Physical Activity and Environment Research in the Health Field: Implications for Urban and Transportation Planning Practice and Research

Chanam Lee
Anne Vernez Moudon

This article reviews literature from the health field investigating the characteristics of environments that support or hinder physical activity. This literature shows that physical activity is associated with objective and subjective measures of accessibility to recreational facilities and local destinations, as well as with neighborhood safety and visual quality. Walking and biking emerge as prominent forms of physical activity and occur primarily in neighborhood streets and public facilities, suggesting that building walkable and bikable communities can address health as well as transportation concerns. The studies help advance environment-behavior research related to urban and transportation planning. They identify behavioral and environmental determinants of physical activity and employ rigorous data collection methods and theoretical frameworks that are new to the planning field. The article concludes that multidisciplinary research will likely yield promising results in identifying the aspects of environments that can be modified to encourage physical activity and physically active travel.

Keywords: *physical activity; walking; biking; environmental determinants; transportation*

This article introduces urban and transportation planning audiences to a body of literature originating from the public health field. The literature consists of twenty recently published empirical studies addressing the environmental characteristics that influence physical activity, including walking and biking.

Understanding and promoting physical activity demand multidisciplinary approaches (Sallis, Bauman, and Pratt 1998; King et al. 2002). This article relies on a

CHANAM LEE is an assistant professor at Texas A&M University, College Station. This work was conducted during her doctoral studies at the University of Washington, Seattle. Her research areas are physical activity, health, urban form, and nonmotorized transportation. She has worked professionally as a land planning consultant, landscape architect, and urban planner.

ANNE VERNEZ MOUDONIS, Dr. ès. Sc., is a professor of architecture, landscape architecture, and urban design and planning at the University of Washington, Seattle. She is president of the International Seminar on Urban Morphology, a faculty associate at the Lincoln Institute of Land Policy, a fellow of the Urban Land Institute, and a national adviser to the Robert Wood Johnson Foundation Program on Active Living Research. Her books include Built for Change: Neighborhood Architecture in San Francisco *(MIT Press, 1986),* Public Streets for Public Use *(Columbia University Press, 1991), and* Monitoring Land Supply With Geographic Information Systems *(with M. Hubner, John Wiley, 2000).*

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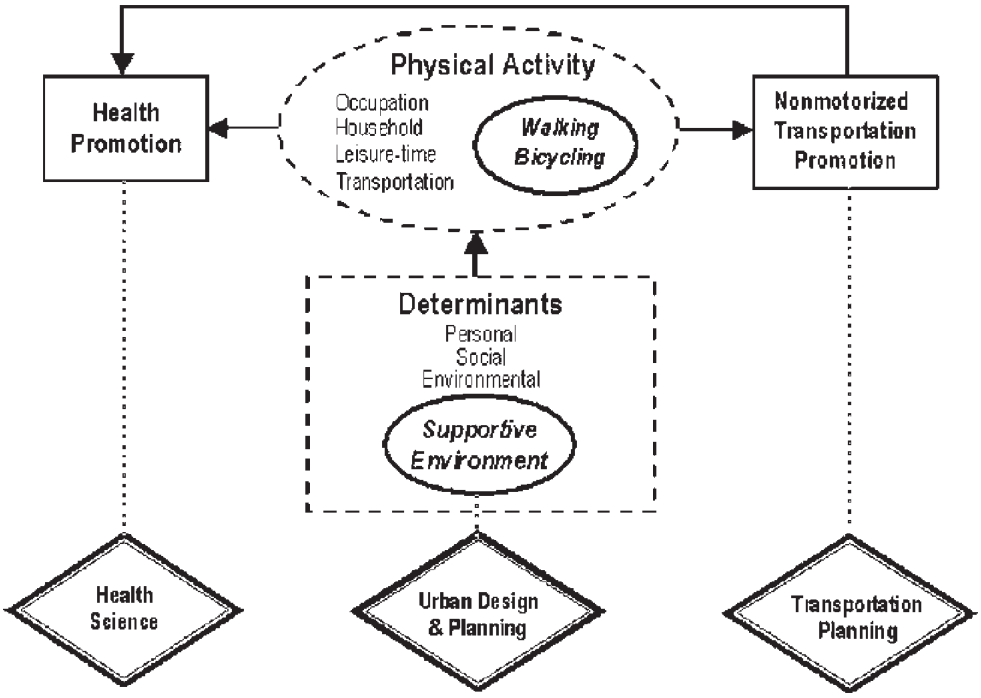

FIGURE 1. Conceptual Framework for Multidisciplinary Research and Polity for Physical Activity Promotion

multidisciplinary framework that connects physical activity from the health perspective to the transportation perspective. Also, the importance of physical environments in supporting walking and biking brings in a third player, the urban design and planning professions, that have the capability to intervene in the environment (Figure 1) (Lee and Moudon 2001).

A few recently published review articles have taken a similar multidisciplinary approach to physical activity. Frank and Engelke (2001) connect public health and urban planning. They review selected empirical evidence showing the health benefits of physical activity and environmental influences on physical activity and on modes of travel. Handy et al. (2002) bring the urban and transportation planning literature to the public health audience. Saelens, Sallis, and Frank (2003) address the same audience with a focus on empirical studies from transportation planning that analyze the impact of environments on walking and biking. Missing is a systematic review for planning audiences of the public health literature dealing with the environmental determinants of physical activity. This article fills the gap and examines lessons for future practice and research.

Public health research sorts physical activity into four purpose-related categories: (1) recreational or leisure time activity, (2) work-related activity, (3) household-related activity, and (4) transportation-related activity (Centers for Disease Control and Prevention [CDC] 1996). Roberts et al. (1996) state that walking and biking are unique forms of physical activity because they transcend these traditional physical activity classifications. Walking and biking figure prominently as popular forms of physical activity, as they are accessible, affordable, and readily incorporated into one's daily routine. They also begin to address challenges that both health and transportation professionals face, namely, the preponderance of sedentary life styles and the increased dependence on automobile travel. At the same time, any effort to promote walking and biking as means of active transportation must take into account the impediments to walking and biking brought by environments built after World War II, which have been shaped primarily for and by automobiles. As the majority of the country's population now lives in postwar, automobile-oriented environments (Pendall, Fulton, and Harrison 2000), health and transportation professionals need to work closely with urban designers and planners to address environmental factors that support or hinder physically active travel.

The studies reviewed in this article have already shaped large research- and community-based programs promoting active living environments.[1] They provide insights into the relationship between, and the

methodological challenges of research on, physical activity and environment.

SIGNIFICANCE AND PURPOSE

Urban and transportation planning professionals have paid a considerable amount of attention to the impact of the built environment on travel patterns (e.g., Ewing and Cervero 2001; Boarnet and Crane 2001; Handy 1996; Steiner 1994). The effects of the built environment on travel mode choice and the potential for the environment to be modified to reduce automobile use have been extensively studied. However, research findings still remain tentative especially on nonmotorized travel behaviors and, therefore, the subject of continued debates (Crane 1996). Methodological problems generic to this type of study include (1) complex and interrelated variables that are often spatially clustered and/or nested, (2) numerous confounding factors, (3) limited data availability on nonautomobile travel and environments, (4) difficulty in effectively quantifying the built environment, (5) the use of large spatial and analytic units of analyses, and (6) difficulties in establishing causality (Federal Highway Administration [FHWA] 1999; U.S. Department of Transportation [USDOT] 2000). Also, parallel transportation research focuses on environmental variables limited to roadway conditions. Personal and social determinants of walking and biking are rarely addressed (Moudon and Lee 2003).

A few reviews of the public health research on the determinants of physical activity exist already (e.g., Humpel, Owen, and Eva 2002; National Public Health Partnership [NPHP] 2001; Sallis, Bauman and Pratt 1998: Seefeldt, Malina, and Clark 2002). These reviews are written primarily for the health audience, and, with the exception of Humpel et al., they tend to focus on studies dealing with personal and social determinants of physical activity. Their discussion of physical environmental determinants is limited, possibly due to a broad and often loose definition of environments in the public health research published to date (Saelens, Sallis, and Frank 2003). In contrast, this article provides a structured review of empirical studies concerned with community-based, physical environmental determinants of physical activity. These studies contribute to urban and transportation planning in the following ways: (1) they further the testing of specific physical environmental variables that are associated with physical activity, including walking and biking; (2) they point to neighborhood places where people are engaged in physical activity; (3) they identify barriers perceived to be present in their environment discouraging people from being more active; and (4) they introduce methodological and theoretical approaches that can be useful for planning research. In addition, this article employs a conceptual framework that can facilitate the classification and evaluation process of the environmental variables used in the studies reviewed.

This review has three purposes. The first is to highlight the studies' key findings confirming walking as the most common type of physical activity and identify preferred places for, and perceived barriers to, physical activity. The review proceeds to examine the environmental variables used, acknowledging those with strong empirical evidence for supporting physical activity (see the appendix for a classification of the studies based on the type of measures, objective and/or subjective, used for the independent variables capturing environments). Third, lessons are drawn from both the findings and the theoretical and methodological frameworks of the reviewed studies. The article concludes with a discussion of the findings' implications for practice and research in promoting active living, possibly filling gaps or strengthening existing knowledge in urban and transportation planning fields.

METHODOLOGICAL FRAMEWORK OF THIS REVIEW

The structure of this review is based on the criteria employed for the literature selection and the Behavioral Model of Environment (BME) as a conceptual construct to evaluate the chosen studies' environmental variables and key findings.

Criteria for Literature Selection

Twenty public health studies are chosen for this review, based on their contribution to building empirical evidence of community-based physical environmental determinants of physical activity. The studies focus on outdoor environments and lifestyle-based physical activities. They consider various types of physical activity, including, but not limited to, walking and biking. Excluded is research dealing solely with private and indoor environments (e.g., home, school or work-site environment, interior building design), small environmental cues (e.g., signs next to elevators), or social and policy-related environmental factors (e.g., advocacy efforts, school-based programs, and laws and regulations).

