking to and from public transit.⁵⁴

Many of the environmental factors associated with active transportation among youth are similar to findings with adults. Two reviews^{56,57} found consistent evidence that proximity to destinations and the presence of paths for walking and bicycling are important for active transportation among youth.⁵⁸ Living in neighborhoods with high density and a variety of non-residential land uses such as parks, play areas, and recreational facilities is associated with higher rates of active transportation in children⁵⁸ and overall physical activity.⁵⁷ One difference from the evidence on adults is that for children, the importance of commercial uses close to home is more equivocal.⁵⁸

A commonality across adults and children is the concern regarding safety from traffic as a barrier to physical activity. Parental concern about personal and traffic safety has been associated with whether children are allowed to walk or bicycle in their community or to and from school.^{56,59} Focusing on behavior-specific correlates, such as with active transport to school, promises to clarify associations and provide more concrete guidance regarding environmental interventions.^{57,60} Higher rates of walking to school have been consistently associated with closer proximity to school, greater population density, and supportive pedestrian infrastructure and safety conditions on the route.^{57,59,60} Active transportation to school supplements, and does not replace, other physical activity.⁵⁶

Many of the built environment characteristics described often occur simultaneously in urban areas. Places with high density usually are well-connected, have destinations close by, and are well-served by infrastructure for walking, bicycling, and public transportation. This covariation suggests that isolating the effects of built environment characteristics on physical activity outcomes is methodologically difficult and may be conceptually unwise because cumulative effects of several environmental attributes may be required to have a large effect on behavior. Some studies have focused on the package of attributes by sampling individuals from neighborhoods deemed a priori as highly supportive or unsupportive of physical activity. Although not unanimous,²² the evidence consistently indicates that walking is higher in high-walkable neighborhoods than in low-walkable neighborhoods. A walkable environment was defined based on its land use mix, street connectivity, residential density, and retail intensity. In a study of 32 neighborhoods in Seattle (WA) and Baltimore

(MD) regions, neighborhood walkability was related to both higher reported walking for transportation (20–40 more minutes per week) and higher objectively-measured total physical activity (35–49 more minutes per week).⁶¹ An international study showed adults in the most activity-supportive environments were twice as likely to meet physical activity guidelines as those in the least-supportive neighborhoods.⁵¹

There are fewer studies focusing on rural populations, even though rural residents are at high risk of poor health outcomes.⁶² For rural residents, traffic safety, recreation facilities, and trails were most consistently associated with physical activity.

Built environments and obesity

Studies on associations between the built environment and obesity have produced mixed findings in adults. Although some neighborhood studies found that walkable neighborhoods protect against overweight and obesity,^{61,63} a review concluded there are inconsistent associations of walkable neighborhoods and their components with obesity-related outcomes.⁴⁶ Body fat accumulates over time, so studies of cumulative exposures rather than cross-sectional associations may be more likely to detect impacts of the built environment. Alternatively, cross-sectional associations could be due to self-selection bias and not be confirmed in longitudinal studies. A large study showed significant cross-sectional, but not longitudinal associations between built environments and weight status.⁶⁴ It is possible that longitudinal changes in built environments must be substantial and well-measured to detect associations with BMI change.

Among children, the evidence on associations between the built environment and obesity or overweight appears equally mixed. Galvez et al⁶⁵ reported that, although most built environment variables were not associated with childhood obesity in 15 studies, distance to playgrounds and density of rail stations were associated with obesity in the anticipated direction. In a prospective study, active commuters to school had significantly lower BMI than non-active commuters, but active commuting to school was not associated with BMI change.⁶⁶

Interventions and active transportation

Although bricks and mortar solutions are important, research has emphasized the importance of programming and policies to support infrastructure changes. Programming for active transportation to schools (such as safe routes to school and the walking school bus) has been associated with increased physical activity among children, though the studies are methodologically weak.⁶⁷ Policies play a crucial role in encouraging active transportation. A review concluded there is sufficient evidence that community-scale land use regulations and policies can be effective in increasing walking and bicycling.⁶⁸ Policies also support complementary strategies such as programs and promotions to encourage active transportation. This is particularly apparent in interventions to promote bicycling in which single strategies had little effect, but uncontrolled evaluations of cities that used multiple strategies, including protected bicycle facilities, bicycle sharing, and policies favoring cyclists, appeared to be consistently effective.⁶⁹

Disparities in Access to Activity-Supportive Built Environments

Disparities in access to parks and recreation facilities

In light of the potential of parks and recreation facilities to increase physical activity, understanding the extent of their availability and quality in low income and racial/ethnic minority communities is of importance in efforts to eliminate health disparities. A national study³⁴ showed that areas with college educated populations were 3 and 4 times more likely,

respectively, to have at least 1 park or other outdoor recreation resource than areas with less educated residents. Neighborhoods with populations that were 95% minority and overwhelmingly without college education (5% or less) had 46% lower odds of having at least one recreation facility. Having a recreation facility nearby is only one aspect of addressing income and ethnic disparity. Quality of facilities, safety, and recreation preferences of community member should also be considered.

