WHAT DEFINES WALKABILITY:

WALKING BEHAVIOR CORRELATES

by

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EXECUTIVE SUMMARY

At one point in time, cities grew as compact and vibrant entities focused on the downtown. In these close-knit environments, residents had the ability to walk or bicycle to destinations due to the fact that they lived in close proximity to where they worked and entertained. However, as development patterns slowly changed, cities began to sprawl outward causing an automobile dominated society that has lead to a number of negative effects, including traffic congestion and increased sedentary lifestyles.

Due to these problems, the city planning and public health professions are now supporting walkable communities that are designed to promote walking and bicycling to nearby destinations. However, the implementation of walkability in an environment has been hindered by the fact that planners and public health practitioners have not adequately determined what measurable variables define walkability. While a number of studies and reports have attempted to define walkability, there are few occasions when similarities exist. Further complicating the task of defining walkability is the difficulty that exists in identifying the strongest correlates of walking.

The objective of this paper is to examine the literature focused on walkability and the walking behavior to decipher a compact list of proxy variables from those cited in research that can serve as a working definition of walkability. A synthesis of the literature will also determine if walkability actually produces an increase in walking, and whether this increase is for transportation or recreational purposes. As a result of the findings from these research questions and the literature reviewed in this paper, recommendations for future actions for planners are proposed to help improve the implementation of walkability in the built environment.

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OVERVIEW

THE GROWTH OF AMERICAN CITIES

Cities have seen a vast change in the way they have grown in size and developed spatially over the last 100 years. In the early twentieth century, the United States developed in the form of compact, mixed-use neighborhoods where residents could live, work, and entertain all within the same environment. However, with the emergence of the automobile, zoning laws, federal government mortgage policy, and modern architecture, this pattern slowly began to change. By the end of World War II, development patterns had completely shifted to conventional neighborhood development, which consisted of a rigorous separation of land uses that required heavy use of the automobile [1].

Even today conventional neighborhood development is popular. Suburban rings around cities continue to grow farther and farther away from once vibrant downtowns. While once compact and downtown focused, cities are now experiencing these rapid outward expansions due to factors such as government polices that separate land uses, mass use of the automobile, and the perceived 'American dream' of having a single-family house on a large lot with a backyard and garage. As a result, cities across America have begun to encounter social and public health problems, and what the Congress for the New Urbanism categorizes as "disinvestments in central cities, the spread of placeless sprawl, increasing separation by race and income, environmental deterioration, loss of agricultural and wilderness, and the erosion of society's built heritage as one interrelated community-building challenge" [2].

Even though this decentralized, sprawled pattern has become the norm in neighborhood development, it has not come without consequences. New suburban subdivisions that lack a town center and pedestrian-scale have spread out over large areas of countryside even as populations grow relatively slowly. Automobile use per capita has skyrocketed because one is required to travel great distances to most destinations, there by greatly restricting opportunities for non-motorized travel. Auto-oriented developments, such as strip mall have sprung up throughout the suburban landscape, thus reducing the individuality and human character of cities [1]. Between 1982 and 1997, these development patterns have lead to a decrease of more than 20% in urban land density in the United States, there by further increasing the reliance on automobiles. In this same time period, population size only grew 17% while the amount of urbanized land increased by a total of 47% and vehicle miles traveled increased 55 %, rates that are more than triple population growth [3].

WALKABILITY: SOLUTION AND PROBLEM

While there are many options available to combat these trends, the city planning profession has once again begun to place emphasis on designing compact, mixed-use communities that resembles those of decades before. A major goal in this process has been to create ‘walkable’ communities, where the built environment is designed in a way to foster walking and bicycling to nearby destinations rather than requiring individuals to rely strictly on the automobile. The increase in awareness of the potential social, health, and environmental benefits of walkability has led to a rapid rise in the number of walkable communities, also known as neo-traditional developments and new urbanist developments, which have been built across the nation.

While planners use these terms openly, there is little agreement as to what truly defines a walkable environment. In practice and in research, planners tend to apply the term walkability to a variety of places, some of which have large variance in attributes and defining features. In many cases, an area that has the mere presence of sidewalks and mixed land uses is classified as being a walkable environment. The major problem with this current state of practice is that when such occurrence happens, the term walkability loses valuable meaning. The term becomes overused and its importance lessened. To successfully establish the concept of walkability as a formable answer to conventional neighborhood development, a true definition must be generated so create a benchmark as to what environments can be classified as walkable and to help future planners in designing such neighborhoods.

A major research dilemma concerning the literature in this field is that it does not adequately provide a clear answer to what is the true definition of walkability. Instead, much of the walkability literature provides a host of various definitions and variables that are hypothesized to produce an environment that increases the walking behavior. Currently, there is neither one precise way to describe walkability, nor is there a well-defined set of walkability variables that serve as correlates of walking.

As its basic level, a definition of walkability can be simply an area that promotes walking. The obvious problem with this level of detail is that leaves great discretion to the planner as to which environments are designed to successfully achieve the goal of walking. At the other end of the spectrum, a much more complex explanation of walkability would be to require all the possible variables of the built environment that increase the walking behavior and to classify only those areas that that possess these variables as walkable. Unfortunately, this heightened level of detail can step too far by severely limiting what can be defined as walkable. There are hundreds of environmental variables that behavioral scientists have tested for their impacts on the walking behavior, and it is simply not feasible to require that a working definition of walkability include all of them.

It is evident that walkability is an important concept for city planners but a clear understanding of what it is and what variables define the form and behavior is first needed to successfully implement the concept into environments. As stated, in defining walkability, a vast number of variables that potentially increase walkability exist, including accessibility variables, attractive variables, connectivity variables, and safety variables. To show this ambiguity, an example can be provided. There is general agreement that the provision of sidewalks will improve the walkability of a neighborhood, however there is still a host of sidewalk variables that can affect overall walkability: sidewalk width, connectivity to surrounding destinations, the existence of crosswalks, safety features, and lighting. To this point, research has not shown which, if any, of these sidewalk variables serve as the most important correlate of the walking behavior. Therefore, empirical data that has attempted to correlate the effects of these variables has not been able to fully comprise a list of proxy walking variables from all that potentially exist. A major reason for this gap is the difficulty in identifying the strongest correlates as well as problems of adequately measuring their relationship with the walking behavior. The best definition of walkability may therefore lie in the fact that a compact list of variables can be deciphered from the vast number of potential variables so that they may serve as a proxy measure for the remaining walkability variables. When this list is assembled, places that posses those particular variables should exhibit an increase in walking as opposed to places without these proxy variables. However, as this question appears to be answered, there is still great misunderstanding as to what are the true correlates of walkability.

PUBLIC HEALTH PROFESSION TAKES AIM

As practice currently stands, the city planning profession has been pressing the need for more walkable communities in order to help decrease air pollution and traffic congestion from the automobile. Walkable communities are therefore meant to support alternative modes of transportation to important destinations. Due to the fact that nearly a quarter of all personal trips that people make within the U.S. are one mile or less, yet nearly 75% of these short trips are made by car, walkable communities may serve as a potential solution to support active transportation modes [4]. Planners hope that by applying walkability to an environment, automobile trips will be substituted in these short trips for an increase in the number of walking, bicycling, and public transit trips.

While acknowledging the need for better air quality and less congestion, the public health profession has also begun to emphasize walkable communities but for significantly different reasons. Environment-behavior relations first emerged as an important field of study in the early 1960s [5]. At that time, the field was rooted in environmental design, but bridged architecture, landscape architecture, urban design, and urban planning [6,7,8]. Today those trends continue on the public health agenda to examine the influence of the built environment on health. Approximately 300 studies have examined the correlates of physical activity behavior among adults [9]. Using these correlates, public health professionals are trying to determine which built environment variables will help individuals receive recommended levels of physical activity, defined as 30 minutes of moderate-intensity activity on 5 or more days per week [10]. Proven benefits of this type of physical activity include the ability to control weight levels; build strong bones, muscles, and joints; reduce falls among elderly populations; relieve arthritis pain; reduce anxiety and depression; and result in fewer hospitalizations and doctor visits [11]. However, regardless of these demonstrated benefits, nearly 46% of U.S. adults in 2003 did not meet recommended levels of physical activity, either through daily household activities, transportation, or leisure-time activities [12].

With such a small portion of individuals meeting healthy physical activity levels, the public health profession has begun to turn to the built environment as an intervention opportunity. Touting many of the studies that have worked to correlate what variables have the greatest influence on the walking behavior, public health officials see walkability as a potential means to design the built environment in a way that will help combat the "obesity epidemic" [13]. By being designed for walking, individuals living within areas defined as walkable in theory have a greater opportunity to increase their daily physical activity levels. Therefore, regardless of whether a trip's purpose is for utilitarian or recreation, as long as an individual is walking then some health benefits can be accrued.

Determining whether people choose to walk within a walkable community for transportation or for recreational purposes can therefore have a large impact for the city planning and public health professions. If individuals in these communities are simply using walkable communities to exercise, then walkable communities potentially may not be serving their true planning goals of utilitarian travel. One would surely concede that increasing physical activity levels is a noble goal, but if the planning profession proclaims that walkability is meant to reduce automobile travel for increases in utilitarian walking trips, then there potentially could be a disconnect if any increase in walking that results from these environments occurs mostly in the form of recreation.

PROBLEM STATEMENT

As previously stated, there currently is no agreement among planners and public health professionals as to what one precise way walkability should be defined. Likewise, there is also disagreement between what set of walkability variables serve as the best correlates of walking. Due to this ambiguity in planning practice as well as in the literature, there are four primary research objectives of this paper. First, it will attempt to answer the research question 'What measurable variables define walkability?' By examining literature focused on walkability and the walking behavior, it should be possible to extract what variables are most commonly agreed upon by practitioners and researchers as well as determine which ones are more important and how they should be measured. A secondary objective of this research is meant to resolve whether walkability actually translates into an increase in walking. The third objective of this research is to determine whether walkability translates into an increase in transportation or recreational walking. Both the second and third research questions should be answered based on a synthesis of the findings from both literature reviews. While the purpose of this research is not to test a hypothesis, there is still the general belief that the conclusions will show that places that exhibit variables of walkability, which will be defined based on the findings from the literatures, will result in an increase in walking. Furthermore, it is hypothesized that this increase in walking will be primarily for recreational purposes as opposed to utilitarian travel. The final objective of this paper is to use the findings from each of the three research questions to provide a set of recommendations for planners and public health professionals on ways to potential improve the implementation of walkability into the built environment.

Literature Review: Walkability

A Host of Options

For many of the above stated reasons, walkability has become increasingly popular in the city planning and public health fields. There is, however, great discrepancy in the depth and purpose of walkability literature. At times, one will find a resource that is designed solely to detail the intricacies of walkability, while another document may focus on walkability but in a secondary manor. Typically when this occurs, walkability is defined by a journal's author in the context of conducting a study focused on testing built environment effects on activity levels or transportation mode outcomes. Articles that come from journals such as the Journal of the American Planning Association, American Journal of Public Health, or the Transportation Research Record fall within this latter category. Documents produced by national walking experts, such as Dan Burden of Walkable Communities, Inc., and other national and state governments usually focus solely on helping others understand what walkability encompasses, and therefore falls under the former category. As such, a quick glance of this research will produce a wide range of documents, including both peer reviewed and fugitive literature. In order to provide the most capable definition of walkability, both forms of this literature are included in this discussion. A total of 12 documents are used in the following sections to highlight the discrepancy in defining walkability. A list of tables is included in the Appendix that provides a basic synopsis of the major research findings relative to walkability in all included literature.

Defining Walkability: Findings From the Literature

The largest and most in-depth definition of walkability comes from Dan Burden, Executive Director of Walkable Communities, Inc. In two separate articles, Burden divides walkability variables into a set of several groupings. However, it is particularly interesting to note that these groupings are not identical between the two articles. In his first article "Rating System for Walkable, Active Living, Active Transportation," [14] Burden uses 11 categorical variable groupings to define walkability. However, in his second article "Walkable Community Criteria," [15] the number of groupings is reduced to 8. The problems of defining walkability through the literature are highlighted here in the fact that even between documents by one author there a small discrepancy exists. Variables that do overlap include accessibility, aesthetics/attractiveness, and connectivity. Some classifications that are not included in both documents are the location of neighborhood schools, maintenance, promotion, and density. Summaries of the variables that are used to define walkability by Burden are provided on the following page in Table 1. A full listing of variables can be found in the Appendix.

While Table 1 only highlights a small portion of the variables that Mr. Burden uses to define a walkable area, they provide an excellent example of the broad types of variables that can be used to designate areas as walkable. Examination of these articles in the Appendix will further show the level of detail that is prescribed. Requirements such as having all public spaces located within 800 feet of at least 90% of homes, having at least 15% of lawns dedicated to landscaping, and block lengths that are between 400 – 600 feet long, all work to increase the pedestrian feel of an environment, but may be too strict qualifications. This could therefore have the affect of disqualifying some environments as being classified as walkable should they not meet these standards, regardless if the environment is truly pedestrian-friendly in other aspects.

Table 1: Walkability Variables Defined by Dan Burden, Walkable Communities, Inc.