Keyword searches of several computerized databases, including MedLINE, PsycINFO, and Web of Science, and publication searches from the federal and local public health agencies identified the twenty studies. Keywords included *walk*, *bike*, *bicycle*, *cycle*, *physical activity*, *environment*, *community*, *determinant*, *environmental determinant*, *environmental factor*, *facilitator*, *enabler*, *barrier*, *correlate*, *neighborhood*, *neighborhood factor*,

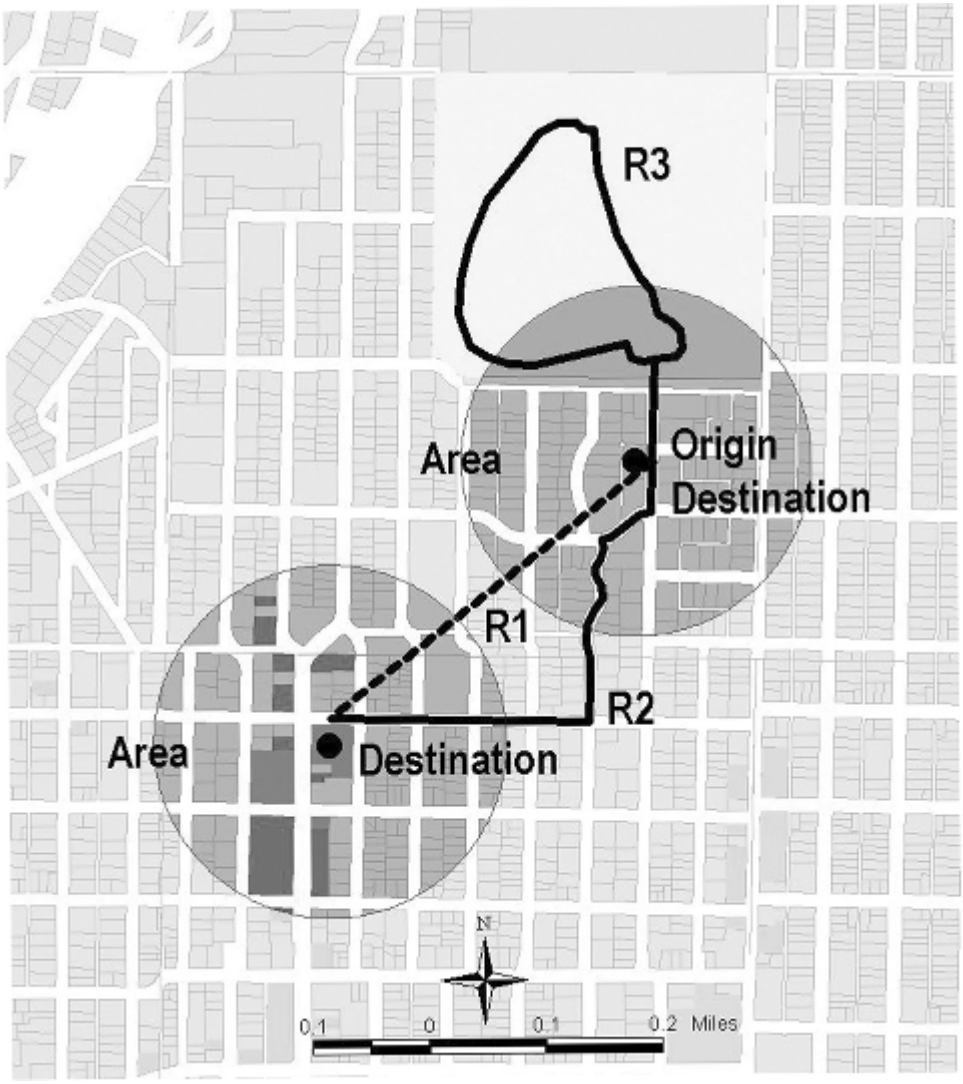

FIGURE 2. Behavioral Model of Environment: Three Components of Origin/Destination, Route, and Area.
SOURCE: Moudon and Lee (2003, 23). Used with permission.
NOTE: R1 = airline route to destination; R2 = street network route to destination; R3 = recreational route.

and *neighborhood effect*. The initial literature search was conducted during September 2002 and periodically updated until June 2003.

Use of the Behavioral Model of Environment

Physical environmental factors influencing physical activity are numerous and subject to complex interactions among themselves. A theoretical model can become useful, as it serves to conceptualize and operationalize environmental factors and their relationships (Saelens, Sallis, and Frank 2003). This review employs a BME (Moudon and Lee 2003), which identifies the generic parts of environments affecting outdoor physical activity, specifically walking and biking. The BME also points to areas where interventions can be made to better support these activities (Figure 2). The model organizes classes of variables characterizing the three components of the environment for promoting walking and biking: origin/destination (OD), route (R), and area (A).

THE ORIGIN AND DESTINATION OF THE WALKING OR BIKING TRIP (ORIGIN/DESTINATION OR OD)

Any given walking and biking trip starts and ends at certain points. The types and locations of origins and destinations play a determinant role in one's decision to walk or bike (e.g., Goldsmith 1992; USDOT 1995; Steiner 1998; Rutherford et al. 1995; Handy 1996). Trip destinations also relate to trip purpose. Regular commute-trip destinations include work site and school,

and social or shopping-trip destinations include grocery stores, malls, restaurants, coffee shops, parks, and so on. Trip origins can vary depending on how an individual trip or a trip chain is defined, but home or work locations generally serve as common origins. *Destinations* must be relatively proximate to origins in order to allow for the option to walk or bike. Points of origin and destination are spatially different for transportation but may be the same for recreation or exercise (e.g., walking around the neighborhood).

THE CHARACTERISTICS OF THE ROUTE TAKEN FOR THESE TRIPS (ROUTE OR R)

The characteristics of the *route* between origin and destination consist of not only the physical conditions of, and along, the roadway but also the quality influencing the safety, convenience, comfort, and enjoyment of walkers and bikers. The combination of these characteristics affects one's decision to walk or bike and how long one is willing to walk or bike (e.g., Rapoport 1987; Corti, Donovan, and Holman 1997). Roadway characteristics are commonly measured as the number of vehicle lanes, vehicular speed, slope, and presence of sidewalks and bike lanes, as well as the number of cars, bikers, or people on the roadway. *Route* qualities are often measured subjectively as the users' rating of perceived safety, convenience, and visual quality of the roadway and roadside environments.

THE CHARACTERISTICS OF THE AREAS AROUND ORIGIN AND DESTINATION PLACES (AREA OR A)

Area characteristics consist of social and behavioral aspects of the physical environment, such as the uses of land, activities that take place, and the intensity of these uses and activities. Population density, floor area of commercial buildings, street block size, and number of street intersections are a few common examples of variables used. They are often measured objectively, using publicly available spatial and/or tabular databases (Ewing and Cervero 2001). Subjective measures of the *area* component include people's perception of the area or neighborhood quality, such as safety from crime, friendliness, and enjoyable scenery.

The area component concerns the volumes of, and the choices of, routes and activities available for walkers and bikers. The intensity and mix of land uses in an area affect how much potential and actual walking or biking activities the area will generate or attract (FHWA 1999; Moudon et al. 2001). The overall patterns of street networks (e.g., small grid, large grid, culs-de-sac, loops) are considered as an area component in this model, while the characteristics of individual street segments belong to the route component. The types of street networks along with the land uses patterns affect the level of choices that people can have in the area. For example, small gridlike streets and mixed land uses provide more alternative routes and often various travel modes, such as transit, when moving from the origin to destination.

Considerations of environment from all three components of the BME are important, and these components are not mutually exclusive of each other. Many variables address more than one component of the BME (Figure 3). For example, measures of accessibility to destinations often overlap with both the OD and the R components, and both aspects of accessibility influence one's decision to walk or bike. Having a destination located within a walkable or bikable distance from home (OD) allows for the option to walk or bike. At the same time, the route quality (R), such as sidewalk or bike lane connectivity, quality of the roadside environment, and street-crossing conditions, influence one's actual decision to engage in walking or biking.

This model serves as a conceptual framework for discussing the findings of this review, especially in the review of environmental variables tested in the studies to influence physical activity, walking, and biking.

METHODS USED IN THE STUDIES

Tables A1 through A4 in the appendix provide an overview of the methodologies used in the chosen studies. Table columns are lettered (A through I) to guide the discussion of each element of the methods. Included in this section are the study population and sample; theoretical framework; dependent variables capturing dimensions of physical activity, including walking and biking; independent variables classified into objective and/or subjective measures; confounding variables controlled for; data collection methods; and statistical techniques for data analyses.

Study Population (A) and Sample (B)

Study populations are mainly adults in general but also include children, older adults, minorities, students, and women. Sample sizes for the quantitative studies (Tables A1 through A3) are large, ranging from a few hundreds to more than one hundred thousand. Several studies use existing population-based surveys, resulting in relatively large sample sizes. The surveys include the Behavioral Risk Factors Surveillance System (BRFSS) (CDC n.d.) and the National Health and Nutrition Examination Survey (NHNES) from the United States and the Australian Activity Survey (AAS) from Australia.

A majority of the studies employ probability (or random) sampling techniques, often incorporating clustering and stratification strategies. Probability sampling

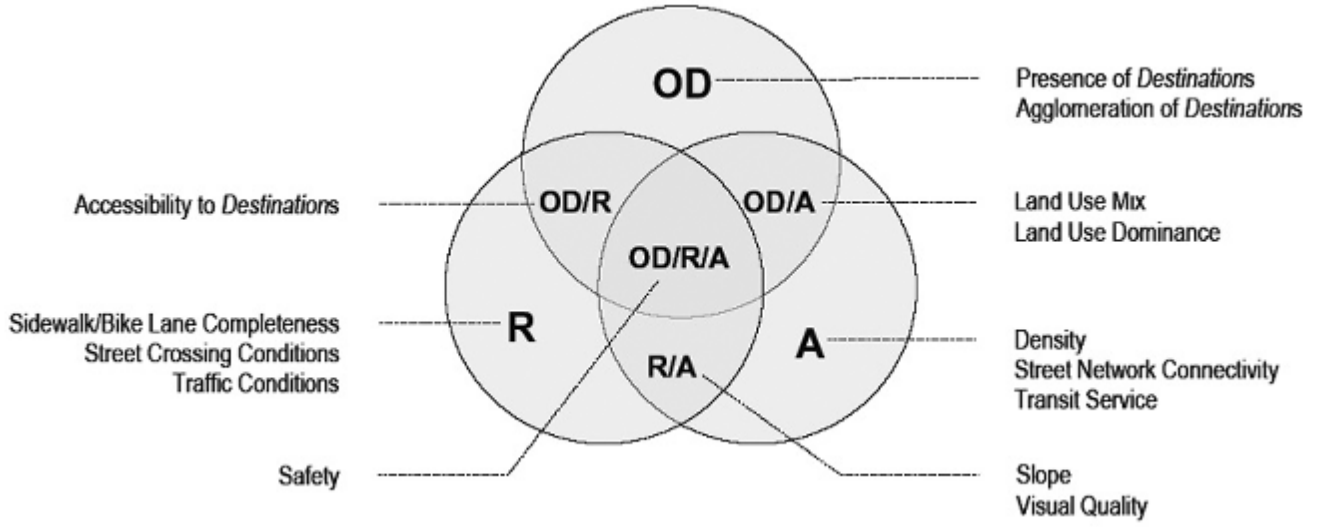

FIGURE 3. Behavioral Model of Environment: Conceptual Structure, and Examples of Variables

ensures the generalizability of study findings to large populations. The technique is less common in the planning field where primary data collection efforts are less frequent and limited.