Disparities in built environments relevant to active transportation

It appears that disparities in access to activity-supportive community environments vary across attributes. There is little evidence that Hispanics and Blacks, or that low income populations, are disadvantaged with respect to the density of areas in which they live.^{70,71} Racial and ethnic minority and low-SES groups may be particularly sensitive to the built environment. In a review, light traffic, safety from crime, and sidewalks were most consistently associated with physical activity among Black Americans.⁷¹ However, low-SES or high-minority neighborhoods appear to have less supportive environmental conditions for active transportation. A review concluded that disadvantaged neighborhoods had poorer aesthetics and worse conditions related to traffic safety and crime safety.⁷¹ For example, a study of two US regions found that lower- and higher-income neighborhoods did not differ substantially on commonly assessed walkability variables, but lower-income neighborhoods had less favorable values on pedestrian/cycling facilities, aesthetics, access to recreation facilities, traffic safety, and crime safety.⁷² These poor conditions could potentially overcome the beneficial effects of living in a walkable low-income neighborhood.

Recommendations for Environment and Policy Change

Recent recommendations for increasing physical activity and reducing obesity and CVD risk retain some educational focus (e.g., benefits of physical activity, behavior change skills), but most emphasize more sustainable and broader reaching environmental and policy changes. Various organizations' recommendations^{15,16,73-77} in these areas are provided in Table 1, with sample strategies that target environmental or policy change. These recommendations have different desired outcomes (e.g., obesity prevention versus physical activity promotion only), but considerable overlap in the types of proposed intervention strategies.

As seen in Table 1, the recommendations target many of the contexts encountered in daily living, such as transportation systems, neighborhood built environments, schools, worksites, and the media. These recommended strategies are also broad in type, targeting changes in physical activity across multiple domains, from encouraging changes to the availability of resources for leisure time physical activity (e.g., more parks and green space) to changes in zoning and land use patterns expected to impact transportation choices.

An example set of recommendations is the American Heart Association's (AHA) recent policy strategies for achieving ideal cardiovascular health published in *Circulation*.¹⁵ In addition to an emphasis on the healthcare system, the recommendations include strategies for targeting built environment (e.g., walk/bike trails, safe routes to schools) and policy interventions (e.g., shared use agreements for recreation facility use between schools and communities). The predecessor to these strategies within AHA appears to be the 2003 guide for improving cardiovascular health at the community level,⁵ which included many of the same environment and policy recommendations. It is noteworthy that the more recent recommendations had considerably less focus on individual-level education (e.g., school curriculum about CVD risks), perhaps recognizing the need to prioritize environment and policy changes before expecting educational interventions to be effective.

From recommendations to interventions

Recommendations summarized in Table 1, based on limited evidence and often expert opinion, have guided large-scale initiatives to implement change in built environments and policy. Some evidence regarding environment and policy interventions does exist. The December 2009 supplement to *American Journal of Preventive Medicine* highlighted outcomes from communities engaging in environment and policy change through the Robert Wood Johnson Foundation's Active Living by Design program. For example, Jackson, Michigan developed "Project U-Turn". In addition to physical activity education and programming, changes in the physical environment (e.g., construction of a rail-trail) and policy (e.g., streets must accommodate all modes of travel –including pedestrians and bicyclists) around physical activity were realized, with corresponding increases in active transportation.⁷⁸

The "Shape Up Somerville" trial compared community-wide interventions for childhood obesity in Somerville, Massachusetts to two non-intervention cities matched on socio-demographic factors. "Shape Up Somerville" interventions cut across levels of the ecological model and included pedestrian infrastructure/safety, walk to/from school campaigns, and new school play equipment. Most notable is that this comprehensive set of community-wide interventions had a documented impact on reducing child overweight/obesity prevalence⁷⁹ and increasing physical activity⁸⁰ at the population level.