Source	Walkability Variables
Burden, Dan. Walkable Communities, Inc.	**Location of facilities:** • Public spaces located within 800 ft of at least 90% of all homes **Adequacy of walkways:** • Sidewalks minimum of 5 ft wide, separated from curbs, cover 80% of homes and 100% of principle streets • Priority established to assure critical missing gaps in sidewalk system are completed. **Connectivity:** • Block lengths 400 - 600 ft • All stores within ¼ mile walk (5 min) of absolute center • Street has good block form, usually grid pattern **Street orientation:** • Homes setback 15 - 25 ft **Density:** • At least 6-7 du/a; encouraged 10-11 du/a **Street speeds:** • Most streets 15 - 25 mph. Collectors permitted 30 - 35 mph. • Traffic calming devices (curb extensions, street narrowing, tree canopies, on street parking) used **Aesthetics:** • At least 15% of individual front yard space devoted to landscaping. • Neighborhood has quality streetscapes. • Pleasant sitting places located every 200 ft. **Land use:** • Variety of services within 2500 ft of 80% of all homes. Includes 2 - 3 small stores and at least 1 civic use. **Affordability:** • 20% of housing stock should be affordable **Neighborhood schools:** • Elementary schools located to where 80% of all children with a walk of no more than 2500 ft.

Another leading discussion of walkable environments comes from The Ahwahnee Principles, a total of 23 principles devised by planning professional in Yosemite at the Ahwahnee Lodge in 1994 [16]. While they do not provide a strict prescription for what variables define walkability, they list a set of principles that are better indicators of walkable communities than others. These principles can be thought of as proxy ways to build walkable environments, and therefore serve a purpose in this analysis. Important factors that are mentioned in this document include "integrating communities with housing, shops, work places, schools, parks and civic facilities," access to transit, diversity housing types, adequate open space, well-connected pedestrian paths, and proper street orientation. As can be seen, connectivity, accessibility, mixed land uses, and aesthetics are all covered by the Ahwahnee Principles. However, due to the fact that they are only principles, the document does not go into any detail of what constitutes street orientation or well-connected pedestrian paths, for example. Instead, the Ahwahnee Principles provide a very broad definition of what defines walkability, which could potentially lead to great discrepancy when trying to implement these goals in practice.

The Pedestrian and Bicycle Program from the State Safety Office of the Florida Department of Transportation use twelve categorical variable groups to define how to create walkable communities [17]. Again, similar results show up. Linked walkways, school placement, transit, and land use are factors that the Pedestrian and Bicycle Program deem as important walkability variables. While these grouped variables are similar as previous literature, there is still some discrepancy in level of detail. Here again sidewalks are defined as having a minimum of 5 ft width, much like recommendations from Burden [14,15], but this document goes further by defining that the total width with trees should be 7 feet. Other features that are very similar are recommendations to use traffic calming devices, such as raised crossings, traffic diverters, and roundabouts to slow traffic around schools and in neighborhoods. A difference between this document and other research is that some important areas are given less detail. Variables such as building setbacks, mixed land uses, and school siting are mentioned but do not include prescriptions for their use, thus leaving subjective judgment to the practitioner. Furthermore, some walkability variables are completely left out. The Florida Department of

Transportation does not mention the importance of connectivity of sidewalks, street patterns, and other pedestrian facilities.

New factors in the walkability discussion that arise from the Florida Department of Transportation include intersections, American with Disabilities Act (ADA), signal placement, and illumination. Table 2 details these new categories in more detail. As can be seen, the Florida Department of Transportation further expands the type of variables that can be used to define walkability.

Table 2: Walkability Variables from Florida Department of Transportation

Source	Walkability Variables
Florida Department of Transportation, State Safety Office, Pedestrian and Bicycle Program.	**Intersections:** • Maximum crossing widths should be 48 ft. Slip lanes, medians, and bulbouts should be used to reduce crossing exposure. • Roadway geometry should dictate turning speeds of below 20 mph on left turns and 10 mph on right turns. **American with Disabilities Act:** • Two curb ramps should be constructed on each street corner. **Signal placement:** • Box span, mast arm, and corner pole signal placements should be used. **Illumination:** • Approaches to and all street corners should be well illuminated. • All intersections should illuminate crossing and waiting areas and/or create backlighting to make pedestrian silhouette clearly visible on approach. **Automobile backing:** • Side lot, on-street and pocket parking should be included in zoning regulations to eliminate opportunities for backing over walkways. • Center walkways in landscaped areas, “U” pattern dropoffs, and long throat driveways lined with sidewalks should be considered.

While the above literature focuses mainly around fugitive resources, many peer-reviewed articles cover topics centered on walkability. In this process, many attempt to test the effect of neighborhood design on factors such as travel mode or physical activity levels. In a study conducted by Saelens, et al [18], neighborhood-based differences in physical activity levels are studied based on these environmental scale measures. In this research, a number of walkability variables are studied for their impacts on physical activity levels. Residential density, proximity to non-residential land uses, connectivity, street patter, walking facilities, aesthetics, traffic safety, crime safety are considered as variables that impact the walkability of an environment. Saelens further defines walkability by differentiating between levels of walkability. A high-walkable neighborhood is characterized as one with a concentration of non-residential land uses along a main corridor of the neighborhood and a street pattern that is mostly grid-like, with short block lengths and few cul-de-sacs, thus an indicator of greater street connectivity. Saelens defines a low-walkable neighborhood as one with longer block lengths, a mixture of grid-like and curvilinear street patterns, and more cul-de-sacs. While these classifications are small and broad, they provide yet another example of how varied the term walkability is applied.

In a much more detailed research study, Shriver [19] conducted a survey of four Austin, Texas neighborhoods to test the influence of environmental design on pedestrian travel behavior. Using two pairs of neighborhoods classified as either a traditional neighborhood, typically known to be more walkable, or a modern neighborhood, designed solely for automobile use, Shriver classifies walkable environments based on three broad characteristics: transportation system, land use, and urban design. Table 3 on the following page details what types of variables fall under each category.

As noted in the transportation system classification, Shriver applies heavy importance to the street network a neighborhood to determine if it is walkable. Serving as a proxy for accessibility to measure directness and route options, Shriver uses variables such as block lengths, number of 4-way intersections, sidewalk system that covers over 90% of neighborhood streets, lengths of other pedestrian and bicycle walkways, and the availability of transit. The term ‘opportunity-accessibility’ is applied to land use, and is defined as the number and variety of destinations that can be reached by foot. New walkability variables that Shriver applies however fall under the urban design category, which are used to determine features that encourage individuals to be outside and participate in street life. Of all the walkable variables provided by Shriver, it must be noted that none provide an actual prescription of what or how much a walkable neighborhood should have. Instead, the article simply states that a traditional or walkable neighborhood typically has a greater number of each variable than a modern neighborhood.

Table 3: Walkability Variables from Shriver, 2004

Source	Walkability Variables
Lead Author: Shriver, Katherine. **Title:** Influence of Environmental Design on Pedestrian Travel Behavior in Four Austin Neighborhoods **Source:** Transportation Research Record 1578 **Year:** 1997, 1578: 64-75	**Transportation system:** • Number and type of blocks and intersections. Defined as local accessibility; involving directness and route options. • # intersections with boundary roads • # 4-way intersect • % blocks ≥ 90% sidewalk coverage • Length of hike and bike trails • # official bicycle routes • # bus transit routes/# of stops **Land use:** • Potential for economic interaction. Measures defined as opportunity-accessibility. Includes number, variety, type, and location of destinations that may be comfortable reached by foot, as well as match with resident needs. • # commercial services, office sites, restaurants, government/community, school/day care/religious, parks and greenbelts • Duration and distance to destination **Urban design:** • Potential of streets to encourage people to participate in street life. • Outdoor seats per residential dwelling • Off-street parking spaces per dwelling • Street trees per block • Outdoor seats per commercial use • Bike spaces per commercial use • Parking spaces per commercial use • News vending per commercial use

A different method used to define and assess walkability in research has been the use of case studies. In this type of study, researchers examine and compare specific study areas that are deemed to have built environment characteristics that have traditional, neo-traditional, or modern neighborhood design. Neo-traditional neighborhood design is a recent attempt to design and construct neighborhoods focused on pedestrian and bicycle travel rather than the automobile as they were before WWII (with traditional neighborhoods).

Southworth [20,21] has two studies that use a case study to compare and contrast the characteristics of these types of neighborhoods in California. In Southworth & Owens [20], three levels of walkability variables are examined to provide a very in-depth assessment of what defines walkability. Community level variables include the large scale patterns of streets, land use, and growth patterns over time. Variables that assess neighborhood level compare intermediate patterns of blocks, streets, and intersections in primarily single-family neighborhoods in which would require less than 10 minutes to walk across. Finally, the individual street and house lot level are examined, including street cross-sections, lot configurations, and building types.

Table 4 provides a summary of the major highlights from Southworth & Owens [20]. A fully detailed explanation of the findings can be found in the Appendix. Variables that are used in this particular piece of literature to define walkability include the major repetitive ones, including mixed land uses, residential density, gridiron street pattern, shorter block lengths, narrow street widths and lot sizes, small setbacks, and the location of garages and porches. More importantly, due to the fact that Southworth's research is based on case study methodology, the article is able to provide a set of prescriptions for the size and scope of some of the variables based on what is found in the actual environment. For example, rather that stating that a walkable environment has narrow streets and lot widths, results provide the reader with a specific set of ranges for each (32-36 feet street widths; 30-40 feet lot widths). It is interesting, however, to note that the presence of sidewalks is not mentioned.

Southworth [21] continues the use of the case study methodology by comparing the urban form of two neo-traditional neighborhoods and one traditional, turn-of-the-century streetcar suburb in California. Southworth [21] is unique in that it gives readers the opportunity to learn how very different three urban environments can be, regardless if they are all classified as walkable. Therefore, the findings from this article are of particular importance because it proves that there can be variance in describing walkability.

Variables that are used to define the walkability of each neighborhood in Southworth [21] include neighborhood character, land use patterns, public open space, street design and circulation patterns, pedestrian access, and transit. Within each of these categories, a number of individual variables are included. Architecture, location of garages, and presence of trees and sidewalks are factors that contribute to the pedestrian character of an environment. A mix of housing type, housing architecture, lot sizes, and densities comprise land use patterns. Street design and circulation patterns measure connectivity levels through analysis of street patterns, number of blocks, intersections, access points, and cul-de-sacs. Finally, pedestrian access determines if a neighborhood has pedestrian facilities, including the presence of sidewalks, bike paths, and connection to retail and service destinations. Table 5 characterizes a portion of the variation found within the three walkable neighborhoods from Southworth [21].

Table 4: Walkability Variables from Southworth & Owens, 1993

Source	Characteristics Found in Walkability Neighborhoods
Lead Author: Southworth, Michael O. **Title:** The Evolving Metropolis **Source:** Journal of the American Planning Association **Year:** 1993, 59(3)	**Community level:** • Patterns of street network identified: *speculative gridiron* • *Impact*: Increasing focus on self-contained subdivision planning has eroded integrity of public street framework and severed connections between neighborhoods. • Patterns of land use identified: *contained commercial/fragmented residential* • *Impact*: Development at urban edge has separated land uses. Finer grained separation of uses within buildings, neighborhoods, and communities can support more time-and energy-efficient lifestyle and create more diverse places to live. As residential density increases and land uses increasingly intermingled, opportunities to live and work in same space increase. **Neighborhood level:** • Street patterns that contribute to quality and character of a neighborhood: length of streets and number of intersections, small number of cul-de-sacs, and loops in each unit of land • Gridiron form: Has more land devoted to streets, blocks, intersections, and points of access than other street designs. Offers shortest trip lengths and largest number of route choices. • Impact: Residential neighborhoods are suffering degradation of pedestrian accessibility and of perceptual coherence as a result of disconnected and closed street patterns. **Street, lot, and house level:** • Gridiron streets have 50 - 60 ft right-of-way, pavement widths of 32 - 36 ft, and adjacent planting strips and sidewalks on both sides. • Lot sizes ranged from 30 - 40 ft wide • Slower traffic speeds due to narrower on-street parking. • As lots became bigger, houses have been set back farther from street, weakening the spatial edge of the street and dissolving sense of enclosure. • Garages located along back alleyways. • Front porch has position of dominance on residential street.

Table 5: Walkability Variables from Southworth, 1997

Source	Characteristics Found in Walkability Neighborhoods
Lead Author: Southworth, Michael O. **Title:** Walkable Suburbs. An Evaluation of Neo-Traditional Communities at the Urban Edge **Source:** Journal of the American Planning Association **Year:** 1997, 63(1): 28-44.	**Character**: • Street trees present • Alleys for garage access or located on side of home • Front porches, small, set back garages • Sidewalks line narrow streets **Land use patterns:** • Housing types and architecture vary. Including granny flats above garages. • Lot sizes range from small town house lots to ¼ acre lots. • Lot widths range from 30 - 66 ft. • Density ranges from 1.28 – 25 du/acre **Public open space:** • Have many, small, and varied areas ranging from 20 - 28% of site. • Includes village greens, pond, shallow lagoons and large and small recreational parks. **Street design and circulation patterns:** • Local streets narrower, have sidewalks and street trees • Street patterns are mainly gridiron in resemblance. Some cul-de-sacs. • Streets widths range 30 - 36 ft • Sidewalks range 4 - 5 ft in width with planting strip • Alleys 26 ft wide with 12 ft paved lane and 7 ft grass strips on each side. • # blocks ranges between 16 – 24; # intersections ranges between 20 - 41 **Pedestrian access:** • In these particular developments, destinations are too far for people to walk. • Pedestrian facilities are mostly used for recreation, not functional needs. • About half of homes are more than a ½ mile walk. **Transit**: • Includes shuttle bus to Metro station and bus transit • Some infrequent bus service. • Good transit access. Within ¼ mile of all residents.