Theoretical Framework (C)

The social ecological perspective provides a broad frame of reference for studies reviewed here, emphasizing the dynamic interplay between the personal behavioral and environmental factors (Sallis and Owen 1997; Stokols 1992). In contrast to traditional health behavior theories that focus on the role of personal factors on behavior, this perspective stresses the importance of both sociocultural and physical environmental factors in behavior change.

The social ecological approach has a foundation in social cognitive theory (Bandura 1986). First introduced as social learning theory by Bandura (1977), social cognitive theory is based on the assumption that individuals are generally motivated to engage in behaviors that will result in rewards and to avoid punishments (Bandura 2001). The theory focuses on motivational factors and self-regulatory mechanisms that contribute to a person's behavior, in addition to environmental factors. It explains human behavior in terms of a continuous reciprocal interaction between individual, behavioral, and environmental influences.

Social cognitive theory has been widely adopted in the area of health promotion (Seefeldt, Malina, and Clark 2002). The same concepts of multi-level, interactive influences on behavior change are used in the social ecological perspective (e.g., Baker et al. 2000; McLeroy et al. 1988; Sallis and Owen 1997; Stokols 1992). The latter views behavior as determined by personal, social, organizational, community and policy factors, and emphasizes the need for the environmental interventions in health promotion programs (McLeroy et al. 1988).

Additional theories contribute to the construction of reviewed studies: the theory of planned behavior, emphasizing the role of intention to perform the behavior and perceived behavior control to influence actual behavior (Ajzen 1988, 1991); the theory of trying, focusing on the conscious process of forming the intention to behave before performing the behavior (Bagozzi and Warshaw 1990); and the theory of behavior setting, emphasizing the importance of dynamic and interactive real-life settings in which human behaviors take place (Baker 1968).

Many theories share core constructs that are applied in the studies as attitude toward physical activity, social environment, perception of neighborhood resources, opportunities and benefits of physical activity, skills needed to perform physical activity, and so on. Six studies have a basis in social cognitive theory, three of which (King et al. 2000; Booth et al. 2000; Hovell et al. 1992) derive their independent variables directly from its constructs. Another study (Giles-Corti and Donovan 2002) selects individual factors associated with physical activity based on the theory of planned behavior and the theory of trying. Sallis et al. (1997) consider the theory of behavior setting by focusing on two common behavior settings, home and neighborhood, to investigate the influences of perceived environmental factors on physical activity.

Dependent Variables (D)

Dependent variables in public health studies often include engagement in, or total amount of, physical activity. While all types of physical activity are considered, most studies focus on unstructured, moderate activities such as walking and biking, with seven studies using walking specifically as their dependent variable.

Dependent variables are often self-reported and dichotomized or categorized for analysis. They include engagement in (1) overall physical activity, (2) sufficient level of physical activity for health benefits[2]—based on energy expenditure or total amount of physical activity, (3) leisure or exercise physical activity, and (4) specific types of physical activity such as walking, jogging, swimming, and so on. Other dichotomous variables include whether participants use specific types of recreational facilities, such as gyms, parks, sidewalks, bike lanes, trails, swimming pools, tennis courts, health clubs, open spaces, golf courses, and so on.

Continuous dependent variables considered include total amount (frequency and duration combined) of (1) physical activity, (2) leisure time physical activity, (3) household-related physical activity, (4) walking, and (5) vigorous activities. Also studied is the prevalence of walking to work. These continuous variables are sometimes transformed into categorical or dichotomized variables for analyses (e.g., Berrigan and Troiano 2002; Booth et al. 2000; Wilcox et al. 2000; Bauman et al. 1999).

Independent Variables (E, F)

A large number of independent variables measure personal and social determinants of physical activity, some of which are considered also as control variables (see G below). Environmental factors as independent variables, the focus of this review, are classified into objective and subjective variables. Out of the total twenty studies, only three include both objective and subjective measures (Table A1), four use objective measures only (Table A2), and ten use subjective measures only (Table A3). The remaining three studies are exploratory, and no independent variables are specified.

Objective measures cover the spatial characteristics of residential locations in terms of accessibility, density of people or development, and geographic locations (e.g., urban or costal location). These variables are derived from maps and measurements using the Geographic Information System (GIS). One study of preschoolers uses a direct observation method to measure both dependent and independent variables (Klesges et al. 1990). Two studies identify road network distances to recreational facilities, one of which also considers the presence of barriers (hills and heavy traffic) along the route (Troped et al. 2001). An early study based on objective measures (Sallis et al. 1990) uses the total number and density of pay and free exercise facilities near home to estimate accessibility to these facilities. Berrigan and Troiano (2002) use housing stock age as a proxy for the neighborhood's urban form characteristics.

Subjective measures of physical environmental factors address perception of safety, convenience, comfort, visual quality, neighborhood character, and presence of or proximity to exercise facilities and shops.

Confounding Variables (G)

Most studies control for one or more of the confounding factors, such as age, sex, education, and income. However, reporting of their relationship with the dependent variable is often brief and vague. Such factors as transit service and objectively measured traffic conditions, which often confound the relationship between physical activity and environment, are not addressed in any of the studies. Neither are socioeconomic factors specific to transportation behaviors, such as car ownership.

Data Collection (H)

Data are collected specifically for the individual study (13 out of the 20 studies) or come from reliable secondary sources. Primary self-reported data come from telephone interviews, or less frequently, mail surveys. Many of the surveys use questions from the existing questionnaires mentioned earlier (e.g., Berrigan and Troiano 2002; Ball et al. 2001; CDC 1998, 1999). The three exploratory studies (Table A4) use focus-group methods to generate the data. Primary data sources for objective variables include observations (Giles-Corti and Donovan 2002; Klesges et al. 1990), mappings (Sallis et al. 1990), and GIS-based measurements (Troped et al. 2001).

Statistical Analyses (I)

Descriptive statistics and correlation analyses are often complemented by logistic regression analysis, which is a common choice with a dichotomized dependent variable. Almost half of the studies use logistic regression alone or combined with other analyses. The popularity of the logistic regression method likely comes from the health field's traditional interest in achieving a sufficient level of physical activity for health purposes. This method is effective in explaining the likelihood of achieving a threshold. Yet, the dichotomization may result in loss of information that can only be examined at a more fine-grained scale. Three studies (Craig et al. 2002; Rutten et al. 2001; Hovell et al. 1992) use hierarchical regression models to

consider nested data structures, as they include variables at multiple levels (e.g., individual- and neighborhood-level variables). Ball et al. (2001) use a structural equation model, which is a multivariate analysis for investigating the underlying structure of usually a large number of variables, to analyze perceived environmental factors. All but Hovell et al.'s study (1992) are cross-sectional, and therefore causality assumption of the statistical analyses may not hold.

FINDINGS FROM THE STUDIES

The studies together yield general findings about (1) walking as the most common type of physical activity, (2) preferred places for physical activity, and (3) barriers to physical activity. An inventory of empirically tested environmental variables associated with physical activity is included and discussed in terms of the BME.

Walking as the Most Common Type of Physical Activity

Four studies (Ball et al. 2001; Booth et al. 1997; Giles-Corti and Donovan 2002; Troped et al. 2001) report walking as the most frequently engaged physical activity. Walking is confirmed to be a preferred form of physical activity by an overwhelming majority of study populations across different gender, age, and income groups (Table 1). However, the degrees of popularity vary across subgroups (Table 1). Findings show that walking is more prevalent among women and older adults (Booth et al. 1997). Stephens et al. (1985) report that walking is more popular among typically inactive segments of the population, such as ethnic minorities and the elders. Gardening, swimming, and jogging are among other frequently reported activities.

The preference of walking is further supported in studies outside the twenty selected articles included here (e.g., Bull et al. 2000; Siegel, Brackbill, and Heath 1995; Statistics Canada 1998-99; Go for Green 1998; CDC 2000a, 2000b). These studies together help affirm that promoting walking is the most practical way to achieve healthful levels of physical activity. U.S., Australian, and Canadian populations appear to practice walking and biking for recreation more so than for transportation. The CDC (2000b) found that most people when they walk for recreation walk at least 30 minutes at a time, reaching a sufficient threshold of daily activity for health benefits. Yet walking for utilitarian purposes may be shorter: for example, the Nationwide Personal Transportation Survey (USDOT 1995) reports that most walking trips last only about five to ten minutes. Additional research will help sort out the purposes behind the total amount of walking people do.

Preferred Places for Physical Activity

Outdoor and freely available neighborhood facilities are most frequently used for physical activity (Table 2). Neighborhood streets are most commonly used places in the Giles-Corti and Donovan (2002) and Troped et al. (2001) studies. Giles-Corti and Donovan (2002) find that 46 percent of the respondents use their neighborhood streets for exercise, compared with only 11 percent using gyms, health clubs, or exercise centers, and 9 percent using sport or recreation centers. There are studies outside the twenty articles that further demonstrate the popularity of neighborhood streets as places for physical activity (Brownson et al. 2001; Bull et al. 2000). Brownson et al. (2001) report that neighborhood streets are used by more than 66 percent of the respondents who reported some degree of physical activity, while only 21 percent used an indoor gym and 25 percent used a treadmill. Other freely available public open spaces, such as parks and trails, are also common places for exercise (e.g., Giles-Corti and Donovan 2002).

The popularity of neighborhood streets may be explained in part by their easy accessibility from home and potential to serve a dual purpose: in BME terms, they are both *destinations* for recreational activities and *routes* to get to places. The prevalence of walking as physical activity also explains the attractiveness of streets that are natural venues for walkers. This finding points to opportunities for increasing walking and biking for transportation purposes.

Barriers to Physical Activity

The studies also show that people feel the built environment is not supportive enough to induce physical activity. Long distances separating places, lack of safe places and facilities for recreation, and poor accessibility to recreational facilities are among the common barriers people perceive exist in their environment (Table 3). While some environmental barriers are difficult to modify, such as bad weather conditions (e.g., Brownson et al. 2000) and short daylight hours (Hahn and Craythorn 1994), many can be modified or eliminated.

Table 3 summarizes the barriers into four broad categories, including opportunity, distance, access, and safety barriers. Both opportunity and distance barriers relate to the OD component of BME, as they concern availability of proximate destinations from origins. Access barriers include both OD and R components and focus on lack of high-quality, route-related facilities for walkers and bikers. Safety barriers involve unsafe roadway conditions often due to poor maintenance and perceived fear of crime, traffic, accident, injury, dogs, and people. Access and safety barriers include perhaps some of the easiest ones to lift to support physical activity.