Among the largest initiatives was the CDC's *Communities Putting Prevention to Work* (CPPW) grant program, which awarded over \$250 million in 2010 to change environments and policies to improve nutrition and physical activity and prevent obesity. (<http://www.cdc.gov/CommunitiesPuttingPreventiontoWork/communities/index.htm>).⁸¹ Recommended strategies were based on MAPPs: Media, Access, Point of decision information, Price, and Social support/services (<http://www.cdc.gov/CommunitiesPuttingPreventiontoWork/strategies/index.htm>).⁷⁴ Strategies ranged from improving physical activity in school physical education (access) to subsidizing memberships to recreational facilities (price) to promoting safe routes to school (e.g., social support/services) (Table 1). Experience with these initiatives, and systematic evaluations, will lead to a better understanding of how to accomplish policy and environmental change in diverse communities and provide important information about the impact of these changes.

Summary and Conclusions

There is a growing consensus that large changes in population levels of physical activity and other behaviors required to improve cardiovascular health will require major modifications in environments and policies. Ecological models are the conceptual basis for comprehensive interventions that emphasize environmental and policy changes and that can have widespread and sustainable effects. These interventions are complemented with individual education and motivation and efforts to change social support and norms. Physical activity-specific ecological models indicate which environmental factors are expected to be related to physical activity in multiple life domains: leisure/recreation/exercise, occupation (school for youth), transportation, and household. Over the past decade, a proliferation of interdisciplinary research has generally supported hypotheses derived from ecological models and identified specific built environment attributes and combinations of attributes that are related to physical activity, mainly for recreation and transportation purposes, and obesity. It is becoming clear that racial-ethnic minority and low-income communities are disadvantaged in access to recreation facilities, positive aesthetics, and protection from traffic. These results provide an empirical rationale for intervention.

There are recent examples of environmental changes or community-wide multi-level interventions that had positive effects on physical activity or obesity. Continuing research needs are to improve the rigor of study designs, confirm subgroup- or context-specific built environment associations, identify optimal combinations of attributes, improve understanding of the policy change processes required to achieve environmental changes, and evaluate multi-level interventions.

Both research teams and community-based initiatives are collaborating with a wide range of professionals and sectors of society, such as recreation, transportation, city planning, architecture, landscape architecture, geography, criminal justice, and law, in addition to health professionals and behavioral scientists. These diverse teams have stimulated innovations in research, new approaches to intervention, and improved connections with decision makers who can make environment and policy changes in non-health sectors of society. The practice of physical activity promotion, obesity prevention, and CVD risk reduction has changed to reflect the shift to multi-level interventions. Major foundations and public health agencies are implementing community-based interventions targeting environment and policy change. Continuing challenges for these community-wide interventions are to maintain support for the multi-sector, long-term efforts required to change environments, evaluate interventions so they become ever more evidence-based, and integrate explicit chronic disease prevention objectives into professional practices of diverse disciplines, government agencies, and industries whose primary work can affect physical activity and health.