As Table 5 shows, even within neighborhoods that are classified as walkable, there can be variance in what variables are present. Regardless of the variance in street widths, lot sizes, and block numbers, the fact that each of the three neighborhoods posses these variables proves that they are important walkability variables. The prescriptions in size merely help reduce subjectivity when applying the variables. In Southworth findings, many of the previously mentioned walkability variables are present. However, it is important to note the findings regarding land use and pedestrian access within these walkable communities. Southworth's case study shows that within these communities, destinations are located too far for individuals to walk. Therefore, facilities such as sidewalks are primarily used for recreational rather than utilitarian purposes. Contrary to other literature, this is the first article that defines walkability without listing mixed land uses within a quarter or half-mile, a reasonable walking distance, of homes as a major variable. Even in the one walkable neighborhood that does posses a town center and other small commercial uses, about half of the homes are more than a half mile walk, thus out of utilitarian travel distance for most individuals.

While much of the previously discussed literature provides a wide range of definitions for walkability, each includes at least some variety and more importantly detail of what variables are included. However, this is not the case in all research. In many articles, the term walkability is used with only small attention paid to what exactly it comprises, and in some cases, no definition is given at all. Instead what occurs in this type of literature, an environment is merely stated as being walkable or having a high or low walkability level. With the literature only proclaiming that an environment is designed to foster more walking, it is left up to the reader to determine what this walkable environment actually looks like in reality. This lack of detail is when the term walkability runs the risk of being most overused, and therefore has a higher risk of losing meaning.

A study conducted by Friedman, et al [22] provides an example somewhat similar to this problem. In this research, the effects of nontraditional neighborhood design on travel characteristics are tested. While Friedman does use variables to define how the study areas are defined as walkable, there are only a few listed and include only the very broadest and most obvious variables. Mixed land uses, the existence of a downtown commercial district with on-street curbside parking, interconnected street grid pattern, and residential neighborhoods in close proximity to nonresidential land uses are the only variables used to define the walkable environments. No prescriptions, attention to traffic, schools, open space, pedestrian facilities, or other significantly noted variables are included.

In another article that tests environmental design on pedestrian travel, Lund [23] uses a narrower definition of walkability, however, one that is not detailed enough to contribute significantly to a well defined walkability definition. Walkability variables that are included in Lund's research are access to retail and parks, route directness, quality of pedestrian environment, and quality of local park/shopping areas. As is evident, some of the most widely recognized variables are present, such as mixed land use and presence of pedestrian facilities like sidewalks, with many others left out. Variables such as schools, access to transit, and connectivity are not mentioned.

At the complete end of the spectrum are articles and reports that discuss walkability without never truly providing a definition at all. It is understood that the focus of these types of articles are not centered solely on the built environment and consequently walkability, and therefore may not feel the need to provide a detailed definition of the term. However, the ways in which this term is presented in the articles adds significant confusion to any definition of walkability. In Rohrer, et al [24], walkability is the center of a study focused on testing for self-rated health in primary care patients. In this study, an area is defined as walkable solely if it has "convenient places to walk." Therefore, an environment could be classified as walkable if there are mixed land uses located within walk distances of residential uses, regardless if there is a lack of other necessary pedestrian facilities, such as sidewalks.

Litman [25] provides much of the same result. In this report, a variety of methods are provided to measure the economic value of walkability. However, a vague attempt is made to define walkability. According to Litman, walkability is defined as “the quality of walking conditions, including factors such as the existence of walking facilities and the degree of walking safety, comfort, and convenience.” Focusing on pedestrian facilities, safety, comfort, and convenience are variables that have been mentioned in other research, but this particular report does not detail what is meant by each variable. A number of assumptions must be made to correctly identify how walkability is portrayed: pedestrian facilities possibly referring to sidewalks, crosswalks, and other similar facilities; safety defined as variables that increase traffic and/or personal safety, such as traffic calming measures or neighborhood watch organizations; comfort could be presence of seating, street trees, or good street orientation; and mixed land uses and good connectivity and accessibility defined as convenience. However, any one of these assumptions could be incorrect. Therefore as is evident, this vagueness allows for a subjective interpretation of what could be classified as walkable.

SUMMARY OF WALKABILITY FINDINGS

As much of literature surrounding walkability suggests, there is neither one way nor a set pattern to define what variables constitute a walkable environment. Depending on the source and purpose of an article or report, discussions of walkability vary based on level of detail, the size of built environment, recommendations for size and scope such as length, width, and density levels, and can posses any number of different variables. Table 6 on the following pages provides a summary of the major findings from the walkability literature. The categories of walkability variables that are most cited are presented in addition to any prescriptions made available. It is important to note that the categories presented in Table 6 are by no means an exhaustive list of walkability variables as those presented are only the ones that were heavily cited in the literature included in this research. As there may be additional categories and variables that are not included, it is only intended to highlight the major agreements and disagreements in walkability definitions. Among the included research, a total of 13 categories of walkability variables were found. Depending on the category, there are a number of individual variables within each category that can be applied. For example, the high connectivity category includes variables such as block length, number and type of intersections, and connections to destinations.

The findings show that the two most prevalent categories in the literature are the presence of pedestrian facilities and high accessibility to other uses, each with nine different articles mentioned their importance to a walkable environment. These findings are consistent with the walking behavior literature that show that the presence of pedestrian facilities [28, 30-31, 35, 28, 41] and accessibility to other uses [27, 29, 30-32, 35, 37-38, 41] are most associated with increases in walking. In defining these two variables, both the walkability and walking behavior literature agree that pedestrian facilities should be measured based on the presence of sidewalks, crosswalks, and other walking trails, typically 5 feet wide, in an environment. Likewise, accessibility to other uses is a way to measure the proximity of uses to one another as well as to residential areas. Most literature defines the proper measurement for this proximity as ½ mile in distance. Other highly cited categories include the presence of mixed land uses, high street and pedestrian connectivity, presence of a grid-like street pattern, presence of parks and open space, attractive aesthetics, low traffic speeds, and access to transit. Valuable walkability variables that appear the fewest number of times in the literature consist of close street orientation, increased residential density, neighborhood school location, and compliance with the American with Disabilities Act (ADA).

Table 6: Summary of Findings from Walkability Literature

Walkability Variable	Source	Prescription for Variable
Parks, plazas, and open space	Burden, Walkable Communities, Inc.	Within 800 ft of 90% of homes
	Corbett & Velasquez, 1994	Only for presence
	Florida Department of Transportation, 1995	Only for presence
	Lund, 2003	Only for presence
	Shriver, 1997	Only for presence
	Southworth, 1997	Within ½ mile of homes
Pedestrian facilities (Presence of sidewalks, crosswalks, and walking trails)	Burden, Walkable Communities, Inc.	5 ft wide; cover 80% of homes and all streets; planting strip
	Corbett & Valasquez, 1994	Only for presence
	Florida Department of Transportation, 1995	5 – 7 ft wide; cover all streets; planting strip
	Lund, 2003	Only for presence
	Saelens, et al, 2003	Only for presence
	Shriver, 1997	90% of streets
	Southworth & Owens, 1993	Only for presence
	Southworth, 1997	4 – 5 ft wide with planting strip
	Litman, 2003	Only for presence
High connectivity (block lengths, intersections, connections to destinations, etc)	Burden, Walkable Communities, Inc.	400 – 600 ft block length; connections to streets, schools, parks, and other areas within $1/4^{th}$ mile walk of center
	Corbett & Valasquez, 1994	Connections to all destinations
	Saelens, et al, 2003	Short block lengths
	Shriver, 1997	Only presence of intersections with boundary roads and 4-way intersections
	Southworth & Owens, 1993	Short block lengths, high number of intersections
	Southworth, 1997	High number of intersections
Street pattern	Burden, Walkable Communities, Inc.	Grid or similar highly connected pattern
	Friedman, et al, 1994	Grid
	Saelens, et al, 2003	Grid
	Shriver, 1997	Grid (high presence of 4-way intersections)
	Southworth & Owen, 1993	Grid
	Southworth, 1997	Grid or modified rectilinear pattern

Table 6: Summary of Findings from Walkability Literature, *continued*

Walkability Variable	Source	Prescription for Variable
Mixed land uses	Burden, Walkable Communities, Inc.	Mix of retail, commercial, civic, and variety of housing types; Within 2500 ft of 80% of homes; 20% of housing stock should be affordable
	Corbett & Valasquez, 1994	Mix of retail, commercial, civic, and variety of housing types
	Florida Department of Transportation, 1995	Mix of retail, commercial, civic, and variety of housing types
	Friedman, et al, 1994	Mixed use downtown commercial district
	Lund, 2003	Mix of retail and commercial
	Saelens, et al, 2003	Mix of retail and commercial
	Shriver, 1997	Mix of retail, commercial, civic, and variety of housing types
	Southworth & Owens, 1993	Mix of retail, commercial, civic, and variety of housing types
Accessibility / Convenience to other uses (Proximity to destinations within walking distance)	Burden, Walkable Communities, Inc.	Destinations within 1/8th mile
	Corbett & Valasquez, 1994	Destinations located in close proximity to one another and to residential uses
	Florida Department of Transportation, 1995	½ mile radius used for acceptable walking distances between trip origins and destinations
	Friedman, et al, 1994	Destinations located in close proximity to one another and to residential uses
	Saelens, et al, 2003	Destinations located in close proximity to one another and residential uses
	Shriver, 1997	Destinations located in close proximity to one another and residential uses
	Lund, 2003	Important destinations located in close proximity to one another and residential uses
	Rohrer, et al, 2004	Convenient places to walk
	Litman, 2003	Convenient places to walk
Street orientation (setback, lot width, etc)	Burden, Walkable Communities, Inc.	Setbacks 15 – 25 ft
	Corbett & Valasquez, 1994	Street orientation that contributes to energy efficiency of community
	Southworth & Owens, 1993	Lot widths 30 – 40 ft; Garages located along alleyways; Porches located along sidewalk
	Southworth, 1997	Lot widths 30 – 66 ft

Table 6: Summary of Findings from Walkability Literature, *continued*

Walkability Variable	Source	Prescription for Variable
Aesthetics (Friendly neighborhood, attractive, pleasant architectural design, vegetation, etc)	Burden, Walkable Communities, Inc.	Homes along 90% of streets have pleasing architecture; 15% of front yard space devoted to landscaping; Benches every 200 ft; Presence of street trees
	Corbett & Valasquez, 1994	Only for presence of landscaping
	Florida Department of Transportation, 1995	All commercial, entertainment, and school areas should be well illuminated; Intersection lighting should illuminate crossings and waiting areas
	Saelens, et al, 2003	Presence of street trees; Interesting things to look at; Homes have attractive architecture
	Shriver, 1997	Presence of street trees; Outdoor seating in residential and commercial areas
Residential density	Burden, Walkable Communities, Inc.	At least 6 – 7 du/a; Should be 10 – 11 du/a
	Saelens, et al, 2003	Only for presence of higher density
	Southworth, 1997	1.28 – 25 du/a
Traffic calming and street speeds	Burden, Walkable Communities, Inc.	Most streets 15 – 25 mph; Collectors 30 – 35 mph; Speed reductions through street narrowing, curb extensions, tree canopies, mini-circles, on-street parking
	Corbett & Valasquez, 1994	Streets should be designed to reduce speeds
	Florida Department of Transportation, 1995	15 – 20 mph around schools
	Saelens, et al, 2003	Only for presence of low traffic volumes and speeds
	Litman, 2003	Only for presence of safety features
Neighborhood schools	Burden, Walkable Communities, Inc.	Elementary school located to where 80% of all children can walk no more than 2500 ft; Middle school reach 80% of all children within 5000 ft
	Florida Department of Transportation, 1995	Sites should have specific pedestrian access points; Low traffic speeds for roads; Traffic calming devices used to reduce speeds

Table 6: Summary of Findings from Walkability Literature, *continued*

Walkability Variable	Source	Prescription for Variable
Access to transit	Burden, Walkable Communities, Inc.	Transit stops within ¼ to ½ mile of trip origins
	Corbett & Valasquez, 1994	Only for presence
	Florida Department of Transportation, 1995	½ mile distance to transit stops from trip origins; Bus stop at far-side of intersection to prevent visual obstruction
	Shriver, 1997	Presence of high number of transit routes and stops
	Southworth, 1997	Presence of transit stops within ¼ mile of residents
American with Disabilities compliant	Burden, Walkable Communities, Inc.	New walkway, trail and sidewalk construction is ADA compliant. 2 curb ramps per corner
	Florida Department of Transportation, 1995	2 curb ramps per corner; 1 curb ramp on each side of marked mid-block crossing

Literature Review: Behavioral Outcomes

The Connection to the Walking Behavior

As the walkability literature has shown, a definition of walkability centers on a list of variables that are hypothesized to have the largest effect on the walking behavior. Therefore, in order for an environment to produce an increase in walking, it must first possess the variables that have been proven to be correlates of walking. While much of the walkability literature has attempted to create a list of variables that has the behavioral outcome of increased walking, one of its primary problems is that the empirical data that it relies upon has not adequately determined the effects of these variables on the walking behavior. Identifying the strongest correlates and properly isolating their relationship with the walking behavior is a current research dilemma. Regardless of this difficultly, many attempts have been made to decipher what factors influence the decision to walk. Table 7 better explains the range that exists in walking correlates. Produced from the National Bicycling and Walking Study from the Federal Highway Administration, this list of variables comes from a compilation of reports and case studies that were used to identity ways of increasing bicycling and walking [26]. As evident, walking correlates include both subjective and objective factors, and range distance and traffic safety to weather and built environment factors.