TABLE 1. Preferred Type of Physical Activity

Preferred Type of Physical Activity	Level of Preference	Subjects	1st Author and Year Published
Walking for recreation	86.1% in previous 4 weeks (1)	American adults living in Arlington, MA	Troped 2001
	38% of young and 68% of older adults (1) in previous 2 weeks	Young and older sedentary Australian adults	Booth 1997
	68.5% in the previous 2 weeks (1)	Australian adults	Giles-Corti 2002
	38-52% males and 41-64% females (depending on sex, age, education, and environmental factors) in the past 2 weeks	Australian adults	Ball 2001
Walking for transportation	72.1% in the past 2 weeks	Australian adults	Giles-Corti 2002

Other Studies (outside the 20 selected articles)

Preferred Type of Physical Activity	Level of Preference	Subjects	1st Author and Year Published
Walking for recreation	80.6% of females and 73.4% of males during a week (1)	Western Australian adults	Bull 2000
	50.4% of males and 69.2% of females during a week (1)	Western Australian adults	Bull 2000
	44.1% during a week (1)	American adults	CDC 1996
	42% (walking was the only leisure time physical activity for 21% of them) during a week	American adults	CDC 2000b
	37.7% of males and 52.5% of females during a week	Overweight American adults	CDC 2000a
	69% (75% females and 64% males) (1)	Canadian adults	Statistics Canada 1998-99
	85% at least sometimes (1)	Canadian adults	Go for Green 1998
	35.6% (1)	American adults	Siegel 1995
Walking for transportation	58% at least some times	Canadian adults	Go for Green 1998
	42% in previous 2 weeks	Western Australian adults	Bauman 1996
	25% during a week	Western Australian adults	Bull 2000
	21% to local facilities	Western Australian adults living in Perth	Seaton 2001
	4% to work (8% used public transport, of which 55% walked 15+ minutes as part of trip)	Western Australian adults living in Perth	Seaton 2001
	24.6% of males and 25.1% of females during a week (3)	Western Australian adults	Bull 2000
Biking for recreation	48% biked for leisure or recreation	Canadian adults	Go for Green 1998
	9.8% of males and 7.4% of females during a week (8)	Western Australian adults	Bull 2000
	15.4% during a week (4)	American adults	CDC 1996
	24% (19% females and 28% males) (4)	Canadian adults	Statistics Canada 1998-99

(continued)

TABLE 1 (continued)

Preferred Type of Physical Activity	Level of Preference	Subjects	1st Author and Year Published
Biking for transportation	26% at least sometimes	Canadian adults	Go for Green 1998
	2% to local facilities	Western Australian adults living in Perth	Seaton 2001
	1% to work	Western Australian adults living in Perth	Seaton 2001
	4.9% of males and 2.6% of females during a week (12)	Western Australian adults	Bull 2000
Gardening/yard work	37.0% males and 38.2% females during a week (2)	Western Australian adults	Bull 2000
	29.4% during a week (2)	American adults	CDC 1996
	48% (45% females and 51% males)	Canadian adults	Statistics Canada 1998-99
	8.2% during a week	Overweight American adults	CDC 2000a
Swimming/ surfing	13.4% of males and 11.2% of females during a week (4)	Western Australian adults	Bull 2000
	6.5% during a week (9)	American adults	CDC 1996
	24% (24% females and 24% males) (4)	Canadian adults	Statistics Canada 1998-99
	19% in previous 2 weeks (2)	Young and older sedentary Australian adults	Booth 1997
Jogging/running	12.1% of males and 6.1% of females during a week (6)	Western Australian adults	Bull 2000
	9.1% during a week (7)	American adults	CDC 1996
	9.6% of males during a week	Overweight American adults	CDC 2000a

NOTE: Numbers in parentheses show the rank based on the activity's level of prevalence reported in the study: recall period (or frequency of engagement in the activity) and the rank based on the prevalence of activity are reported only when the information is available from the corresponding study. CDC = Centers for Disease Control and Prevention.

Personal and social factors are also reported to hinder physical activity. Lack of time (e.g., Brownson et al. 2001; King et al. 2000; Eyler et al. 1998) is the leading factor that discourages physical activity. This finding suggests that supporting walking for the dual purpose of exercise and transportation may help increase levels of physical activity. Other personal barriers include poor health (Eyler et al. 1998; Owen and Bauman 1992), child care responsibility (Hahn and Craythorn 1994), and lack of energy (King et al. 2000). Personal safety concerns raised pertain to injuries, falls, traffic accidents, and so on. Common social barriers include not having company (Hahn and Craythorn 1994) and not seeing other people exercising (Wilcox et al. 2000). Studies outside the twenty articles report additional deterrents of physical activity, including lack of interest (Vuori, Oja, and Paronen 1994; Owen and Bauman 1992), self-consciousness about one's appearance (Brownson et al. 2001), and costs of structured physical activity programs (Booth et al. 1997). However, it must be noted that these findings still remain inconclusive, and several variables have shown both positive and negative impact on physical activity (i.e., hills, self-consciousness about physical appearance, and unattended dogs). These mixed findings may be partly due to lack of representativeness in the studies' participants and their environmental conditions (e.g. Eyler et al. 1998; Hahn and Craythorn 1994; King et al. 2000). Because the impact of these variables on physical activity differs depending on age, gender, and ethnic background, intervention strategies tailored to the sociodemographic composition of the specific community are likely to be effective in promoting both physical activity and nonmotorized travel.

Environmental Variables Empirically Tested to Influence Physical Activity

The twenty studies address the three components of the BME in varying degrees. Individual studies typically consider only one or two of the components, and variables included often do not capture comprehensively the forms and characteristics of the built environment. As a result, the relative strength of association between individual environmental variables and phys-

TABLE 2. Preferred Place for Physical Activity

Preferred Place to Do Physical Activity	Type of Physical Activity	Level of Preference	Subjects	1st Author and Year Published
Neighborhood streets	Physical activity	45.6% (1)	Western Australian adults	Giles-Corti 2002
	Physical activity for recreation	79.1% (2 among the bikeway users after the bikeway); 64.1% (1 among the nonusers)	American adults living in Arlington, MA	Troped 2001
Parks	Physical activity for recreation	20.7% Parks and recreation facilities (2 among the nonusers of the Minuteman Bikeway, parks and recreational facilities combined)	American adults living in Arlington, MA	Troped 2001
Public open space	Physical activity	28.8% (2)	Western Australian adults	Giles-Corti 2002
Beach	Physical activity	22.7% (3)	Western Australian adults	Giles-Corti 2002

Other Studies (outside the 20 selected articles)

Preferred Place to Do Physical Activity	Type of Physical Activity	Level of Preference	Subjects	1st Author and Year Published
Neighborhood streets	Physical activity	66.1% of the respondents who reported some degree of physical activity (1)	American adults	Brownson 2001
	Walking for recreation	52.3% (1)	Western Australian adults	Bull 2000
	Running/jogging for recreation	33.3% (1)	Western Australian adults	Bull 2000
Shopping malls	Physical activity for recreation	37.0% of the respondents who reported some degree of physical activity (2)	American adults	Brownson 2001
Parks	Physical activity for recreation	29.6% of the respondents who reported some degree of physical activity (3)	American adults	Brownson 2001
	Walking for recreation	12% (2)	Western Australian adults	Bull 2000
	Running/jogging	18.5% (2)	Western Australian adults	Bull 2000
Walking and jogging trails	Physical activity for recreation	24.8% of the respondents who reported some degree of physical activity (4)	American adults	Brownson 2001
Cycle paths	Walking for recreation	8.9% (4)	Western Australian adults	Bull 2000
	Running/jogging	8.4% (4)	Western Australian adults	Bull 2000
Beach	Walking for recreation	9.9% (3)	Western Australian adults	Bull 2000
	Running/jogging	16.5% (3)	Western Australian adults	Bull 2000

NOTE: Numbers in parentheses show the rank based on the place's level of prevalence for the particular physical activity reported in the study: level of preference is reported based on the entire population, not on those who are active only, unless noted.

ical activity is not systematically examined, nor is the issue of likely covariance between environmental variables assessed. Nonetheless, significant correlations are found between some of the individual environmental

TABLE 3. Physical Environmental Barriers to Physical Activity

BME Component	Criteria	Perceived Environmental Barriers	Type of Physical Activity	Subjects	1st Author and Year Published
OD	Opportunity barrier	No facilities	Physical activity	Older Australian	Booth 2000
		Lack of land for recreation (unstructured and passive activities)	Physical activity	Focus group of Australian adults	Hahn 1994
	Distance barrier	Travel distance	Physical activity	Focus group of Australian adults	Hahn 1994
OD/R	Access barrier	Access (cost, lack of transportation and programs)	Physical activity	Focus group of older minority American adults	Eyler 1998
		(Rural residents) Lack of a walking trail or malls	Physical activity	Focus group of older minority American adults	Eyler 1998
		Limited footpaths and cycle ways	Physical activity	Focus group of Australian adults	Hahn 1994
		Access difficulties include badly maintained or unsafe foot or cycle paths, unsafe pedestrian crossings, and road safety for pedestrians and cyclists	Physical activity	Focus group of Australian adults	Hahn 1994
		Lack or poor access to facilities (lack of pedestrian or bike routes)	Walking	American adults	Brownson 2000
OD/R/A	Safety barrier	Unsafe footpaths and cycle ways	Physical activity	Focus group of Australian adults	Hahn 1994
		Safety (traffic, people, dogs)	Physical activity	Focus group of older minority American adults	Eyler 1998
		(Rural, suburban and urban) Fear of the surroundings and crime	Physical activity	Focus group of older minority American adults	Eyler 1998
		Lack of safe places to exercise	Walking	American adults	Brownson 2000
		Lack of safe places to exercise	Physical activity for recreation	Older female minority American adults	King 2000
		Fear of injury	Walking	American adults	Brownson 2000
		Fear of injury	Physical activity	Older Australian	Booth 2000
		Fear of injury	Physical activity for recreation	Older female minority American adults	King 2000
		Fear for personal safety	Physical activity	Focus group of Australian adults	Hahn 1994

Other Studies (outside the 20 selected articles)

BME Component	Criteria	Perceived Environmental Barriers	Type of Perceived Activity	Subjects	1st Author and Year Published
OD	Distance barrier	Distance	Walking and biking for transportation	Canadian adults	Go for Green 1998
		Distance too far to get to places on foot	Walking for transportation	West Australian adults	James 2001
OD/R	Access barrier	Too uncomfortable to walk	Walking for transportation	West Australian adults	James 2001

(continued)

TABLE 3 (continued)

Other Studies (outside the 20 selected articles)					
BME Component	Criteria	Perceived Environmental Barriers	Type of Perceived Activity	Subjects	1st Author and Year Published
		Lack of pleasant route	Walking and biking for transportation	Canadian adults	Go for Green 1998
		Lack or poor access to facilities	Walking and biking to work	Finnish adult workers	Vuori 1994
R/A	Safety barrier	Fear of accident	Walking and biking to work	Finnish adult workers	Vuori 1994
		Fear of injury	Walking and biking to work	Finnish adult workers	Vuori 1994
		Traffic safety/bad road	Walking and biking for transportation	Canadian adults	Go for Green 1998

NOTE: BME = Behavioral Model of Environment; OD = origin/destination; R = route; A = area.

variables and physical activity, after controlling for sociodemographic factors. Tables 4 and 5 list the variables as objective and subjective measures, respectively, classifying them according to the components of the BME, and specifying the type of physical activity environmental variable associated with them, along with the direction of the association.