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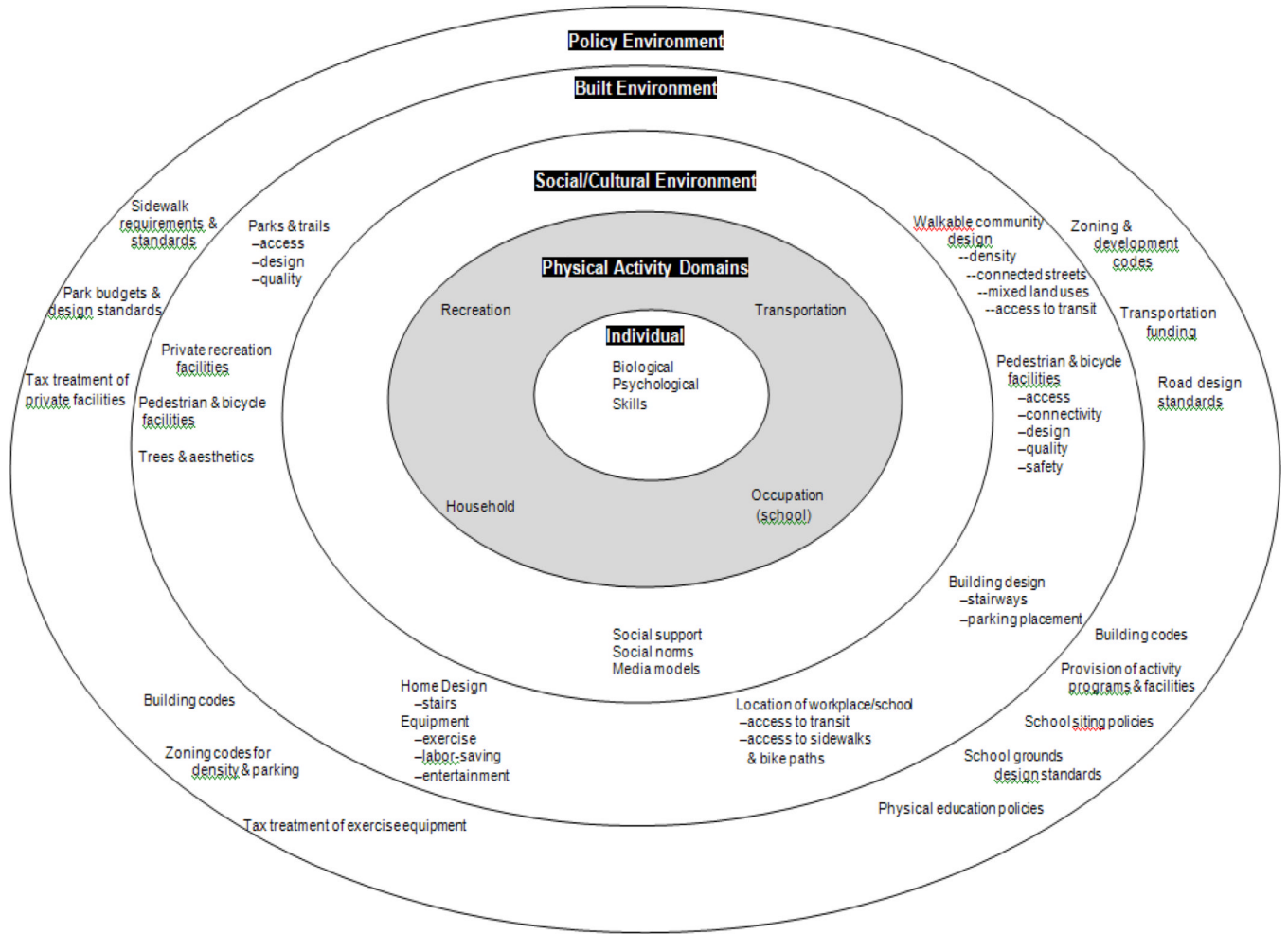


Figure 1.
 An Ecological Model of Four Domains of Physical Activity
 Adapted from reference 14