Table 7: Factors Influencing the Walking Behavior

Type of Factor	Walking Variables	
Personal and subjective factors	• Distance • Traffic safety • Convenience • Cost • Valuation of time • Valuation of exercise	• Physical condition • Family circumstances • Habits • Attitudes and values • Peer group acceptance
Objective factors	• Distance • Traffic safety • Weather • Topography	• Infrastructural factors: o Pedestrian facilities, traffic conditions o Access and linkage of pedestrian facilities to desirable destinations o Existence of competitive transportation alternatives o Street lighting

Source: USDOT [26]

Even with an understanding of what variables potentially affect the decision to walk, little empirical evidence has proven which of the above variables serve as the strongest correlates of this behavior. However, there has been a considerable amount of attempts to do such a feat. In order to create a satisfactory definition of walkability and to test whether previous definitions are adequate and include the proper variables, one must examine the walking behavior literature. Creating a list of variables that have been proven to be the strongest correlates of walking can then inform researchers and practitioners on what variables should be included in a working definition of walkability. While the articles included in this literature review are not a comprehensive list of all attempts to correlate the built environment with the walking behavior, they do provide an adequate range of literature that will help draw meaningful conclusions as which variables should be included in a walkability definition. A total of 15 documents are used in the following sections to highlight the most important correlates of the walking behavior. A list of tables is included in the Appendix that provides a basic synopsis of the major research findings relative to this behavioral outcome in all included literature.

Correlates of Walking: Findings from the Literature

In an attempt to test the relationship of aesthetics, convenience, and company with walking for exercise of Australian adults, Ball, et al [27] found that recreational walking is directly associated with all three putative environmental influences, regardless if one was in good or poor mental and physical health. Variables that were assessed under the category of aesthetics include neighborhood friendliness, attractiveness, and pleasantness of walking near one's home. Accessibility to destinations within walking distance is categorized as convenience, and company is defined as having someone, either another person or a pet, to walk with in one's neighborhood.

In another study of Australian adults, Giles-Corti & Donovan [28] studied the influences of individual, social environmental, and physical environmental variables on walking for transportation, recreation, and for meeting recommended levels of walking. Results showed that in the previous two weeks following a household telephone survey, 72% of respondents had walked for transportation, 69% for recreation, but only 17% received recommended levels of walking. In addition, social environmental variables, such as those that assess company, were significantly associated with meeting recommended levels. Physical environmental variables that were found to be correlated with walking include access to open space, low traffic volumes, presence of street trees and sidewalks, and mixed land use. Table 8 provides a summary of the strength of the physical environment variables findings from Giles-Corti & Donovan [28]. It is important to note that Giles-Corti found that there was weak evidence associating aesthetics with walking levels, a contradictory finding from Ball, et al [27].

Table 8: Correlates of Walking from Giles-Corti & Donovan, 2003

Source	Physical Environment Variables
Lead Author: Giles-Corti, Billie **Title:** Relative Influences of Individual, Social Environmental, and Physical Environmental Correlates of Walking **Source:** American Journal of Public Health **Year:** 2003, 93(9): 1583-1589	• Relative to respondents in bottom quartile of access to public open space, odds of walking at recommended levels were 47% higher among those in top quartile. • Those who lived on street with one or both of no major traffic and street trees were 50% more likely to reach recommended levels of walking. • In comparison to those who had no sidewalk and no shop on their street, those who had access to either or both were about 25% more likely to reach recommended levels of walking. • Weak evidence that those who achieved recommended levels were more likely to live on a street that was aesthetically pleasing, with minor traffic, trees, sidewalks, or local shop.

Using a website-delivered self-help physical activity program in a workplace setting, Humpel, et al [29] studied changes in perceived environmental attributes on neighborhood walking levels. Findings from the study show that men who increase their perceptions of aesthetics were 2.25 times more likely to have increased walking and twice as likely to walk more than recommended levels than men who did change their perceptions of aesthetics. Convenience of walking destinations, such as other land uses, and smaller perceptions of traffic problems were also associated with positive increases in walking for men and women.

In Hoehner, et al [30] four categories of variables are tested on their influences on transportation and recreational physical activity levels. Using a cross-sectional study of a low-walkable and high-walkable city in the United States, variables such as land use, recreational facilities, transportation environment, aesthetics, and the social environment are examined for their affects on minutes of walking and bicycling. Results showed that 50% of individuals living in the high-walkable city were more likely to meet recommendations for physical activity through transportation activity, compared to 36% of those living in the low-walkable city.

Likewise, 73% of respondents living in the high-walkable city were more likely to meet recommendations through recreational activities, compared to 54% living in the city classified as low-walkable.

The findings from Hoehner, et al [30] found a number of variables associated with walking for transportation or recreational activity. Mixed land use, proximity to parks, trails, and open space, presence of transit stops, attractive features, street trees, and company were all associated with walking for either form of walking. Variables that were found to have little or no association include the perceived presence of sidewalks along neighborhood streets (only slightly positive) for transportation activity and no association for recreational activity, and traffic safety was not associated with either form of walking.

The influence of home- and neighborhood-based physical activity opportunities are assessed for their impacts on walking by Powell, et al [31]. A direct relation was found between convenience of walking places and the proportion of respondents meeting current physical activity recommendations via the walking behavior. Significant variables that are most notable include convenience to parks, walking trails, and other destinations as well as neighborhood sidewalks. Data from Powell, et al [31] suggests that proximity is an important factor in identifying places to walk.

While the previous articles have tested primarily convenience to destinations and walking facilities, a study conducted by Cervero & Duncan [32], and based on data from a travel survey in the San Francisco Bay Area, expands to include other built environment factors such as density, block size, and other street and urban design characteristics. Table 9 highlights many of the findings from Cervero & Duncan [32].

Table 9: Street and Urban Design Factors Affecting Walking from Cervero & Duncan, 2003

Source	Physical Environment Variables
Lead Author: Cervero, Robert **Title:** Walking, Bicycling, and Urban Landscapes: Evidence from the San Francisco Bay Area **Source:** American Journal of Public Health **Year:** 2003, 93(9): 1478-1483	**Pedestrian-friendly factors**: • Block size / intersection attributes of trip origins accounted for 21.5% of total variance in walking/bicycling trips. • Areas with 4-way intersections (gridiron street patterns) and 5 or more converging streets (even higher levels of connectivity) positively associated with pedestrian-friendly factor. **Walking-Choice Model results**: • Trip purpose weighted heavily in predictive powers of walking. Social purposes (0.886), recreation/entertainment (0.809), eating/meal purposes (0.688), and shopping purpose (0.623) on a 0-1 scale scored highest (p=0.000). • Impedance factors: Trip distance (-1.970), slope (-4.109), rainfall (-0.729), dark (-0.158), and neighborhood quality (-0.766) all decreased likelihood of walking. • Only built environment factor significant was land use diversity at trip origin (within 1-mile radius of person's residence). Balanced, mixed-use environs with retail services significantly induced walking. Land use diversity at destination encouraged walking; however relation was statistically weak. • Pedestrian-friendly designs at neither organ nor destination had much bearing on mode choice. Intersection configurations and block sizes exerted inconsequential influences on walking.

As can bee seen, results from the walking-choice model show that trip purpose weighted heavily in predicting whether one walks: with social trips and recreation/entertainment outweighing transportation trips for shopping. Factors found to impede walking include trip distance, terrain slope, weather, and neighborhood quality. Land use diversity at trip origin was found to be significantly related to walking. While no relationship was found for intersection configurations and block sizes, street designs consistent with the grid pattern (4-way intersections) were found to be correlated with being pedestrian-friendly. Findings from Cervero & Duncan [32] suggest that density (as reflected by employment accessibility) and land use diversity exert stronger pressures than urban design on decision to walk.

Employment density, population density, and land use mix are tested for their influences on walking for utilitarian travel in Frank & Pivo [33]. Findings show that walking trips to work were found to be positively correlated with all three factors, while walking trips for shopping was only correlated with employment density and population density. More importantly however, results indicate that an increase in population density can result in both a increase in origin and in destination walking trips for shopping and to work. Contradictory to other findings, mixed land uses was found to be only associated with walking for work trips.

In an in-depth analysis using data from the metropolitan Atlanta region, Lawrence, et al [34] found that the number of minutes one performs moderate physical activity, such as walking, per day is significantly correlated with land use mix, net residential density, and street connectivity. Land use mix was found to have the greatest correlation of walking minutes, then residential density followed by street connectivity. In order to control for the effects of each of these variables upon one another, a walkability index was created to integrate each into a formula with weights to predict the variation in number of minutes spent walking per day. Significant findings from the walkability index indicate that individuals, on average, were 30% more likely to record meeting 30-minutes of walking per day with each increase in walkability index quartile. The odds of meeting recommended levels of walking were 2.4 times greater for the highest quartile (4^{th}) group than those in the least walkable group.

Ease of pedestrian flow, street design characteristics, route directness, and residential density are measured in Moudon, et al [35] for their affects on pedestrian travel in 12 neighborhood centers in the Puget Sound area. Using a case study approach, sites that are have variables that are hypothesized to be more or less walkable are compared for their ability to generate pedestrian volumes per site as well as how each site design characteristics affects those volumes. Urban environments with a density of greater than 7 du/a, high land use mix, presence of sidewalks, and residential and commercial destinations within walking distance of homes were considered walkable. As Table 10 indicates, sites with these characteristics averaged 26 more pedestrians walking per hour than suburban sites. The summary statistics of site design measures also shows that factors such as block length and sidewalk system completeness increase the number of individuals walking within their environment.

Table 10: Site Design Characteristics Affecting Pedestrian Travel from Moudon, et al 1997

Source	Site Design Characteristics Affecting Pedestrian Travel
Lead Author: Moudon, A.V. **Title**: Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments **Source**: Transportation Research Record 1578 **Year**: 1997, 1578: 48-55	**Average pedestrian volumes per site (per hour per 1000 residents):** • High walkability environments (urban): 38 • Low walkability environments (suburban): 12 **Summary site design measures and pedestrian volumes**: • Block size (ha): U=1.1; S=12.8; ratio= 1:12.2 • Street system length: U=48; S=15.9; ratio= 1:0.33 • Sidewalk system length: U=60.5; S=12.6; ratio= 1:0.21 • Sidewalk system completeness: U=1:0.97; S=1:0.55; ratio= 1:0.57 • Population density (people/ha): U=34.3; S=31.5; ratio= 1:0.92 • Pedestrians/hr/1000 residents: U=38; S=12; ratio= 1:0.33 • Pedestrians/hr: U=217; S= 68; ratio: 1:0.30

While many of the previously included literature highlights walking for any purpose, a number of articles test the built environment for its affects solely on walking trips to transportation. In Cervero & Gorham [36], transit neighborhoods are compared to automobile-oriented neighborhoods for their abilities to produce walking trips to work. Transit neighborhoods have high proportions of 4-way intersections (grid pattern) with higher density and mixed uses compared to the auto neighborhoods with many cul-de-sacs and low density development. Findings show that pedestrian modal shares are up to 13% higher in all seven pairs of transit neighborhood analyzed, generating around 120% more pedestrian trips than the matched auto neighborhoods.

In another article written by Cervero [37], mixed land use, housing type, and residential density are examined for their affects on creating walking to work trips based on data from the 1985 American Housing Survey. Variables that were found to be most correlated with walking are density, having commercial and other non-residential land uses within 300 feet of one's home, and residing within a quarter mile of one's job. Housing types of with increased density also significantly increased the probability of walking. However, the presence or absence of neighborhood shops was found to be a better predictor of mode choice than residential densities for walking, thus suggesting that mixed land uses are more important than density levels.

Craig, et al [38] furthers the research on factors affecting walking to work by expanding the variables to include social dynamics, walking routes, ability to meet pedestrian needs, and complexity of stimulus in the environment as well as many of the more researched variables such as the number of destinations within walking distance of one's home and mixed land uses. Based on data from Canadian adults, factors that contributed and hindered walking to work were found. Variables with the greatest influence on walking to work found to be significant included the lack of obstacles, such as debris, construction, and maintenance, safety from crime, the amount of time and effort required, meeting pedestrian's needs (continuity of routes, multiple route choices), and existence of continuous sidewalks and paths. Lack of features making neighborhood accessible by all individuals, overload of visual and auditory stimuli, high traffic threats, potential for crime, and a lack of variety of destinations were found to inhibit walking to work. Table 11 shows the findings from the regression model used in Craig, et al [38]. See the Walking Behavior Summary Tables in the Appendix for a detailed definition of each variable category used by Craig, et al. Variables that are included in this regression analysis are chosen because they attempt to test a comprehensive list of variables that are commonly agreed upon by practitioners to have affects on the walking behavior. Contrary to other findings in the literature, aesthetics was found to be an insignificant factor in predicting walking to work.