Generally, objective measures emphasize accessibility to destinations in the residential neighborhood environment, corresponding mainly to the *OD* and *Route* components of the BME. Subjective measures include a wide range of variables considering all three components of the BME. Most *route*- and *area*-based attributes are measured subjectively.

OD-related variables, such as the presence of, and proximity to, exercise facilities in the neighborhood, whether perceived or actual, play a role in people's levels of physical activity. This is consistent with findings in the planning literature that distance to destinations is a determinant factor for transportation mode choice (USDOT 1995). Most destinations included in the studies are considered for their recreational opportunities. As a result, some of the typical *route*-related variables in the planning research, such as neighborhood streets and walking trails, are often treated as *destination*. This reflects the health research's focus on engagement in physical activity itself, rather than on means of travel. Most studies emphasize residential location as the *origin* for physical activity and travel. Specific *destination* facilities found to foster physical activity include public facilities such as footpaths, trails, parks, public open spaces, and cycle tracks, as well as private facilities such as gyms, health clubs, recreation centers, and swimming pools.

A relatively small number of studies show associations between *route*-related variables and levels of physical activity (e.g., Corti, Donovan, and Holman 1997; Craig et al. 2002; Troped et al. 2001). In Craig et al. (2002), subjectively measured variables, including continuity and choices of walking route, as well as traffic threats and other obstacles along the route, contribute to explain variations in the composite environmental score used to evaluate the routes. The scores are found to be associated with levels of walking to work. Troped et al. (2001), on one hand, find the objectively measured presence of hills to negatively influence the use of a local bikeway. King et al. (2000), on the other hand, find the perceived presence of hills to be positively related with physical activity. This apparent discrepancy is likely due to the different measurement types (objective versus subjective) and different dependent variables used by the studies (i.e., respondents seeking to reach a bikeway perceive hills as a barrier to accessing the bikeway, but respondents seeking leisure time activity or household-related physical activity perceive hills as an attractor, possibly because they afford good views). Positive associations are also reported between levels of physical activity and the perception of tamed traffic conditions, pedestrian-friendly facilities (e.g., footpaths, signage, street lights, etc.), and effective traffic control measures, as well as with increased visual quality, perceived safety, and convenience.

Important objective *area*-based variables include steep terrain, home age, and costal and urban residential locations. The latter three variables are used as proxies for general urban form characteristics. While proxies may be an efficient means to address the multiple, highly interrelated variables that represent the built

TABLE 4. Objective Measures Influencing Physical Activity

BME Component	Criteria	Objective Measures of Physical Environmental Variables	Relationship with Dependent Variable Found	1st Author and Year Published
OD	Destination quality	Park size	1 Use of local parks	Corti 1997
		Other amenities available at the facility	1 Use of pay exercise facility	Corti 1997
OD/A	Availability of destinations	Number of local shops	1 Walking around their neighborhood	Corti 1997
		Number of destinations	Contribute to explain variations of environment score among neighborhood	Craig 2002
OD/R	Accessibility to destinations	Access to facilities (this relationship stronger for beach, river, golf courses, and tennis courts; less clear for other facilities)	1 Use of facilities	Giles-Corti 2002
		Access to exercise facilities	1 Likelihood of achieving physical activity as recommended	Giles-Corti 2002
		GIS road network distance to trail	2 Bikeway use	Troped 2001
		Distance from home to pay facilities	Contribute to explain difference between sedentary and exerciser groups	Sallis 1990
	Convenience of destinations	Rating of perceived convenience of specific facilities	Contribute to explain difference between sedentary and exerciser groups	Sallis 1990
R	Route quality	Steep hill barrier along the route to the facility	2 Bikeway use	Troped 2001
A	Density	Density of total exercise facilities within 1 km	Contribute to explain difference between sedentary and exerciser groups	Sallis 1990
		Density of pay facility	1 Exercise	Sallis 1990
	House age	Living in housing built before 1973 (as a proxy for the residential neighborhood's urban form)	1 Likelihood of walking 20+ times/week (only in urban/suburban area); this relationship did not hold for rural area	Berrigan 2002
	Geographic location	Costal residential location	2 Likelihood of being sedentary	Bauman 1999
		Costal residential location	1 Likelihood of being adequately active	Bauman 1999
		Costal residential location	1 Likelihood of being vigorously active	Bauman 1999
	Neighborhood characteristics	Degree of urbanization	1 Physical activity	CDC 1998
		Degree of urbanization	2 Physical inactivity (strongest in South region: 12.3% higher prevalence of physical inactivity in rural area)	CDC 1998

NOTE: 1 or 2 sign shows the direction of association that the independent variable has with the dependent variable (1 = positive, 2 = negative). BME = Behavioral Model of Environment; OD = origin/destination; R = route; A = area; GIS = Geographic Information System; CDC = Centers for Disease Control and Prevention.

environment, they may not pass the test of external validity if they fail to show any effect after controlling for other sociodemographic factors and/or more extensively studied individual environmental factors such as density or land use mix. Subjectively measured *area*-based variables, such as the perception of enjoyable scenery, are also found to influence physical activity (King et al. 2000). Amenities and aesthetic features are shown to increase the use of local parks (Corti, Donovan, and Holman 1997). Perception of environmental

TABLE 5. Subjective Measures Influencing Physical Activity

BME Component	Criteria	Subjective Measures of Physical Environmental Variables	Relationship with Dependent Variable Found	1st Author and Year Published
OD	Availability of destinations	Perceived presence of park	1 Likelihood of being sufficiently active	Booth 2000
		Perceived presence of recreation center (correl)*	1 Likelihood of being sufficiently active	Booth 2000
		Perceived presence of cycle track (correl)	1 Likelihood of being sufficiently active	Booth 2000
		Perceived presence of golf course (correl)	1 Likelihood of being sufficiently active	Booth 2000
		Perceived presence of swimming pool (correl)	1 Likelihood of being sufficiently active	Booth 2000
		Self-reported distance to trail—trail as destination	2 Bikeway use	Troped 2001
		Perceived opportunities	1 Physical activity (weak but significant)	Rutten 2001
OD/R	Proximity/ accessibility	Perceived proximity and accessibility	1 Use of local parks	Corti 1997
		Facility's accessibility and proximity to home or work, or facility's location along the route to work	1 Use of pay exercise facility	Corti 1997
OD/A	Mix of destinations	Variety of destinations	Contribute to explain variations of environment score among neighborhood*	Craig 2002
OD/R/A	Accessibility to destinations	Baseline number of convenient facilities (number of exercise facilities, such as aerobic dance studios, bike lanes, and running tracks, perceived as convenient)	1 Walking	Hovell 1992
R	Walking route availability	Presence of footpath	1 Walking around their neighborhood	Corti 1997
		Presence of walking paths	1 Walking around their neighborhood	Corti 1997
		Availability of walking routes (sidewalks, paths)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
	Walking route quality	Safe footpath for walking	1 Likelihood of being sufficiently active	Booth 2000
		Traffic control measures	1 Walking around their neighborhood	Corti 1997
		Little difficulty using footpaths (correl)	1 Likelihood of being sufficiently active	Booth 2000
R/A	Walking system quality	Inclusive of pedestrian (people-oriented buildings, signage, amenities)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Meets pedestrian's need (route continuity, route choices, crossing lights, topography, traffic, obstacles)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Traffic threats (amount, speed, separation from traffic)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Obstacles (debris, construction, maintenance)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Time and effort required to walk—more specific (route directness, topography, obstacles, characteristics of intersections)	Contribute to explain variations of environment score among neighborhood*	Craig 2002

(continued)

TABLE 5 (continued)

BME Component	Criteria	Subjective Measures of Physical Environmental Variables	Relationship with Dependent Variable Found	1st Author and Year Published
A	Walking system quality	Walking system (continuity)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
	Transportation system quality	Transportation system (connection to other modes of transportation, bike parking, benches at transit stops)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
	Neighborhood characteristics	Neighborhood character perceived as residential compared to mixed or commercial	2 Bikeway use	Troped 2001
		Availability of amenities	1 Use of local parks	Corti 1997
	Visual quality	Aesthetic features including lakes and bird life	1 Use of local parks	Corti 1997
		Complexity of stimulus (amount and variety of visual and auditory stimuli)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Potential overload of stimulus (amount and variety of visual and auditory stimuli)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Perceived presence of enjoyable scenery (total sample)	1 Physical activity	King 2000
		Perception of environmental aesthetics	1 Walking for exercise	Ball 2001
	Area quality	Perceived presence of hills (total sample)	1 Physical activity	King 2000
		Perception of convenience of environment	1 Walking for exercise	Ball 2001
	Perceived safety	Safety from crime (lighting, front porches, escape routes, people around, street type, etc.)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Potential for crime (graffiti, vandalism, disrepair, street lighting, etc.)	Contribute to explain variations of environment score among neighborhood*	Craig 2002
		Perceived safety	2 Physical inactivity (this relationship strongest among persons aged 65+ years and minorities) (correl)**	CDC 1999
		Perceived safety	2 Physical inactivity among older adults (controlling for race, education, age, sex)	CDC 1999

NOTE: 1 or 2 sign shows the direction of association that the independent variable has with the dependent variable (1 = positive, 2 = negative). *(correl) means that the associations are tested as bivariate relations only, without controlling for confounding fac-

aesthetics and convenience are associated with increased level of walking for exercise (Ball et al. 2001).

Overall, the studies use relatively specific objective measures of *route* and *destination* related to recreational facilities, but general and aggregated objective *area*-based measures. Compared to urban and transportation planning research, considerations of land use patterns, such as density, mix, and route characteristics, remain limited in the health field. Only Craig et al. (2002) find density and variety of destinations to be significant contributors to the composite neighborhood score, which is correlated with walking to work. Also, measures to capture proximity, accessibility, or convenience remain loosely specified; clear definitions of, and distinctions between, these terms will be needed in future research.