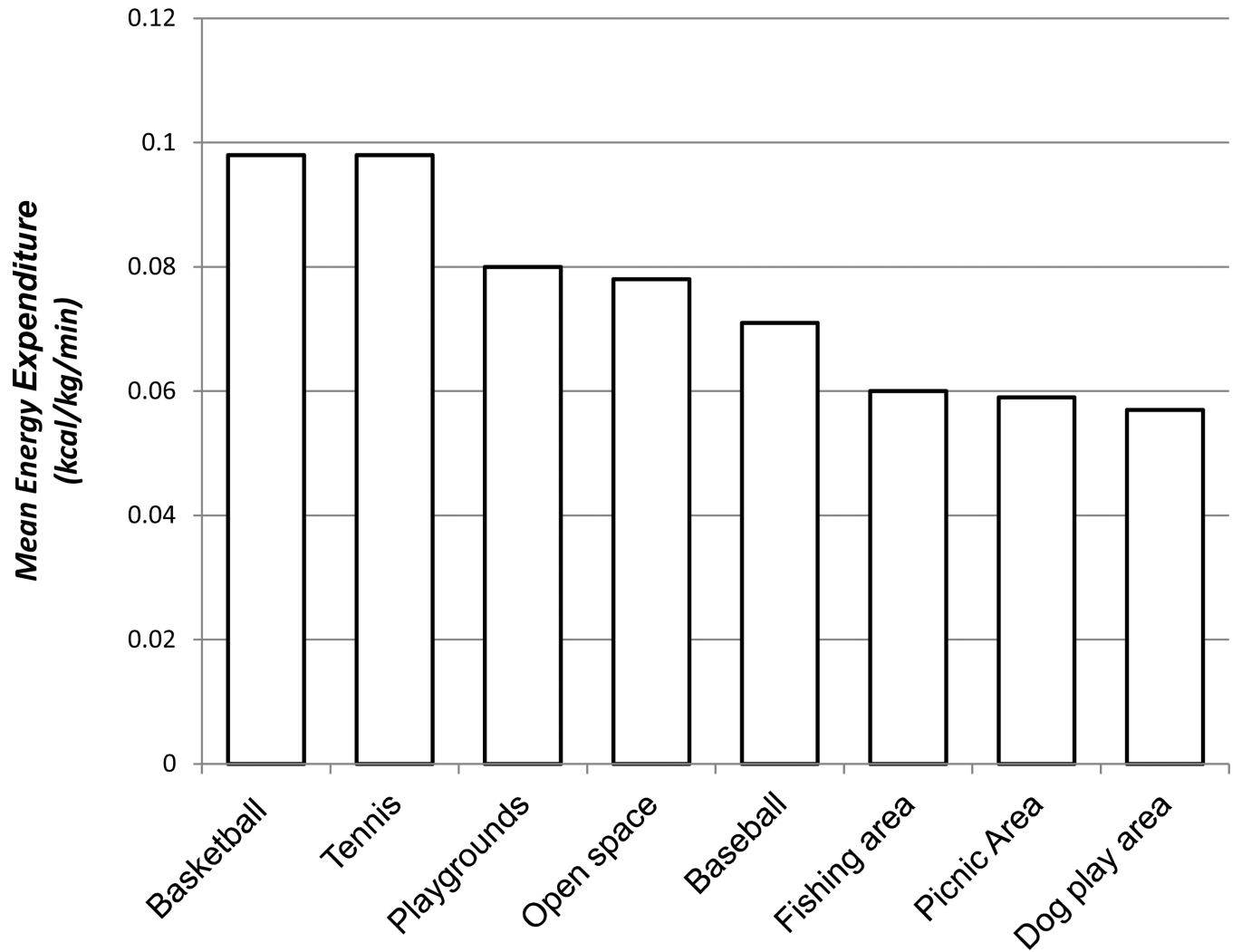
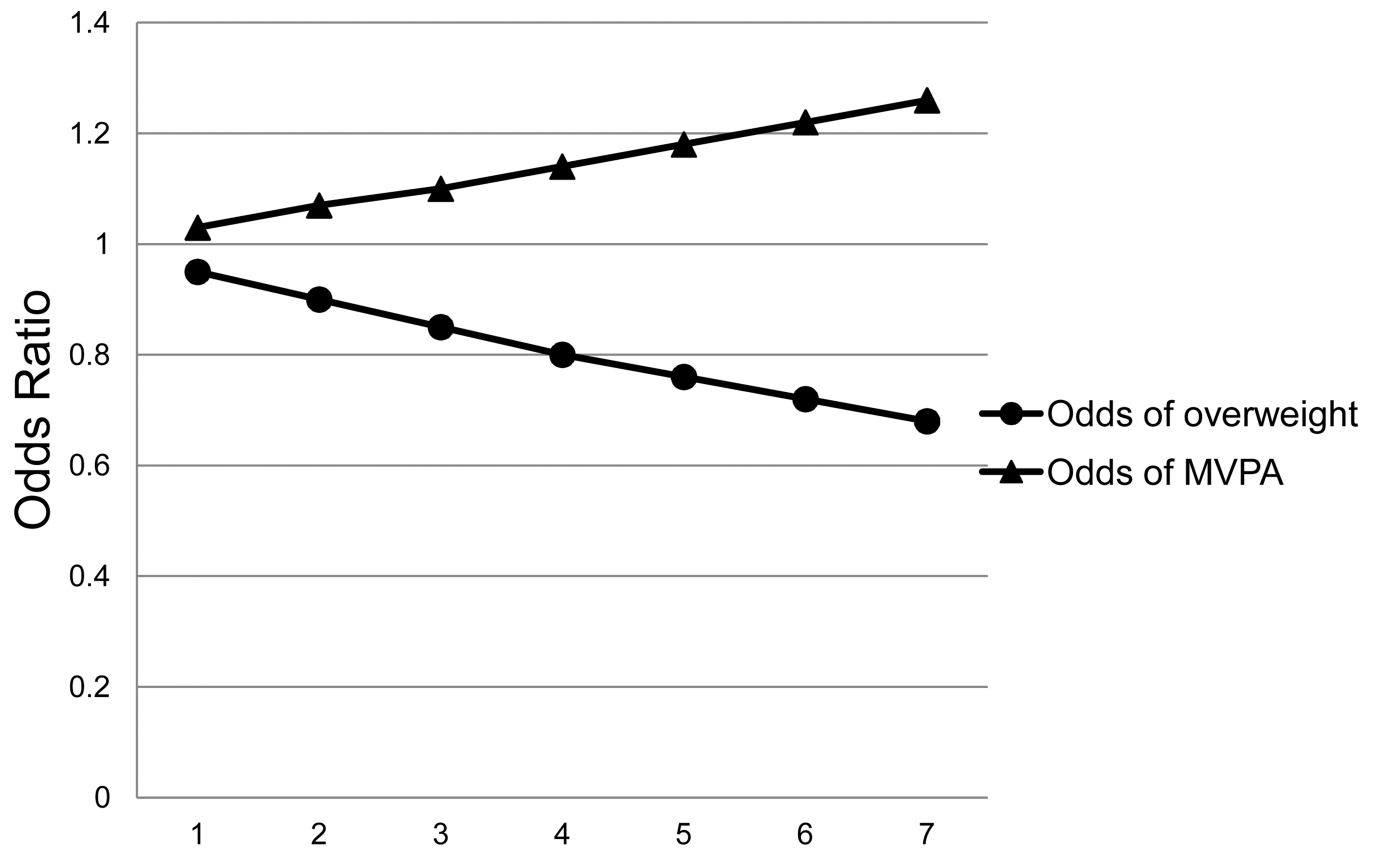