Table 11: Regression Results for Neighborhood Environment: Walking to Work

Variable	Coefficient	p-value
Variety of destinations	-0.76	0.044
Inclusive of pedestrians	-1.76	0.000
Exclusive of pedestrians	-1.82	0.000
Social dynamics	-1.07	0.005
Walking routes	0.82	0.031
Meet pedestrian’s needs	1.19	0.002
Walking system	0.78	0.039
Transportation system	0.66	0.104
Complexity of stimulus	-1.26	0.001
Potential “overload” of stimulus	-1.68	0.000
Visual interest	-0.32	0.401
Visual aesthetics	0.23	0.533
Time and effort required	1.32	0.001
Traffic threats	-1.42	0.000
Lack of obstacles	2.20	0.000
Safety from crime	1.98	0.000
Potential for crime	-1.42	0.000

Source: Craig, et al [38]

As found by previous research, whether one has company to walk with in an environment can affect if that person is physically active in the first place. Furthermore, it is often thought that as the number of individuals increase outside, safety levels also increase due to the increased eyes on the street and the mere physical presence of more active individuals. A study by Jacobsen [39] attempted to test these hypotheses by comparing amount of walking and the pedestrian injuries incurred in collisions with motor vehicles around the world. Results show that the risk of injury does decrease with an increase of trips on foot. Jacobsen found that a community doubling its walking can expect a 32% increase in injuries, however, the probability that one particular individual will be injured by motor vehicle declines. It is assumed that this reduction is due to adaptation of motorist behavior; where motorists expect and experience people walking in the built environment and therefore alter take them into consideration when driving by using slower speeds and safer driving measures.

Focusing solely on public open space, Giles-Corti, et al [40] studied the affects of proximity to, attractiveness, and size of parks, recreational facilities, sports fields, and other common open space on walking levels of Australian adults. Overall use of these open spaces was found to be positively associated with accessibility. Size was found to be more important than attractiveness in determining use of open space, after proximity was taking into consideration. However, accessibility was not significantly associated with achieving overall sufficient levels of walking (30 minutes of moderate activity on most days of the week).

Since the majority of walking behavior literature up to this point as been focused on determining the correlates of walking for adults, one article detailing with special populations is added. King, et al [41] studied the affects of convenience of destinations on walking levels for transportation and recreational activity of older women. Results confirm that mixed land uses and accessibility to those destinations are once again significantly correlated with walking trips. Furthermore, a positive relationship was found between the number of destinations and number of walking trips.

SUMMARY OF WALKING BEHAVIOR FINDINGS

As the results from the walking behavior literature show, there can be great difficulty in predicting what variables serve as the strongest correlates of walking. Problems with isolating the affect of one variable over another causes trouble in accurately labeling what variables are most important. Furthermore, the literature shows that it is also difficult to assess a wide variety of variables at once. Instead, many focus on testing the affects of one or two specific variables, such as access to open space or convenience to destinations, as opposed to testing multiple variables. Only one article, Craig, et al [38], did attempt to include a multitude of variables, but results show that many variables were found to be insignificant.

Table 12 on the following pages provides a summary of the major findings from the walking behavior literature. The major categories of variables that are most cited are presented as well as the primary influence on the walking behavior. If an article made a distinction between recreational or transportation walking, it is also noted. Much like the walkability literature review, the categories presented in the walking behavior literature are not an exhaustive list of possible variables that influence walking. They primarily focus on variables of the built environment and are only the ones heavily cited in the included literature. Among the walking research included, a total of 14 categories of variables were found, with some having a larger number of individual variables listed within the category.

Table 12 shows that the two most prevalent variables in the walking behavior literature are accessibility to destinations and mixed land uses, each with nine different articles testing their influence on walking. Other highly cited correlates of walking include employment and residential density, the presence of pedestrian facilities such as sidewalks, attractive aesthetics, and high connectivity of streets and pathways. Other variables that were proven to be strong correlates of walking but not tested in a large number of articles include access to public open space, low traffic volumes and speeds, company, access to transit, presence of the street trees and a variety of housing options.

Table 12: Summary of Findings from Walking Behavior Literature

Walking Correlate	Source	Finding
Aesthetics (Friendly neighborhood, attractive, pleasant architectural design, vegetation, etc)	Ball, et al, 2001	Associated with **recreational** walking.
	Giles-Corti & Donovan, 2003	Weak evidence.
	Hoehner, et al, 1994	Associated with **recreational** walking.
	Humpel, et al, 2004	Associated with walking.
	Craig, et al, 2002	Association, but not statistically significant for **transportation** walking.
Presence of street trees	Giles-Corti & Donovan, 2003	Associated with walking.
	Hoehner, et al, 1994	Associated with both **transportation** and **recreational** walking.
Accessibility / Convenience (Proximity to destinations within walking distance)	Ball, et al, 2001	Associated with **recreational** walking.
	Hoehner, et al, 1994	Positively associated with **transportation** walking.
	Humpel, et al, 2004	Associated with walking.
	Powell, et al, 2003	Positively associated with **recreational** walking.
	Cervero & Duncan, 2003	Associated with **transportation** walking for trip origin.
	Moudon, et al, 1997	Associated with **transportation** walking.
	Cervero, 1996	Associated with **transportation** walking.
	Craig, et al, 2002	Association, but not statistically significant for **transportation** walking.
	King, 1994	Associated with **transportation** walking for older women.
Company (Walking with another individual)	Giles-Corti & Donovan, 2003	Associated with walking.
	Ball, et al, 2001	Associated with **recreational** walking.
	Hoehner, et al, 1994	Associated with large numbers of active individuals in an environment for **transportation** walking.
	Craig, et al, 2002	Not associated with **transportation** walking.
	Jacobsen, 2003	Having other individuals walking in environment increases walking and decreases risk of injury.
Access to public open space	Giles-Corti & Donovan, 2003	Associated with walking.
	Hoehner, et al, 1994	Associated with **recreational** walking.
	Giles-Corti, et al, 2005	Associated with **recreational** walking.
	King, 1994	Associated with walking for older women.

Table 12: Summary of Findings from Walking Behavior Literature, *continued*

Walking Correlate	Source	Finding
Mixed land use	Giles-Corti & Donovan, 2003	Associated with walking.
	Hoehner, et al, 1994	Associated with **transportation** walking.
	Humpel, et al, 2004	Associated with walking.
	Cervero & Duncan, 2003	Associated with **transportation** walking for trip origin. Encourages walking at destination but statistically weak.
	Frank & Pivo, 1004	Associated with **transportation** walking at trip origin and destination.
	Frank, et al, 2005	Associated with walking.
	Cervero & Gorham, 1995	Associated with **transportation** walking.
	Cervero, 1996	Associated with **transportation** walking.
	King, 1994	Associated with walking for older women.
Pedestrian facilities (Presence of sidewalks, crosswalks, walking trails)	Giles-Corti & Donovan, 2003	Associated with walking.
	Hoehner, et al, 1994	Associated with **transportation** walking. No association found with **recreational** walking.
	Powell, et al, 2003	Associated with **recreational** walking.
	Moudon, et al, 1997	Associated with **transportation** walking.
	Craig, et al, 2002	Associated with **transportation** walking.
	King, 1994	Associated with walking for older women.
High connectivity (block lengths, intersections, connections to destinations, etc)	Cervero & Duncan, 2003	Inconsequential influences on **transportation** walking.
	Frank, et al, 2005	Associated with walking.
	Moudon, et al, 1997	Associated with **transportation** walking.
	Cervero & Gorham, 1995	Associated with **transportation** walking.
Street pattern	Cervero & Duncan, 2003	Grid pattern associated with pedestrian-friendliness.
	Cervero & Gorham, 1995	Grid pattern associated with pedestrian-friendliness.
Low traffic volume and speeds	Giles-Corti & Donovan, 2003	Associated with walking.
	Hoehner, et al, 1994	Not clearly associated with walking.
	Humpel, et al, 2004	Associated with walking.
	Craig, et al, 2003	Associated with **transportation** walking.

Table 12: Summary of Findings from Walking Behavior Literature, ***continued***

Walking Correlate	Source	Finding
Density (Employment or residential)	Cervero & Duncan, 2003	Employment density associated with **transportation** walking.
	Frank & Pivo, 1994	Employment and residential density associated with **transportation** walking.
	Frank, et al, 2005	Residential density associated with walking.
	Moudon, et al, 1997	Residential density associated with **transportation** walking.
	Cervero & Gorham, 1995	Residential density associated with **transportation** walking.
	Cervero, 1996	Residential density associated with **transportation** walking.
Access to transit	Hoehner, et al, 1994	Associated with **transportation** walking.
	Cervero & Gorham, 1995	Associated with **transportation** walking.
	Craig, et al, 2002	Associated with walking, but not statistically significant.
Housing variety	Cervero, 1996	Higher mix of housing options associated with **transportation** walking.
Other	Craig, et al, 2002	Lack of obstacles, safety from crime, accessibility for special populations, and low amounts of time and effort required all associated with walking.

Synthesis of Findings

What Does the Literature Tell Us

If one reoccurring theme arises in the preceding literature reviews, it is that there is neither an easy way to measure the built environment nor an accurate way to predict how it will affect behavior. These problems occur due to a number of reasons. First, identifying factors that are associated with physical activity is a basic research concern in behavioral outcomes literature. In order for researchers to accurately state that one variable will substantially increase the probability of an outcome, causality must be established. However, in behavioral research there is the possibility of multiple factors that cause one to walk. These additional causal factors, or determinants, therefore make it difficult for research to label the causality of one particularly variable accurately [42].

Isolating the influence of a particular variable on the walking behavior is also difficult due to the presence of intervening variables, known as mediating variables, which affect the causal pathway between exposure to the determinant and the outcome [42]. An individual's behavior is based on a wide variety of variables, including time, effort, gender, weather, distance, topography, and built environment factors, and these variables affect whether one walks regardless if a walkability variable is present in the built environment. Therefore, exposure to a factor does not inevitably lead to the behavioral outcome. Placing causality on any one built environment factor is thus difficult because of these other mediating factors affecting one's decision to walk [42]. Unfortunately, there has not been a methodology devised in behavioral intervention studies to control for all of these factors which is a major problem in this area of research. It is quite unlikely that behavioral outcomes research can truly demonstrate causality for physical activity due to the fact that causal variables vary greatly among setting and individuals. Future research can only continue attempting to control for as many mediating variables as possible in hopes of discovering proper causality of built environment factors on the walking behavior.

Furthering this problem of determining the correlates of walking lays in the fact that discrepancy that can also occur when testing such variables. Since many of the walking variables are tested in different environments with varying characteristics, it is also impossible to obtain the same results every time. Every built environment has different mediating factors and individuals with dissimilar preferences interacting in that environment. Therefore, as study areas change, a factor that is found to be strongly associated with walking in one area may not be significant in another, or worse, found to be not correlated at all in the new environment. This fact is highlighted in Table 12 of the Summary of Walking Behavior Findings section. As can be seen in the Findings column, some articles find that a variable is correlated with walking while others do not. Examples of this occur with aesthetics, accessibility, company, access to transit, connectivity, and traffic safety.

Differences in correlation between the walking behavior and each one of these variables can also occur for other reasons. As previously stated, many of the articles included in the literature review focus on a small number of variables to determine their influences on the walking behavior. Such a specialized study allows researchers to center on a certain type of walking, such as the walk to work trip recreational trip. Since it is hypothesized that different variables affect these walking behaviors, a different set of variables are included in the study. For example, in Ball, et al [27] accessibility to destinations was found to be positively associated with walking for recreation. In this article, a total of three variables, aesthetics, convenience (accessibility), and company, are studied for their impacts on exercise walking. However, in

Craig, et al [38] a total of 18 variables are included in the research, which is focused solely on walking to work, or transportation purposes. Regardless of these discrepancies, the findings from the walking literature do provide a basis for what built environment variables could be the most important correlates of walking, which can help inform the construction of a working walkability definition.

The findings from the walkability literature review underscore the large differences that can occur when attempting to define walkability. The ability of a walkable environment to improve traffic congestion and physical activity levels shows that is a very important concept for planners and public health officials. Securing a proper definition should help achieve these goals as well as aid the implementation of walkability in the built environment.

The walkability literature highlights that the two major problems in defining walkability are variance in the number of variables included in one's definition and the level of detail to which each variable is defined. As previously stated, 13 total categories were cited as potential variables for walkability in the included literature; however not all articles include every category. For example, in definition provided by Litman [25], only the presence of pedestrian facilities such as sidewalks and walking trails, accessibility to destinations within walking distance, and traffic calming measures and low street speeds are emphasized. According to this definition, many areas could be defined as walkable which should not be included. Imagine a large strip mall and adjacent parking lot with an apartment complex located across a six-lane road that just happens to have sidewalks and a low speed limit. Since residents of the apartment complex could, in theory, reach the strip mall by walking, it could be considered a walkable environment since it meets all of Litman's requirements. However, in all likelihood, this environment will produce a minimum amount of pedestrian activity. These individuals will most likely use an automobile to access the shopping center for safety reasons. While this hypothetical situation may not realistic, it does highlight the fact that this type of minimal definition can cause problems.