LESSONS FOR FUTURE PRACTICE AND RESEARCH IN PROMOTING ACTIVE LIVING

This review suggests the development of complementary knowledge bases in health and urban/transportation planning and unveils new promising avenues for urban and transportation practice and research on the relationship between land use and transportation behavior. At the level of professional practice, envi-

ronmental interventions involving the design of streets and the location of destinations in neighborhoods show potential to support increased levels of physical activity and physically active travel. At the level of research, the public health field offers advanced theoretical and methodological perspectives on human behavior and provides useful insights into conceptual frameworks that can guide further empirical testing of the relationship between behavior and environment.

Lessons for Practice: Areas of Possible Intervention

EVIDENCE SUPPORTING LATENT DEMAND FOR WALKING AND BIKING AS MEANS OF TRAVEL

Consistent evidence of people's predilection for walking and, to a lesser degree, biking, suggests that walking and biking can become more common forms of both exercise and transportation in the future. Further supporting the potential of walking and biking as means of achieving high active living standards is the seemingly unfailing predominance of neighborhood streets as popular places for exercise. Given that current street environments often poorly accommodate these activities, the large reported amounts of recreational walking and biking on streets suggests that providing appropriate street design and proximate routine destinations (e.g., retail shops and service facilities) will likely increase levels of walking and biking for travel.

Transportation behavior research has long pointed to a latent demand for walking and biking trips. Many automobile trips are short enough to be substituted by walking or biking. In the United States, 27 percent of automobile trips are shorter than 1 mile, and 40 percent are shorter than 2 miles (USDOT 1990). These distances are well within the reported walkable and bikable ranges of 0.74 mile to 2 miles, as conditioned by people's general health, perception, and attitude (Bernhoft 1998; USDOT 1995; Puget Sound Regional Council [PSRC] 2001). In addition, the majority of vehicular trips are made for nonwork purposes, some of which could feasibly be replaced by slower travel modes—38 percent of total trips are for social and recreation purposes, and another 35 percent are for family and personal businesses (USDOT 1995). In Canada, people report that they not only can but also want to increase their participation in walking and biking for transportation purposes (Go for Green 1998, 17). Most people also recognize the health value of walking (NPHP 2001, 7). As a result, the potential to convert latent demand for walking and biking into actual travel behavior change seems high; one of the key approaches to this change will likely be through changes in the built environment.

PROMOTING LAND USE INTENSITY AND MIX, AND INVESTING IN PEDESTRIAN AND BICYCLE FACILITIES

The studies confirm the importance of proximate and attractive destinations to support walking and biking. They strengthen and complement existing evidence in urban and transportation planning research, where such route-oriented variables as the presence of pedestrian and bicycle infrastructure (e.g., sidewalks, bike lanes, etc.), and area-related ones, such as density, land use mix, and street types, can be associated with increased levels of walking and biking (e.g., Cervero and Kockelman 1997; Ewing, Deanna, and Li 1996; Frank and Pivo 1994; Handy 1996; Hess et al. 1999; Kitamura, Mokhtarian, and Laidet 1997; Moudon et al. 1997).

During the past several decades, the lack of sufficient coordination between land use and transportation planning and the limited public expenditures in nonmotorized facilities—less than 2 percent of total federal transportation budgets are allocated for pedestrian and bicycle facilities and programs (FHWA 2002)—have contributed to creating urban environments where walking and biking are marginalized or disregarded as transportation modes. The studies' findings imply that, to enhance the health and well-being of the population, infrastructure for walking and biking needs to become an integral part of public transportation systems and services. Mixing land uses within short distances of each other must also be actively pursued to entice increases in walking and biking for transportation (Rutherford et al. 1995; Hess et al. 1999; Moudon and Hess 2000).

TARGETING ENVIRONMENTAL ENABLERS AND BARRIERS TO PHYSICAL ACTIVITY, WALKING, AND BIKING

Tables 4 and 5 point to specific physical environmental enablers of physical activity. Perceived *area*-related enablers encompass various visual characteristics of the neighborhood, such as presence of aesthetic features, appropriate levels of visual stimuli, and enjoyable scenery. Also positively associated with physical activity are such objective measures of neighborhood as urban and costal locations, older housing, and mixed or commercial-dominant neighborhoods.

Because neighborhood streets are found to be the most frequently used places for physical activity, interventions involving maintenance, comfort, connectivity, continuity, and safety of the transportation infrastructure, and especially *route*-oriented components such as sidewalks and bike lanes, will likely serve as effective

facilitators of walking and biking. Provision and enhancement of trails also seem to increase activity levels (Brownson et al. 2001).

Environmental barriers to physical activity encompass various negative qualities of neighborhoods—mostly *area*-related safety factors including perceived fear of crime, personal injury, traffic, and dogs. Interestingly, the presence of other people in the neighborhood and in places of exercise is found to be a source of both fear and social support, an indicator of the complex influences of environment on perceptions. Removing impediments to physical activity that exist in the physical environment will be a logical first step in promoting active living. Examples of environmental modification toward creating activity-friendly neighborhoods are (1) providing safe places for exercise near homes; (2) locating attractive, routine destinations near homes; (3) connecting destinations with safe, convenient, and pleasant transportation systems; and (4) providing well-maintained, well-lit, and continuous sidewalks and bike lanes.

A socially supportive atmosphere (e.g., the presence of other people exercising in the neighborhood and the opportunity to be physically active with friends or family) will also help remove some of the barriers or further bolster physical environmental enablers of physical activity. Brownson et al. (2001) note that an easy access to supportive environments is a necessary, but not a sufficient, condition to promote physical activity and point to the importance of personal and social factors, such as time, motivation, encouragement, and social support. The concept of reciprocal determinism drawn from social cognitive theory helps explain how personal barriers to physical activity may interact with environmental factors. For example, while it may seem difficult to overcome the fact that people have insufficient time to be active, providing them with an environment that encourages integrating walking/biking with other daily activities such as work, commuting and child care, may get them to walk regularly (Booth et al. 1997, 135). Furthermore, implementing physical environments for active living likely will interact positively with improvements in the social environment, offering people new opportunities to meet with others. As such, reciprocal determinism invites further research in neighborhood environment and behavior to develop effective approaches to modifying environments.

Lessons for Research: Theories and Methods

CONSIDERATION OF ENVIRONMENTS WITHIN SOCIAL ECOLOGICAL THEORIES

As discussed earlier, multiple theories guide health research, and complex theoretical frameworks focusing on behavior and behavior change direct the classification and selection of variables, their interdependencies, and the identification of thresholds related to stated goals for behavior change. These theories have also provided a natural link between research findings and educational programs promoting public awareness of the health benefits of physical activity, as well as its social and psychological rewards at the personal and community levels. They can also add to urban and transportation planning research, which has traditionally been focused on economics, and in which location theory (Alonso 1964), consumer choice, and random utility theory (McFadden 2001) have dominated as explicitly stated research frameworks.

The social ecological model highlights the social, physical, and policy or institutional dimensions of environments (McLeroy et al. 1988). Theoretically grounded social environmental variables included in the reviewed studies rely on social modeling (e.g., Booth et al. 2000; Giles-Corti and Donovan 2002; Hovell et al. 1992), social support (e.g., Ball et al. 2001; Booth et al. 2000; Wilcox et al. 2000), and social reinforcement (Booth et al. 2000). Those are interpersonal variables capturing the relationships between persons and were first addressed in Bandura's (1977) *Social Learning Theory*. Social modeling refers to people's capability to learn a new behavior from observing others (Bandura 1977, 1989). For example, one can be stimulated to walk or bike after observing others in the neighborhood walking or biking. Similarly, social support puts forward the role of one's "significant other" in influencing behavior by doing certain activities together. Social reinforcement can take the form of verbal encouragement to do these activities.

The physical environmental dimension captured in some of the studies also adds such variables as accessibility to recreational facilities (e.g., Giles-Corti and Donovan 2002; Sallis et al. 1990; Troped et al. 2001) and the presence of supportive physical facilities (e.g., Sallis et al. 1997; Wilcox et al. 2000).

Associations between these theory-driven variables and physical activity appear to hold in the studies reviewed. The primary concern at this point is to match the highly developed scope of social environmental theoretical frameworks with similarly sophisticated and rigorous constructs of the physical environment in order to successfully identify physical environmental variables associated with physical activity. Stokols (1992) and Sallis and Owen (1997) call for future research to consider explicitly community-based, physical environmental influences on physical activity. King et al. (2002) propose to place theoretical perspectives along a continuum of personal choice—including the cognitive and behavioral factors affecting physical

activity—and, on the other end of the spectrum, activity-related choice, which is shaped by physical environments and related policies.

BEHAVIOR MODEL OF ENVIRONMENT AS A CONCEPTUAL FRAMEWORK FOR UNDERSTANDING THE BUILT ENVIRONMENT

The BME or a version of the BME, offers a theoretical framework for better understanding the physical environment and, thus, complementing the social ecological approach. The BME helps define environmental variables characterizing activity settings, as they may shape the behavior change. Future research needs to assess systematically which of the BME components has the strongest effect on behavior or which of the variables defining each BME components affect behavior. Such variables as length of route, route attributes (e.g., sidewalks, lighting, etc.), and area characteristics (e.g., number of residents, number of destinations) need to be further investigated to establish their association with levels of physical activity. The influence of the BME components and variables on different types of behaviors, such as walking versus biking, and on different purposes of behavior, such as recreational versus transportation activities, also requires attention.

APPROACHES TO RESEARCH DESIGN, SAMPLING, AND DATA COLLECTION

The studies employ rigorous research design and methods on the behavioral and psychological components of physical activity by (1) ensuring randomness in the sample populations, (2) using tested or validated instruments for data collection, (3) employing a disaggregated approach to data analysis, and (4) considering a broad range of theory-driven psychosocial confounders. Furthermore, the common use of primary data provides targeted and high-quality information tailored to answer specific research questions. It also helps control for confounding factors. Elaborate testing and validation processes for data collection are well established. For example, telephone interviews follow strict protocols to ensure a high response rate and validity of responses. Questionnaires are tested for the question order, wording, recall period (e.g., frequency of walking during the past week vs. past month), and appropriate use of closed- and open-ended questions. Clearly, approaches to collect behavioral data are far more advanced than the approaches to deal with physical environmental conditions. For example, the current research emphasizes a statistically rigorous sampling of the participants but disregards the need to appropriately select the types of environments. To date, many studies rely on an imprecisely measured, or an insufficient range of variations in, the environment, which may limit the ability to detect associations with physical activity.

The idea that people choose to live in an environment that meets their behavioral inclination, commonly called self-selection, can weaken some of the findings on the environmental determinants of physical activity. While none of the reviewed studies address this issue explicitly, they indirectly approach this issue by considering various demographic and psychological factors that underlie the self-selection issue. Further attention is still required to determine the nature and extent of the self-selection problem itself, and the specific factors leading to household location choice.