Figure 2.
Mean energy expenditure (kcal/kg/min) per park in 10 Tampa FL neighborhood parks by activity zones (N=6,922)
Adapted from reference 39



Number of recreation facilities per block group

Figure 3. Relative odds of overweight and >5 bouts of moderate to vigorous physical activity (MVPA) with increasing number of recreation facilities per block group, adjusted for population density
Adapted from reference 34

Table 1

Recent U.S.-based recommendations for modifying built environments and/or policies for physical activity promotion, obesity prevention, and cardiovascular disease risk reduction

Source	Primary target(s)	Levels of intervention	Example built environment or policy recommendation for increasing physical activity	Web access
American Academy of Pediatrics (2009) ⁷³	Physical activity promotion in children	Community	“Create and maintain playgrounds, parks, and green spaces ... [and] means to access them safely”	http://aappolicy.aappublications.org/cgi/collection/committee_on_environmental_health
American Heart Association Policy Strategies (2011) ¹⁵	Ideal cardiovascular health	Community, food supply, healthcare system, media, restaurants, schools, worksites	“Implement zoning/building ordinances that encourage ... pedestrian-friendly streets and roadways with appropriate crosswalks, sidewalks, traffic lights, etc and slower speed limits in walking/biking areas”	http://circ.ahajournals.org/cgi/content/full/123/7.816
CDC* MAPPS[†] interventions for CPPW[‡], ⁷⁴	Obesity prevention	Community, food retailers, media, recreational facilities, restaurants, schools, worksites	Provide “incentives for active transit”	http://www.cdc.gov/CommunitiesPuttingPreventiontoWork/strategies/index.htm
CDC* Recommended Strategies for Obesity Prevention (2009) ⁷⁵	Obesity prevention	Community, public service venues, schools	“Zone for mixed-used development”	www.cdc.gov/obesity/downloads/community_strategies_guide.pdf
Institute of Medicine (2009) ¹⁶	Childhood obesity prevention	Community, retail food outlets and restaurants, worksites, childcare, government nutrition assistance programs,	“Adopt community policing strategies that improve safety and security for park use, especially in higher crime neighborhoods”	http://www.nap.edu/catalog/12674.html
National Physical Activity Plan ⁷⁶	Physical activity promotion		“Increase accountability of project planning and selection to ensure infrastructure supporting active transportation and other forms	http://www.physicalactivityplan.org/

Source	Primary target(s)	Levels of intervention	Example built environment or policy recommendation for increasing physical activity	Web access
White House Task Force on Childhood Obesity (2010) ⁷⁷	Childhood obesity	Federal and state government and agencies, and local community, schools, local businesses and other private sector partners (e.g., entertainment companies)	of physical activity” “The Environmental Protection Agency should assist school districts that may be interested in siting guidelines for new schools that consider the promotion of physical activity, including whether students will be able to walk or bike to school”	http://www.letsmove.gov/white-house-task-force-childhood-obesity-report-president

* CDC = Centers for Disease Control and Prevention

† MAPPs = Media, Access, Point of decision information, Price, and Social support/services

‡ CPPW = *Communities Putting Prevention to Work*