On the other hand however, a too restrictive definition could prevent or slow the implementation of walkability in a community. In the definitions provided by Dan Burden of Walkable Communities, Inc., all 13 categories of variables are included in his definition of walkability. While most, if not all, of the variables included improve the pedestrian-friendliness of the built environment, the inclusion of all variables can lead to the exclusion of some environments as walkable. Furthermore, when attempting to design and implement walkability in an environment, the inclusion of such a vast amount of variables could potentially lead to difficulties. Factors such as adequate funding for installation, land use and zoning restrictions, and agreement among stakeholders can thwart the implementation of some of the variables, there by preventing the creation of a walkable environment. Obvious, there is a tricky balance between the vagueness and inclusion of variables that should be part of a walkability definition.

The second major problem that the walkability literature underlines is the discrepancy that exists within each walkability category in terms of level of detail for prescriptions. For example, there is consensus in the literature that the street pattern of a walkable environment should posses a grid-like structure, as six of the articles mentioning street pattern were all in agreement. Likewise, while only two articles choose to include compliance with ADA, both stated that curbs should have two ramps as opposed to just one. However this occurrence is not the norm. Of the remaining eleven categories of walkability variables, there is some type of disagreement between the articles as to what types of prescriptions there are for each individual variable. While some articles give specific dimensions, for example figures for sidewalks width, block length, setbacks, or traffic speeds, others merely state that they should be taken into consideration. This is a problem for a walkability definition because it allows for a subjective interpretation of what each variable should be.

PULLING IT ALL TOGETHER: A WORKING DEFINITION OF WALKABILITY

A major goal of this research has been to show that there is not one adequate definition of walkability. Consequently, this problem has lead to the application of the term walkability to number of very different environments, some of which may or may not actually produce an increase in walking. In order to combat this trend, a second objective of this research is to examine the findings from the walkability and walking behavior literature reviews to comprise a potential working definition of walkability. By taking into account which variables are the strongest correlates of the walking behavior and those that are most citied as part of walkability definitions, a proxy list of variables can be devised that may serve as a working definition of a walkable environment. The newly combined definition of walkability is a result of analysis of the findings from both literature reviews, where variables that appear in both summary tables are included. Table 13 on the following page provides a listing of variables and prescriptions for the new comprehensive definition of walkability. Prescriptions that are included focus primarily on balancing the need for clarification without being too restrictive. Therefore, many prescriptions provide a range in level of detail as well as include impendent variables that are 'encouraged' rather than required. Each prescription presented in Table 13 is meant to provide planners with a way to operationalize and measure each walkability variable.

In order to deal with many of the problems in defining and implementing this construct, a phased approach is created, ranging from Essential to Encouraged to Extra. Together, each group of walkability variables is ranked based on importance for their combined correlation to the walking behavior (listed top to bottom in Table 13). Research shows that variables most cited in the literature are commonly agreed upon to have the most influence on the walking behavior. Therefore, variables that were found to be most cited by planners and researchers in the walkability and walking behavior literatures are ranked highest, followed sequentially by variables that were found to be important correlates of the walking behavior but cited fewer times as necessary variables in the walkability literature. Using these rankings, the phased approach to the walkability definition was then determined by grouping variables into categories based on the number of times each was cited in the literature reviews. Categories that consistently appear in the literature and are most commonly correlated with the walking behavior are listed as the most important variables. The best working definition of walkability will encompass all of the variables included in each of the three ranked categories.

Variables labeled as Essential are the absolute minimum variables that must be present in an environment to adequately generate walking to be classified as walkable. The four variables, mixed land use, accessibility, presence of pedestrian facilities, and connectivity, are highly cited in both literatures and are well-know within both the planning and public health fields to have this effect. Variables that fall under the Encouraged classification are additional variables that are important to create a well-rounded definition of walkability. Many of these variables, such as street pattern and density, are complementary to variables listed as Essential which further help to increase walking. When implementing walkability in an environment, these variables should be included whenever feasible. The Extra classification is comprised of variables that should be considered when implementing walkability, but not required in a definition to prevent being too restrictive. Other variables, such as neighborhood schools, could fit into the Extra category but are not listed in the table.

Table 13: Synthesis of the Literature- A Phased Definition of Walkability

	Walkability Variables	Prescription
Essential	**Mixed land use**	• Mix of retail, commercial, civic, and variety of housing types • If possible, designed as a downtown commercial district
	Accessibility / Convenience (Proximity to destinations within walking distance)	• Important destinations are located in close proximity to one another and to residential uses • If possible, no more than a ½ mile radius should be acceptable for walking distances between trip origins and destinations
	Presence of pedestrian facilities (Sidewalks, crosswalks, etc.)	• Should have width of 5 – 7 ft • Planting strip should be present if possible • Coverage should extend to at least 80% of all homes and streets
	High connectivity (Block lengths, intersections, connections to destinations, etc.)	• Block lengths should be short. Encouraged to be between 400 – 600 ft in length • Connections to all destinations should be present • High use of intersections with good connectivity (4-way intersections) • Lack of cul-de-sacs
Encouraged	**Street pattern**	• A grid or similar highly connected pattern should be used
	Density	• Residential density should be at least 6 – 7 du/acre but encouraged to be higher (10 – 11 du/acre) • Higher residential densities should be encouraged for multifamily housing (10 – 25 du/acre) • Increased employment density should a focus in commercial areas to increase walking trips to work.
	Aesthetics (Friendly neighborhood, attractive, pleasant architectural design, vegetation, street trees, etc)	• Homes along most streets should have pleasing architecture • Landscaping should be encouraged around residential, commercial, and other gathering spaces • Presence of street trees throughout community • All pedestrian areas should be well illuminated
	Presence of parks, plazas, and open space	• Neighborhood parks, tot-lots, and other public open space should be dispersed throughout environment. • Walking trails and sidewalks should connect to all open space. • Sporting fields should be encouraged.
	Traffic calming and street speeds	• All streets should have a maximum speed of 35 mph but lower if possible. 15 – 20 mph around schools • Street narrowing, curb extensions, tree canopies, mini-circles, on-street parking, and other traffic calming measures should be used to increase traffic safety
Extra	**Street orientation** (setback, lot width, etc.)	• Setbacks should be small, ideally between 15 – 25 ft • Lot widths should be narrow, ideally between 30 – 60 ft • Where appropriate, garages should be located along alleyways • Porches should be located along sidewalk
	Access to transit	• Transit stops should be within ¼ to ½ mile of all destinations and residents

DOES WALKABILITY ACTUALLY RESULT IN AN INCREASE IN WALKING?

In order for walkability to be an important construct for planners and public health officials, it must serve its goals. As previously stated, walkable communities are meant to foster walking and bicycling to nearby destinations rather than requiring individuals to rely strictly on the automobile, thus having the affect of reducing traffic congestion, air pollution, and increasing physical activity. As a secondary research question in this process, it becomes important to determine if walkability actually produces an increase in walking; otherwise, walkability may not serve a purpose and planners will find that other interventions are necessary.

Reexamining the walkability and walking literature can help answer this question. As noted in the literature reviews, many articles test communities that possess walkability variables for their impacts on walking. Results from many of these studies show that walkability does in fact produce an increase in the walking behavior. Friedman, et al [22] found that a walkable environment in San Francisco Bay Area produces nearly a quarter more daily walking trips per household than similar suburban subdivisions. In San Diego, CA, Saelens, et al [18] reports that high walkable neighborhoods produce, on average, 52 more minutes of walking than residents in a low walkable area. Likewise, Shriver [19] found that in Austin, TX, residents of a walkable environment walk to commute three times as more than residents of a modern neighborhood. These findings are consistent with other research as well [23, 43]. It is important to note however that the increase in walking that these walkable communities are experiencing is for the most part in small quantities. This suggests that while walkability shows promise, it is not the complete answer to traffic congestion, lack of physical activity, and other planning and health problems. It does show that there can be incremental gains towards these goals if properly implemented.

WALKABILITY: TRANSPORTATION OR RECREATION

Results showing that an environment containing the walkability variables contributes to an increase in walking are an important finding. Since walking can be distinguished into two groups, utilitarian and recreational walking trips, it becomes equally important to question which form of walking trip this increase in the walking behavior is attributed. Depending on which type of walking is most prevalent in walkable communities, there can be a large impact for the city planning and public health professions. If individuals in these communities are using walkable communities solely to exercise, then walkable communities potentially may not be serving their true planning goals of utilitarian travel. Increasing physical activity levels is an significant goal, but if walkability is meant to induce utilitarian walking trips by substituting away from automobile travel, then there potentially could be a disconnect if any increase in walking that results from these environments occurs mostly in the form of recreation.

Once again, looking to the walkability and walking behavior literature can help answer this question. While some research did not distinguish between transportation and recreational walking, those that did can help determine what variables are the strong correlates for each type of walking behavior. There is a limitation to this process however. Most articles that attempt to determine the affects of walkability or test a correlate of the walking behavior focus primarily on one type of walking. Therefore, some of the findings can be slanted in favor of either transportation or recreational walking. For example, much of the research included in this literature focuses on the walk to work trip. Due to this fact, variables tested in these articles are listed as having an association with transportation walking, without knowledge of its affect on recreational walking. Table 14 provides a listing of what the walking behavior literature found to be the greatest correlates of each type of walking.

Table 14: Walking by Purpose- Findings from Walking Behavior Literature

	Walkability Variables	Number of Articles Citing by Walking Purpose	
		Transportation	Recreation
Essential	Mixed land use	5	0
	Accessibility / Convenience	6	2
	Presence of pedestrian facilities	3	1
	High connectivity	2	0
Encouraged	Street pattern	n/a	n/a
	Density	5	0
	Aesthetics	2	3
	Presence of parks, plazas, and open space	0	2
	Traffic calming and street speeds	1	0
Extra	Street orientation	0	1
	Access to transit	2	0

As the shown, variables that have been found to be correlates of the walking behavior vary on their impacts of generating transportation or recreational walking trips. Due to the nature of the literature included in this research, utilitarian walking dominates the majority of walkability categories, with only 3 of 11 being more closely associated with recreational walking. Even with the fact that much of the research is focused solely on walking to work, some of the findings are still expected. All four Essential variables center on providing the easiest ways to allow pedestrians to travel to important destinations. It is a safe assumption that most individuals who participate in recreational walking do not need commercial, civic, or other mix of land uses to receive the benefits of exercise. However, these variables are necessary to provide pedestrians with the opportunity to walking to carry out daily errands or walk to work. Many of the other variables that are most associated with transportation walking also make sense. For example, having access to transit increases transportation walking due to the fact that uses transit for transportation purposes and one must walk to the transit stop.

The three variables that are found to be most associated with recreational walking are aesthetics, presence of parks, plazas, and open space, and street orientation. Once again these findings from the literature are expected since these types of variables all deal with improving the visual quality and outdoor experience of a pedestrian. While these are important for transportation, they are not necessarily required. However, when one chooses to be physically active outdoors, stimuli in the built environment that are pleasing to the pedestrian can entice one to walk for recreation. Both aesthetics and street orientation accomplish this goal by increasing the streetscape and making an environment more attractive. The presence of parks, plazas, sporting fields, and other public open spaces is associated with recreational walking since most individuals use these facilities for exercise and personal pleasure.

According to these findings, it appears that variables most associated with walkability lead to an increase in transportation as opposed to recreational walking. However, due to limitations mentioned, it becomes difficult to label true causality since many of the articles were biased towards utilitarian walking. Furthermore, some believe that walkable environments cause self-selection, where individuals who live in these environments purposefully choose to do so because of their preferences for transportation walking as opposed to other forms of travel. This phenomenon, if true, further makes it difficult to label causality of the variables. Due to these problems and based on the literature included in this analysis, it is inconclusive whether a walkable community results in more transportation or recreation walking. Further research is needed to test for both forms of walking.

CONCLUSIONS AND RECOMMENDATIONS

With the change in the way that cities have grown over the century, our nation has been confronted with a number of problems. Heavy reliance on the automobile, local land use and zoning laws segregating uses, and changes in preferences for large lot, single-family detached housing has lead to an increase in urban sprawl, environmental deterioration, further separation of race and income, and many public health problems. While there are many options available that can help fight these trends, the city planning profession is now emphasizing the importance of designing walkable communities to foster walking and bicycling to destinations and create a sense of community among residents.

The major point of this research was to show that there is little agreement as to what defines a walkable environment. In practice and in the literature, planners tend to apply the term to a number of built environment scenarios. This pattern is consistent with the findings from the literature review on walkability, which showed no less than 11 different variants of definitions for walkability. Some variables were, however, repeatedly cited and therefore make up a small list of essential variables that must be included in any definition. Mixed land uses, accessibility to destinations within walking distance, the presence of pedestrian facilities such as sidewalks, and good connectivity of roads and pedestrian facilities make up this group of variables.