The timing of data collection is also important to consider for further methodological improvements. Because levels of physical activity and walking and biking vary by season, day of the week, and time of the day (e.g., Vuori, Oja, and Paronen 1994), data collection times must account for these variations. Furthermore, times for behavioral and environmental data collection must be coordinated, especially when using secondary data, which is common in planning research. Otherwise, the findings are subject to misinterpretation or overgeneralization. Longitudinal studies (e.g., before and after intervention study including both case and control samples) should be considered to help establish causality of the environment-behavior relationship. However, direct causality may never be established due to the time, cost, and technical difficulties involving free-living individuals in ever-changing, dynamic environments.

CONSIDERATION OF BOTH OBJECTIVE AND SUBJECTIVE DATA

Objective and subjective measures of environmental factors tend to be correlated, yet differences exist between the two (Sallis et al. 1990). Both types of measures have strengths and weaknesses when used to capture the environmental conditions for walking and biking. The advantages of objective measures may include (1) reduced measurement errors, (2) easy quantification and standardization, and (3) easy translation into policy implications. At the same time, theories of behavior change commonly employed in physical activity promotion suggest that the perceptual characteristics of environment may be more closely related to actual behavior outcomes than the objective characteristics of environment. According to these theories, changes in behavior involve an internalization process assessing the environmental information. Further studies are needed regarding the relative influence of objective and subjective measures on levels of physical activity.

IMPORTANCE OF SPATIAL SCALE AND SPATIAL DEPENDENCY

Many of the studies use the individual respondent as a unit of analysis, creating consistency among the variables. This disaggregated approach allows consideration of individual-level extraneous factors. Neighborhood effects are less well addressed, however, and only a few studies employ hierarchical modeling techniques to deal statistically with multi-level effects, such as individual- versus neighborhood-level effects (Klesges et al. 1990; Craig et al. 2002; Rutten et al. 2001). Also, because most objective measures of neighborhood characteristics come from large aggregated spatial units, such as zip codes, counties, or even larger geographic regions (e.g., Bauman et al. 1999; CDC 1998; Wilcox et al. 2000), the many fine-grained variations in environments that matter for walking and biking are evened out (Hess 2001; Krizek 2001). As a result, associations between physical activity and environment, which may be present at small-area scales, can get lost when data are aggregated to large areas. Potential effects of aggregation and disaggregation of data on behavior need to be investigated.

In addition, spatial dependency or autocorrelations (i.e., people living nearby share similar environmental conditions) are largely overlooked. Measures of environmental variables are known to covary spatially. However, most statistical analyses falsely assume their independency. The simple hierarchical analyses used in several of the studies reviewed offer only limited solutions to this problem. The nature of spatial dependency remains to be understood, and the utility of such techniques as spatial statistics and hierarchical modeling should be examined further (Miller 2001).

MEASUREMENT ISSUES IN BEHAVIORAL AND ENVIRONMENTAL FACTORS

The studies' dependent variables are commonly dichotomized, begging further examination of the potential dilution of patterns of associations that could be observed at a more fine-grained or continuous scale. Systematically comparing associations that the environmental factors have with different measures of dependent variables, such as total amounts, frequencies, and temporal distribution (daily, weekly, seasonally, etc.) of walking and biking, will likely improve our understanding of how supportive environments can help achieve specific types of behaviors.

In most studies, measurements of environmental factors focus on the OD component of the BME (e.g., recreational destinations). Specific area-based measures, along with objective measures of traffic conditions, quality of transit service, and the characteristics of street networks, and so forth, will need to be included in future research (Moudon and Lee 2003).

CONCLUSION

Public health research on the physical environmental determinants of physical activity identifies walking and biking as popular and desirable means of being active. The studies provide evidence that creating activity-friendly communities will increase levels of recreational physical activity. Effective strategies for promoting walking and biking likely will involve adding a transportation function to the existing popularity of recreational walking and biking. Combining recreational and travel-based walking and biking will circumvent the issue of limited time, which people often report as a major barrier to physical activity, and therefore may increase the frequency of physically active travel.

The popularity of neighborhood streets as places for active living further reinforces the potential for walking and biking as means of travel that can contribute to increased levels of physical activity. Yet, multipurpose walking and biking will require environmental interventions to ensure easy, safe, and pleasant access to routine destinations. Intervention strategies must be grounded on empirical evidence, and their successful implementation is conditioned by various factors, including the responsiveness to the existing local environments, resources available, and ease and cost of intervention. Strategies likely to be successful include those targeting specific types of community, such as schools and work sites, and specific groups of people, such as the elders, children, and female, minority, and low-income groups. Consideration of both incentive-based and regulatory interventions seems promising. Corresponding changes will be necessary in current transportation investment procedures that continue to favor vehicular, rather than nonmotorized, modes of travel. Also, the current dependence on automobile travel suggests the need for reevaluating people's lifestyles and preferences. Only by reducing automobile use can walking and biking become widely accepted, readily achievable, habitual, and routine in people's daily life.

Aspects of public health research methods are worth emulating in urban and transportation planning fields. The social ecological model provides a rich theoretical framework to understand the multi-level (social, physical environmental as well as psychological) influences on behavior. Also, systematic validation and testing of survey instruments, and careful consideration of confounding factors and multi-level variables can serve to strengthen urban and transportation planning

research. Published literature in the health field provides exacting details about research protocols, including study limitations, potential bias, and generalizability of the findings. These strict publication standards establish connections between research findings from different projects and help build a systematic and collective research agenda.

The studies point to the need for a theoretical framework to conceptualize and measure physical environments comprehensively. The BME used in this article begins to provide such a conceptual setting. The model indicates that so far, health studies have limited environmental factors to a few of the route and destination components of environments. Future research needs to address the characteristics of areas (neighborhoods and districts) where active living can take place as well as consider correlations between environmental variables. Theoretical frameworks of the environmental conditions will also help sample the full range of variability in environmental factors.

Research in health and urban/transportation fields is complementary. Future multidisciplinary research is likely to promise a better understanding of both the behavioral and environmental aspects of physical activity and physically active travel.

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APPENDIX
Review of Study Methodology

TABLE A1. Studies Using Both Objective and Subjective Measures of Independent Variables

		A	B	C	D	E	F	G	H	I
Source Key	1st Author and Year Published	Study Population	Sample Type/ Size	Theoretical Framework	Dependent Variables	Objective Independent Variables	Subjective Independent Variables	Confounding Factors Controlled/ Considered	Data Collection Method	Statistical Analysis Performed
1	Giles-Corti 2002	Middle-aged adults living in Perth metropolitan area, Western Australia	Probability cluster sample of 1803	Yes: theory of planned behavior, theory of trying (socioecological framework)	Use of facilities Exercise as recommended—30+ minutes on most days of the week	Shortest route from home to recreational facilities including: 1. Golf course 2. Gym/health club/ exercise center 3. Sport and recreation centers 4. Swimming pools 5. Tennis courts 6. Public open space 7. River 8. Beach 9. Other facilities Distances are recorded in 500 m categories (500 m or less to 20 km or more) and then aggregated to create overall spatial access scales (4 levels) Physical environmental determinants measured as direct observation of: 1. Presence of footpath 2. Visible shops in the street 3. Type of street 4. Street trees 5. Level of tree coverage 6. Total spatial access to exercise facilities 7. Total spatial access to natural recreation facilities (river, beach)	Individual determinants include: 1. Attitude toward trying exercise 2. Attitude toward the process of trying 3. Selective norm 4. Frequency of trying in the last 3 months 5. Perceived behavioral control 6. Behavioral skills used last month 7. Intention to try in the next 2 weeks Social determinants include: 1. Club membership 2. Frequency of participation in physical activity by 5 significant others 3. Frequency of a significant other doing physical activity with respondent	Age Sex Education Household income Marital status Number of children age 18 in household	Telephone survey Geographic Information System (GIS) Observation	Unconditional logistic regression Multivariate summarization score

2	Sallis 1990	Adults living in the city of San Diego, California	Random sample of 2,053	No	Frequency (times/week) of vigorous recreational physical activity Engagement of any of 24 activities during the preceding 2 weeks (e.g., aerobic dance, jogging, tennis, swimming, weight lifting, basketball, soccer, racquetball, etc.)	Number of total free exercise facilities within 1, 2, 3, 4, 5 km from home (public park, sports fields, public recreation centers, colleges and universities, public school) Number of total pay exercise facilities within 1, 2, 3, 4, 5 km from home (tennis and racquet clubs, aerobic and dance studios, membership swimming pools, health and fitness clubs, YMCAs and YWCAs, skating rinks) Number of total free and pay exercise facilities within 1, 2, 3, 4, 5 km from home	Perceived convenience of 15 types of exercise facilities (rated) Perceived barriers to exercise	Age Education Income	Mail survey Field mapping	Descriptive statistics F-test for two group differences
3	Troped 2001	Adults living in Arlington, MA	Random sample of 413	No	Use of the Minuteman Bikeway Recreational physical activity during the past 4 weeks Type of physical activity Locations for physical activity	Road network distance to the bikeway from home (closest official access point) Busy street barrier along the shortest network route to access the bikeway Steep hill barrier along the shortest network route access to the bikeway (10+ % slope for at least 100 m—visual examination)	Neighborhood features (including sidewalk, hill, crime) Perceived safety Neighborhood character (residential, mixed, commercial) Distance to bikeway Steep hill barrier Busy street barrier	Age Sex Education Physical activity limitation	Mail survey GIS	Pearson's correlation Logistic regression Multiple logistic regression Likelihood ratio testing

(continued)

APPENDIX (continued)

TABLE A2. Studies Using Objective Measures Only

		A	B	C	D	E	G	H	I
Source Key	1st Author and Year Published	Study Population	Sample Type/Size	Theoretical Framework	Dependent Variables	Objective Independent Variables	Confounding Factors Controlled/ Considered	Data Collection Method	Statistical Analysis Performed
4	Berrigan 2002	U.S. adults aged 20+	Stratified multistage probability sampling of 14,827 adults (with oversampling of African and Mexican Americans)	Yes: loosely based on ecological model	Walking frequency categorized as: 1. None/month 2. 1-19 times/month 3. 20+ times/month	Housing age categorized as: 1. Before 1946 2. 1946-1973 3. After 1973 Suburban/urban vs. rural area	Age Sex Race/ethnicity Education Household income Activity limitation	Used the third National Health and Nutrition Examination Survey Census	Logistic regression
5	Bauman 1999	Adults aged 18+ years living in sixteen health service regions in New South Wales	Stratified random sample of 1,000	No	3 variables constructed (based on energy expenditure drawn from the self-reported activity and weight): 1. Being totally sedentary (50– kcal/week) 2. Being adequately active for health (800+ kcal/week) 3. Being vigorously active (1,600+ kcal/week)	Location of residence—costal versus inland based on postcode	Gender Age Country of birth Education Employment	Used 16,178-respondent telephone survey of New South Wales residents Postcode	Logistic regression
6	CDC 1998	Adults aged 18+ years living in the United States	Population-based random sample of 118,778	No	Engagement in exercise, recreation, or physical activity other than their regular job duties during the past month	Degree of urbanization classified by using the U.S. Department of Agriculture's rural-urban continuum codes (population based)—ten codes collapsed into five categories (spatial unit: county)	Age Sex Education Household income	Used Behavioral Risk Factors Surveillance System (BRFSS) GIS	Logistic regression Correlation analysis