Furthering the confusion in defining walkability is the level of detail for each variable. While one practitioner may simply list that a variable should be present, another may go a step farther by giving a precise prescription for that variable. Discrepancies such as these can both aid and harm the implementation of walkability in the built environment. By providing a range of possible prescriptions as well as listing other variables that are encouraged, planners can use a walkability definition as a toolbox. A range in level of detail provides planners with room to work when implementing walkability, thus allowing one to tailor walkability to varying environments. However, when a walkability definition includes a very precise prescription for all variables, it can make implementation difficult. An example of this would be requiring that all destinations be within ¼ mile of homes. While acknowledging that this requirement would improve the walkability of an environment, it is not feasible because it is impossible to ensure that every home and destination is within that distance. If it was a requirement, it would greatly limit the number of environments that can be labeled as walkable. It is more important to encourage that most destinations be within ½ mile of homes.

Difficulty in defining walkability also lies in the fact that behavioral outcome research has not been successful in isolating the true influence of built environment factors on walking. Meditating variables and personal preferences has prevented researchers from adequately labeling causality for the built environment variables. Findings from the walking behavior literature are consistent with these problems. Depending on which article, the same type of variables were found to be strongly associated with walking, associated but not statistically significantly associated, and no associated at all. Future research and new methodologies will be needed to try to control for these outside variables and therefore attempt to isolate the influence of the built environment factors.

After examining the walkability and walking behavior literature, two general approaches to defining walkability arise. As previously stated, a list of proxy variables can be deciphered from both literatures to determine what the best working definition of walkability is. The other approach comes from colloquial attempts to describe an environment that is better for walking over another. These two approaches have very different meanings for policy and practice. The former, which was ultimately the goal of this research, provides planners with a set of tested and well-documented variables that produce an increase in walking in the built environment. It gives a precise inventory of what variables must be included and what, if any, prescriptions those variables must exhibit. The latter, however, is only acceptable in a comparative manor and should not be used in practice. In discussions of the built environment, it is acceptable to describe one environment as more walkable than another for comparison purposes; however this designation cannot be associated with any particular set of variables as it does not include any specific prescriptions. This usage of walkability is a potential explanation for why the term walkability has become overused in practice. Planners, public health officials, and others identify environments as being more walkable, but without adequately indicating what variables are present to draw that conclusion.

By analyzing the findings from each literature reviews, a newly comprised, working definition of walkability was formed. Again, Table 13 details those variables that are included. The best operational definition of walkability is one that posses all variables included in the table and provides the proper prescriptions to allow for measurement. At a minimum, a walkable environment is one that has a mix of land uses located in close proximity to one another and within ½ mile of residential uses. It provides pedestrians with a network of sidewalks, crosswalks, and walking trails that are at least 5 feet wide. The street pattern is set up to resemble a grid pattern, with block lengths ranging from 400 – 600 feet and a high prevalence of 4-way intersections as opposed to cul-de-sacs, all indicators of high connectivity. Refer back to Table 13 for the additional variables that should be included in a walkability definition as well as the prescriptions that will help test and measure each variable in the built environment.

There are several strengths to this walkability definition as opposed to the others found within the literature. First, it is formed from a compilation of articles and reports centered on this topic. It borrows from wide range of experts in the field, thus making it possible to combine expertise and synthesize it together into one definition. Second, rather than being too vague or restrictive in level of detail for prescriptions, the definition includes a range for adequate detail and distinguishes between what prescriptions are encourages as opposed to required. Finally, the new definition is broken down into three stages based on findings that establish which variables are most essential to a walkable environment. The staged approach builds leeway into the process of defining a walkable environment by providing guidance without being restrictive. As an environment possess more of the variables, it should generate more walking trips as opposed to an environment with only the four essential variables.

Additional synthesis of the findings from the literature found that walkability does translate into an increase in walking. However current research has shown that this increase is only in small quantities per household. But even if these communities increase walking trips by one each day, their aggregated effects can have significant impacts on reduced automobile use and increased physical activity levels. These impacts also highlight the importance of determining whether the increase in walking is a result of transportation or recreational walking. As the literature indicates, some variables are more closely associated with one form than the other. Unfortunately, due to limitations in the articles included in this research, findings were inconclusive as to which form of walking was most prevalent do to walkability. Further behavioral outcomes research is needed to test for both forms of walking to help answer this research question.

RECOMMENDATIONS FOR POLICY AND PRACTICE

With the ability to reduce traffic congestion, improve air quality, build a sense of community, and increase physical activity levels, walkability potentially can serve as a formable answer to our sprawling development patterns. While more research is needed, current literature has shown that walkability does lead to in increase in walking, regardless if it is for utilitarian or recreational purposes. However, the literature has also highlighted the problems of subjectivity can arise in many of the current walkability definitions. Therefore, a set of calls to action are provided to prescribe a list of recommendations for planners in policy and practice to successfully implement walkability into the built environment so that it may better serve all forms of walking. Table 15 provides a summary of each call to action followed by a short description of each recommendation.

Table 15: Summary of Recommendations for Calls to Action

Calls to Action for Better Implementation of Walkability
• Produce more behavioral outcomes research on the walking correlates.
• Perform additional research on the transportation and recreational benefits of walkability in a built environment.
• Generate greater discussion among researchers, planners, and practitioners to improve consistency in definitions and the application of walkability.
• Require that definitions of walkability provide a range of prescriptions to limit subjectivity but provide aid in implementation.
• Ensure consistency in walkability audits so that public officials, planners, and the general public all are looking for the same variables.
• Update land use and zoning codes to allow for compact, mixed use development since the success of walkability hinges on these variables.
• To further encourage utilitarian travel, focus on increased employment densities and a good mix of commercial, office, and retail uses to generate walk to work trips.
• Since automobile dominance will not go away, integrate all modes of transportation into walkable environments.
• Increase public awareness of the planning and health benefits of walkability.
• Ensure that all populations have access to walkable environments by requiring affordability in housing.

CALLS TO ACTION

1. Produce more behavioral outcomes research on the walking correlates.

- As current research has shown, there is great difficulty in accurately identifying what variables are the strongest correlates of the walking behavior. New research and methodologies must attempt to control for many of the mediating factors that affects one's decision to be physically active in an environment. Building this body of literature will help better inform planners as to what are the most important variables in a walkable environment.

2. Perform additional research on the transportation and recreational benefits of walkability in a built environment.

- Because the research question of whether walkability increases utilitarian or recreational walking the most is unanswered, additional research must be conducted to test these affects. It is important that both forms of walking are tested within the same community in order to provide a comparison of variables and their impacts on each form. With this information, planners can better understand how walkability is achieving its goals.

3. Generate greater discussion among researchers, planners, and practitioners to improve consistency in definitions and the application of walkability.

- This research has indicated that there is not much consistency between definitions of walkability. Depending on the source, a host of variation can occur when studying the same construct. In order to reduce the problem, researchers, planners, and practitioners must improve discussion among each other to reduce discrepancies in definitions and help improve the application of walkability in the built environment.

4. Require that definitions of walkability provide a range of prescriptions to limit subjectivity but provide aid in implementation.

- Consistency in variables is not the only important piece in implementing walkability. Definitions must be required to include a range of prescriptions for variables in order to limit the opportunity for subjectivity when applying features to a built environment. Merely listing the need for the presence of narrow roadways does not help in the implementation of walkability.

5. Ensure consistency in walkability audits so that public officials, planners, and the general public all are looking for the same variables.

- While much of the literature surrounding walkability is done by professionals, most of the testing of walkability occurs by public officials, neighborhood planners, and the general public while conducting a walkability checklist in their neighborhood. To further ensure that walkability definitions are consistent with one another, walkability audits must contain the same variables. Attention to the level of detail for each variable in the checklist is also paramount to ensure that all residents are looking for the same types of defining features.

6. Update land use and zoning codes to allow for compact, mixed use development since the success of walkability hinges on these variables.

- The walkability and walking behavior literatures indicate that variables such as mixed land use and the presence of pedestrian facilities are the most essential part of a walkable environment. However many times these types of variables are not allowed to be installed in the built environment due to local law. In order to ensure that these types of variables will be required, land use and zoning codes must be updated to allow for compact mixed use developments.

7. To further encourage utilitarian travel, focus on increased employment densities and a good mix of commercial, office, and retail uses to generate walk to work trips.

- Since one of the main goals of walkability for planners is to reduce automobile use, variables that contribute to this cause must be implemented in a walkable community. The literature proved that higher employment densities and a mix of uses lead to significant increases in walking to work and other transportation walking trips. If planners wish to continue to increase the amount of walking within a walkable environment, they must look farther than only the essential walkable variables and ensure that the many of the encouraged variables, such as higher density, are implemented.

8. Integrate all modes of transportation into walkable environments.

- While walkability is meant to increase walking trips, it is inevitable that individuals will still use the automobile for some trips. Planners must accept this fact and incorporate the automobile into the site designs of a walkable environment in a manor that will not inhibit walking. Likewise, as much of the literature cited, access to other modes of transportation, such as bicycling and transit, is important in fostering walking trips. Therefore, planners must ensure that all modes of transportation are fully intergraded within a walkable environment to provide a range of travel options.

9. Increase public awareness of the planning and health benefits of walkability.

- Most individuals are not familiar with the term walkability and do not know the benefits that can be received by such an environment. While implementing walkability into an environment is a step in the right direction to increasing walking, its success can only go so far. Individuals interacting in these communities must be aware that they have the option to decrease traffic, improve air quality, and improve their own personal public health by walking more within their environment. It is the planner's responsibility to ensure that the general public full understands the potential of these environments.

10. Ensure that all populations have access to walkable environments by requiring affordability in housing.

- The benefits of walkable environments should be experienced by all groups of people. However, many new walkable communities that have been built have raised affordability issues due to the high costs of purchasing homes within these environments, thus pricing out many lower income residents. An environment that fosters walking could potentially most benefit this population since this group of individuals typically do not own an automobile. Therefore, planners must ensure that a variety of housing options, including affordable housing, are available.

FINAL IMPLICATIONS

The major findings from this paper show that three of the four primary objectives were successful. An examination of the literature showed that there were wide discrepancies in how to define walkability and what variables were the best correlates of walking. However, by analyzing these findings, an operational, working definition of walkability that combines the expertise of a variety of researchers and planners was produced. The eleven walkability variables included in this definition can be used as proxy variables for most other variables that can be hypothesized to produce an increase in walking. Prescriptions included for each variable will allow planners to measure them in the built environment.

This research also found that walkability does translate into a small increase of walking in an environment, thus affirming the general hypothesis of this paper. A place that exhibits the variables included in Table 13 does result in an increase in walking. However, the literature reviewed in this paper is inconclusive as to whether this increase in walking is for transportation or recreational purposes.

Finally, the calls to action are meant to provide planners, public health professionals, and researchers with potential ways to help improve the implementation of walkability in the built environment. Each highlights an important factor that was found to prevent walkable environments from having significant impacts on walking behaviors in the literature. Once planners begin to carry out these recommendations in policy and practice, significant gains should be made in building an environment that truly promotes walking.