7	Klesges 1990	Self-selected respondents recruited by response forms distributed to local pediatricians' offices, day care centers, and churches	222 pre-schoolers	No	Activity level of the child (stationary, minimal activity, slow movement, rapid movement)	Direct observations on: 1. Type of physical environment in which the activity was occurring (home, own yard, public playground, street/sidewalk) 2. The persons who were present during the activity 3. The type of interaction between the child and the persons present in the environment	Age Sex Race (all white) Weight Weather conditions allowing for outdoor activity during observation time	Observation	Correlation analysis Hierarchical linear regression

(continued)

APPENDIX (continued)

TABLE A3. Studies Using Subjective Measures Only

		A	B	C	D	F	G	H	I
Source Key	1st Author and Year Published	Study Population	Sample Type/Size	Theoretical Framework	Dependent Variables	Subjective Independent Variables	Confounding Factors Controlled/ Considered	Data Collection Method	Statistical Analysis Performed
8	Ball 2001	Adults living in South Wales, Australia	Random sample of 3,392	Yes: social ecological framework	Frequency and duration of walking for exercise in the past 2 weeks (consider walking of 10+ minutes only)—dichotomized into any or no walking	Aesthetic score measured as ratings (Likert-type scale) of: 1. Neighborhood friendliness 2. Neighborhood attractiveness 3. Pleasantness in walking Convenience score measured by rating of: 1. Shops within walking distance 2. Park or beach within walking distance 3. Cycle path accessible Social environment (company) measured as: Having someone to walk with (yes/no)	Age Sex Education	Used data from the 1996 Australian Activity Survey for the state of New South Wales (telephone survey)	LISREL (confirmatory model—for the 3 perceived environment variable scores)

9	Booth 2000	Adults older than 60 years living in communities in Australia	Systematic randomized sample of 449	Yes: Social cognitive theory	Physical activity participation measured as frequency (counting walking of 10+ minutes only) and amount of: 1. Vigorous activities 2. Walking for exercise, leisure, or recreation 3. Moderate-intensity activities such as gardening Energy expenditure is calculated based on the previous types of activities, and final outcome variables are dichotomized based on total energy expenditure of 800 kcal/week (sufficiently active vs. insufficiently active)	Environmental influence—measured as presence of: 1. Exercise equipment at home 2. Safety or difficulty of walking in the neighborhood during the day 3. Access to facilities (exercise hall, recreation center, cycle path, golf course, gym, park, swimming pool, tennis court, or bowling green) 4. Social environment (friend and family encouragement, etc.) Other nonenvironmental variables included: 1. Sociodemographic measures 2. Attitude 3. Social reinforcement 4. Social modeling	Gender Age Marital status Country of birth Living situation (living alone vs. other) Employment status	Used the Population Survey Monitor data (face-to-face interview)	Chi-square analysis Logistic regression
10	Brownson 2000	Adults living in the 12 rural communities in Missouri, United States	Population-based sample of 1,269	No: only mention environmental and policy approach	Trail use Increase in walking since using trail Walking for exercise in the past month: walker Regular walking (5+ times/week and 30+ min/time): regular walker	Presence of walking trail in area Distance to trail Trail surface Trail length within each community Access to indoor exercise facilities	Age Sex Race/ethnic group Marital status Education Household income Population of the community	Telephone survey on walking behavior, knowledge, and attitude (questionnaire includes standard items from the Missouri BRFSS and additional items)	Prevalence odds ratio
11	CDC 1999	Adults aged 18+ years living in the five selected states of the United States	Population-based random sample of 12,767	No	Physical inactivity (reporting no activity or exercise during the past month)	Ratings of perceived safety from crime in the neighborhood	Race (white, nonwhite)	Used BRFSS	Logistic regression Correlation analysis

(continued)

APPENDIX (continued)

TABLE A3 (continued)

		A	B	C	D	F	G	H	I
Source Key	1st Author and Year Published	Study Population	Sample Type/Size	Theoretical Framework	Dependent Variables	Subjective Independent Variables	Confounding Factors Controlled/ Considered	Data Collection Method	Statistical Analysis Performed
12	Craig 2002	All citizens of the United States	Population (20% sample for the long form including questions on education, income, and usual mode of transportation to work)	No	% walking to work	Environmental score for each neighborhood calculated based on the observer ratings of environmental items including (rated): 1. Number of destinations 2. Variety of destinations 3. Inclusive of pedestrian 4. Social dynamics 5. Walking routes 6. Meets pedestrian's need 7. Walking system 8. Transportation system 9. Complexity of stimulus 10. Potential overload of stimulus 11. Visual interest 12. Visual aesthetics 13. Time and effort required to walk 14. Traffic threats 15. Obstacles 16. Safety from crime 17. Potential for crime	Degree of urbanization Income University education % living in poverty	Census Field observation	Hierarchical linear model (3 levels)

13	Hovell 1992	Adults living in San Diego, California, United States	Random sample of 1,739	Yes: independent variables derived from learning theory and social cognitive theory	Change in total minutes per week of walking for exercise between baseline and follow-up	Neighborhood safety Ease of exercising in the neighborhood Frequency of seeing others exercise Number of exercise facilities (aerobic dance studios, bike lanes, running tracks, etc.) perceived as convenient Sociodemographic variables drawn from learning theory are also included	Age Sex Education Income	Mail survey	Bivariate correlation Hierarchical multiple regression ANOVA
14	King 2000	Minority women 40 years of age or older	Multistage cluster sample by zip; nationwide representative sample of 2,912	Yes: independent variables derived from social cognitive theory	Level of leisure time and household-related physical activity during the past 2 weeks	Sociodemographic variables Health-related variables Psychosocial variables Program-based variables Environmental variables—measured as presence of: 1. Sidewalk 2. Heavy traffic 3. Hills 4. Streetlights 5. Unattended dogs 6. Enjoyable scenery 7. Frequent observation of others exercising 8. High levels of crime 9. Level of safety in walking/jogging alone	Seasonal variation in physical activity (by doing the survey during a 1-year period) Sociodemographic variables	Telephone survey	Descriptive statistics Pearson product-moment correlations Logistic regression
15	Rutten 2001	Adults from the 6 European countries	Random sample of 3,343	No	Engagement in physical activity Health status	Opportunities in their residential area for physical activity Local clubs and providers offering physical activity opportunities Community actions to support physical activity	Income	Telephone survey	Principal component analyses (for questionnaire testing) Descriptive statistics Correlation analyses ANOVA Hierarchical regression

(continued)

APPENDIX (continued)

TABLE A3 (continued)

		A	B	C	D	F	G	H	I
Source Key	1st Author and Year Published	Study Population	Sample Type/Size	Theoretical Framework	Dependent Variables	Subjective Independent Variables	Confounding Factors Controlled/ Considered	Data Collection Method	Statistical Analysis Performed
16	Salllis 1997	Introductory psychology students from San Diego State University, United States	110 college students in psychology	No: concept of behavior setting (mention ecological model and social cognitive theory)	Minutes of walking per week Days of vigorous exercise per week Days of strength exercise per week	Home Environment Scale measured as availability of 15 supplies or pieces of equipment at home that can be used for physical activity Neighborhood Environment Scale including: 1. Neighborhood features (sidewalk, hill, enjoyable scenery, high crime rate [and 4 other variables]) 2. Perceived safety, measured as safety in walking in the neighborhood during the day 3. Neighborhood perception as residential, mixed, or commercial Convenient Facilities Scale, measured as presence of 18 facilities that can be used for physical activity	Age Sex Ethnicity	Not specified	Pearson correlation

17	Wilcox 2000	Women aged 40 or older living in zip code areas with 20+ % of ethnic minorities and urban/ rural area of the United States	Multistage cluster sampling of 2,912	No	Amount of leisure time physical activity in the past 2 weeks (including walking)—categorized into active, underactive, and sedentary	Environmental determinants measured as perceived presence of: 1. Sidewalk 2. Heavy traffic 3. Hills 4. Street lights 5. Unattended dogs 6. Enjoyable scenery 7. Frequently observe other exercise 8. High level of crime 9. Easy access to walking trail, swimming pools, recreation centers, or bicycle path Sociodemographic, psychosocial, and health-related variables are also included	Race Age Education Geographic region (Northeast, Midwest, South, West) Health status	Telephone survey—modified version of BRFSS	Descriptive statistics Pearson correlations Logistic regression

APPENDIX (continued)

TABLE A4 Other Explorative Studies

		A	B	C	D	E/F	G	H	I
Source Key	1st Author and Year Published	Study Population	Sample Type/Size	Theoretical Framework	Dependent Variables	Key Research Questions	Confounding Factors Controlled/ Considered	Data Collection Method	Statistical Analysis Performed
18	Corti 1997	Adults aged between 25 and 67	24 (6-8 per group)	No: only mention social ecological perspective	Physical Activity Use of local parks Walking around their local neighborhood Use of pay facility (gyms, health clubs, and recreation centers)	NA	Socioeconomic status of the participants stratified	4 Focus groups Role-play	None
19	Eyler 1998	Volunteers older than 40, and either Asian American/ Pacific Islander, Black, Hispanic, or American Indian living in California or Missouri, United States	Self-selected group of 80-100 (exact number not specified)	No	Physical activity	Barriers Enablers Benefits Activities Sources Recommendations	NA	10 focus groups (8-10 each group)	NUD*IST qualitative analysis program
20	Hahn 1994	5 community groups from Dubbo and Wellington, New South Wales	Self-selected group of 30-50 (exact number not specified)	No	Activity level	Attitude and knowledge about adequate physical activity Type of physical activity Barriers to more activity Experiences walking and biking around their town	NA	Zoning on council maps (recreational facilities); focus group	None

NOTE: NA = not applicable.

NOTES

1. The programs are Active Community Environments by the Centers for Disease Control and Prevention and Active Living Policy and Environmental Studies by the Robert Wood Johnson Foundation.

2. Generally, thirty minutes or more per day and five or more days per week of physical activity or an energy expenditure of 800 kcal or more per week are considered to be sufficient for health benefits.

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