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APPENDIX

WALKABILITY SUMMARY TABLES

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Burden, Dan **Title**: Rating System for Walkable, Active Living, Active Transportation **Source**: Walkable Communities, Inc. **Year**: Unpublished Manuscript.	**Categorical variables**: • Location of parks, plazas, and open space • Adequacy of walkways • Connectivity • Street orientation • Density • Aesthetics • Street speeds • Neighborhood schools • Land use • Trails • Accessibility	Variables within categories devised by walkability expert Dan Burden.	**Location of parks, plazas, and open space**: • Public spaces should be located within 800 ft of at least 90% of all homes. • These areas meet needs of creating informal gathering places and provide a physical separation between houses. **Adequacy of walkways**: • Sidewalks should be minimum of 5 ft wide and preferably separated from curbs, and cover 80% of homes and 100% of principle streets. • Sidewalks not always needed when speeds on area streets are 20 mph or lower and when traffic is well dispersed. • Alleyways accommodate utilities and driveways, making sidewalks more attractive. **Connectivity**: • Blocks well connected and 400-600 feet in length. Other links, trails, and connections make up for block length deficits. • Streets need not be in grid form but must be short enough to allow ease in reaching most areas by foot. • Connections must be made to primary streets, schools, parks, and other important areas. **Street orientation**: • Homes along 90% or more of streets have pleasing architecture, variety, and provide "eyes facing streets." • Absence of snout garages. Setbacks are typically 15-25 ft and rarely as much as 40-60 ft. • Housing should be clustered around open courts, a "close", or park space. **Density**: • Homes, including accessory units, have densities of at least 6-7 du/a, but should be 10-11 du/a. **Aesthetics**: • Neighborhoods should have quality streetscapes and corner treatments. • At least 15% of individual front yard space is devoted to landscaping. • If fencing is used, it is below 4 foot height and either semi- or highly transparent. • No chain link fences or solid walls facing streets. **Street speeds**: • Most streets and alleys maintain speeds of 15-25 mph. Avenues (collectors) permitted to operated at 30-35 mph. • Absence of speed humps trying to corral speeds created by inappropriate street designs. • Speed reductions handled through street narrowing, curb extensions, tree canopies, mini-circles and other traffic calming devices.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Burden, Dan **Title**: Rating System for Walkable, Active Living, Active Transportation **Source**: Walkable Communities, Inc. **Year**: Unpublished Manuscript.			**Neighborhood schools**: • Elementary schools located to where 80% of all children with a walk of no more than 2500 ft. • Middle school should reach 80% of all children within distance of 5000 ft. • Land use: • Variety of services within 2500 ft of 80% of all homes. Includes 2-3 small stores oriented to neighborhood needs and at least one formal civic building. **Trails**: • Neighborhood served by comprehensive network of multi-use trails, bicycle boulevards, and bike lanes that connect to most locations. **Accessibility**: • Variety of housing types in the neighborhood. 20% of housing stock should be affordable.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Burden, Dan **Title**: Walkable Community Criteria **Source**: Walkable Communities, Inc. **Year**: Unpublished Manuscript.	**Categorical variables**: • Accessibility • Attractiveness • Beneficial • Connectivity • Maintained • Planned • Promoted • Safety and security	Variables within categories devised by walkability expert Dan Burden.	**Accessible**: • New and well-maintained walkways, trails, and sidewalks are continuously available to all important destinations. • Most important features are within 1/8th mile, and a good, well-designed place to wait for a high frequency (10-20 mins) bus is within ¼ to ½ mile. • Priority established to assure critical missing gaps in sidewalk system are completed first, especially around schools, parks, medical facilities, and transit. • New walkway, trail and sidewalk construction is ADA compliant. Two ramps are provided per corner as opposed to one that leads into center of intersection. • In downtowns and business districts, frequent street crossings are provided, ideally every 300 feet. Lanes are no wider than necessary and there are no unnecessary lanes. • Street signals and markings have universal compliance. Diagonal and other span signals have been replaced with box span, but preferably mast arm, post mounted or combinations of post and mast. • High emphasis (International style) marking are found on higher speed and higher volume roads, around schools, parks, and downtowns. • All legs of important crossings are well marked and maintained. • At least 20% of each neighborhood and downtown has housing that is affordable. **Attractive**: • Community has appropriate ramps, medians, refuges, crossings of driveways, sidewalks on all streets where needed, benches, shade and other basic amenities to make walking feasible and enjoyable for everyone. • Ideally shade is continuous in most climates, or at least in clusters each 100-200 ft. • Pleasant sitting places are located every 200 ft. Trash cans at all formal sitting places. • Buildings are built to the street (zero lot line), or have short setbacks with attractive green space and landscape features. • Community is making investment in public art. • Ideally, no home is more than 1/8th mile from a public assembly place. **Connected**: • All stores are within 1/4th mile walk (5 mins) of the absolute center. • Streets, trails, and sidewalks are well linked. Community has good block form, often grid or other highly connected pattern. • Neighborhoods that were built to cul-de-sac or other fractured patterns are being repaired for walking by putting in trail connectors. New policies are adopted to prevent cul-de-sac and street hierarchy patterns.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Burden, Dan **Title**: Walkable Community Criteria **Source**: Walkable Communities, Inc. **Year**: Unpublished Manuscript.			**Maintained**: • Pedestrian walkways and bike lanes and paths are clearly marked and adequate signage present. • Brush and obstacles are cut or grubbed back a total of 40 ft., allowing clear visibility at intersections, along the trail length and does not obscure signs. • Cracks, breaks, and other problems in sidewalks are quickly repaired. **Safe and Secure**: • Traffic moves on main street and in neighborhoods at safe, pleasant, courteous speeds. Most streets designed to keep speeds low. Neighborhood speeds rarely exceed 25 mph. • Streets are tree-lined, have on-street parking, and use other methods to keep speeds under control. • Local law enforcement sponsors child safety campaigns for walking and bicycling. • Citizen or community groups promote safety through education and awareness programs.

Citation	Indicators Evaluated	Conclusions
Lead Author: Corbett, Judith **Title**: The Ahwahnee Principles Toward More Livable Communities **Source**: Center for Livable Communities, Sacramento, CA http://www.lgc/org/freepub/land_use/articles/ahwahnee_article.html **Year**: 1994	**AHWAHNEE PRINCIPLES (Some principles are better indicators of walkable communities than others)** **<u>Community Principles</u>** 1. All planning should be in the form of complete and integrated communities containing housing, shops, work places, schools, parks and civic facilities essential to the daily life of the residents. 2. Community size should be designed so that housing, jobs, daily needs and other activities are within easy walking distance of each other. 3. As many activities as possible should be located within easy walking distance of transit stops. 4. A community should contain a diversity of housing types to enable citizens from a wide range of economic levels and age groups to live within its boundaries. 5. Businesses within the community should provide a range of job types for the community's residents. 6. The location and character of the community should be consistent with a larger transit network. 7. The community should have a center focus that combines commercial, civic, cultural and recreational uses. 8. The community should contain an ample supply of specialized open space in the form of squares, greens and parks whose frequent use is encouraged through placement and design. 9. Public spaces should be designed to encourage the attention and presence of people at all hours of the day and night. 10. Each community or cluster of communities should have a well-defined edge, such as agricultural greenbelts or wildlife corridors, permanently protected from development. 11. Streets, pedestrian paths and bike paths should contribute to a system of fully-connected and interesting routes to all destinations. Their design should encourage pedestrian and bicycle use by being small and spatially defined by buildings, trees and lighting; and by discouraging high speed traffic. 12. Wherever possible, the natural terrain, drainage and vegetation of the community should be preserved with superior examples contained within parks or greenbelts. 13. The community design should help conserve resources and minimize waste. 14. Communities should provide for the efficient use of water through the use of natural drainage, drought tolerant landscaping and recycling. 15. The street orientation, the placement of buildings and the use of shading should contribute to the energy efficiency of the community. **<u>Regional Principles</u>** 16. The regional land-use planning structure should be integrated within a larger transportation network built around transit rather than freeways. 17. Regions should be bounded by and provide a continuous system of greenbelt/wildlife corridors to be determined by natural conditions. 18. Regional institutions and services (government, stadiums, museums, etc.) should be located in the urban core. 19. Materials and methods of construction should be specific to the region, exhibiting a continuity of history and culture and compatibility with the climate to encourage the development of local character and community identity. **<u>Implementation Principles</u>** 20. The general plan should be updated to incorporate the above principles. 21. Rather than allowing developer-initiated, piecemeal development, local governments should take charge of the planning process. General plans should designate where new growth, infill or redevelopment will be allowed to occur. 22. Prior to any development, a specific plan should be prepared based on these planning principles. 23. Plans should be developed through an open process and participants in the process should be provided visual models of all planning proposals.	• The Ahwahnee Principles outline a set of ideas for planning more livable communities built for people, not just automobiles, and provide a vision for an alternative to urban sprawl. • Currently neighborhoods are separated into homogeneous, single-use enclaves, retail stores surrounded by parking lots, and public gathering places and sense of community have been replaced by asphalt. • Top-down, traditional planning of yesterday is no longer acceptable means of making cities. People must be involved. This brings people together to create sense of community, services the needs of the people, and is used and respected by the residents. • These principles show the need for smaller, mixed use communities that promote walking and bicycling and foster a sense of community. • Cities where Ahwahnee Principles are being implemented: Pasadena, San Jose, San Diego, Sacramento, Walnut Creek, Santa Barbara, Plays Vista

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Florida Department of Transportation, State Safety Office, Pedestrian and Bicycle Program **Title**: Walkable Communities: Twelve Steps for an Effective Program **Source**: Author **Year**: 1995, April	Categorical variables: • Linked walkways • Intersections • Americans with Disabilities Act (ADA) • Signal placement • Illumination • Median crossings • Schools • Automobile backing • Access management • Auto-restricted zones (ARZs) and Parking restricted zones • Walking and transit • Land use	Summary of planning, zoning, engineering and development recommendations from the Florida Department of Transportation Pedestrian Facilities Planning and Design Training Course	**Continuously linked walkways**: • Sidewalks should be 5 ft or greater in width with separation from urban area roadway on both sides. Total width with trees 7 feet. • In residential areas, sidewalks along streets and walkway easements where appropriate. • At least 36 inches of walkway should be clear of obstructions and walkway environment should include landscaping. • Wide sidewalks should be constructed in high pedestrian activity generator areas, such as retail centers, civic buildings, transit stops, etc. • Successful downtowns and entertainment districts often find 50/50 ration of walking space to vehicle space. • Street design should provide many links (roughly resembling grid pattern) to local destinations. **Intersections**: • Maximum crossing widths should be 48 ft. Slip lanes, medians, and bulbouts should be used to reduce crossing exposure. • Roadway geometry should dictate turning speeds of vehicles to levels of: below 20 mph on left turns, below 10 mph on right turns. • Pedestrian signalization for a 3.5 ft per second walking speed should be provided. **American with Disabilities Act**: • Two curb ramps should be constructed on each street corner. One curb ramp should be constructed at each side of marked mid-block crossings. Or, crosswalk areas should be raised to curb height. • When pedestrian demand signals are used, independent call poles should be placed at top of each ramp on all signalized intersections. **Signal placement**: • Box span, mast arm, and corner pole signal placements should be used. Diagonal span signals should not be used because they cause motorists to look up. **Illumination**: • Commercial, entertainment, and school areas, as well as the approaches to and all street corners should be well illuminated. • All intersection lighting should illuminate crossing and waiting areas and/or create backlighting to make the pedestrian silhouette clearly visible on approach.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Florida Department of Transportation, State Safety Office, Pedestrian and Bicycle Program **Title**: Walkable Communities: Twelve Steps for an Effective Program **Source**: Author **Year**: 1995, April			**Schools**: • School sites should have specific pedestrian access points. • Roadway geometry should minimize travel speeds to 15-20 mph. • Raised crossings, traffic diverters, roundabouts, on-street parking and other traffic calming devices should be employed. **Automobile backing**: • Side lot, on-street and pocket parking should be included in zoning regulations to eliminate opportunities for backing over walkways. • To reduce conflicts b/w pedestrians and vehicles in parking areas, center walkways in landscaped areas, "U" pattern dropoffs, and long throat driveways lined with sidewalks should be considered. **Access management**: • Pedestrians should have access ways independent from vehicle access to all commerce. • Commercial developments should have shared driveways from main roads. • Side street driveways should be 230 ft from intersections. • Reduced building setback requirements should be used to encourage streetside window-shopping and storefront pedestrian street entries with side and rear lot parking. **Walking and transit**: • ½ mile radius should be used for acceptable walking distances b/w trip origins and transit stops (5-10 min walk). • Bus stops should be at the "far-side" of intersections so the bus does not become visual obstruction for motorists and disembarking passengers trying to cross street. • All transit stops should be easy to reach by walkways, provided with shade, visible, comfortable sitting/waiting space set back from walkways. **Land use**: • New and in-fill development should favor walking over driving. • Land uses should provide a mix of uses, including residential, retail, commercial, and civic. • Neighborhood schools, pocket parks, and neighborhood stores should predominate land use codes, ordinances and regulations. • Shared use parking lots should be emphasized wherever possible.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Friedman, Bruce **Title**: Effect of Nontraditional Neighborhood Design on Travel Characteristics **Source**: Transportation Research Record 1466 **Year**: 1994, 1466: 63-70	**Trip type**: • Home-based work trips • Home-based other trips (home/shop, home/change mode, home/person/social, home/education) • Work-based trips (work/shop, work/education, work/other, work/change mode) • Non-home-based other trips **Community design**: • *Standard suburban communities*: developed since early 1950s with segregated land uses, have a well-defined hierarchy of roads, concentrate site/area access at a few key points via major arterial roadways, have relatively little transit service • *Traditional communities*: mostly developed before WWII, mixed-use downtown commercial district with significant on-street curbside parking, interconnecting street grid and residential neighborhoods in close proximity to nonresidential land uses	Cross-sectional survey *Participants*: Residents of the San Francisco Bay Area *Data Source*: 1980 San Francisco Bay Area Transportation Survey, 9 county area / 34 superdistricts / 550 subzones *Sample Size*: n=450 suburban, n=222 traditional households *Excluded*: San Francisco city and other cities with particular characteristics that could not likely be recreated; exsurburban subdivisions inaccessible to large employment concentrations; respondents in lowest and highest 5%ile income and non-respond to income	**Number of daily trips per household by mode of travel for traditional communities / suburban subdivisions**: • Auto-driver: 5.3 / 7.07 • Auto-passenger: 1.41 / 1.88 • Transit: 0.62 / 0.29 • Bike: 0.35 / 0.24 • Walk: 1.06 / 0.83 • Other: 0.09 / 0.72 **Percentage of total trips by mode of travel and trip type for traditional communities / suburban subdivisions**: *Home-based work* • Auto-driver: 73 / 83 • Auto-passenger: 8 / 7 • Transit: 11 / 44 • Bike: 2 / 2 • Walk: 4 / 3 *Home-based non-work* • Auto-driver: 51 / 60 • Auto-passenger: 21 / 23 • Transit: 7 / 3 • Bike: 6 / 3 • Walk: 14 / 10 *Home-based other* • Auto-driver: 70 / 77 • Auto-passenger: 7 / 11 • Transit: 5 / 2 • Bike: 2 / 1 • Walk: 15 / 8 *All trips combined* • Auto-driver: 61 / 68 • Auto-passenger: 16 / 18 • Transit: 7 / 0.3 • Bike: 4 / 2 • Walk: 12 / 8

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Friedman, B. **Title**: Effect of Nontraditional Neighborhood Design on Travel Characteristics **Source**: Transportation Research Record 1466 **Year**: 1994, 1466: 63-70			• Percents in traditional community probably represent upper end of expectation of neo-traditional communities. • High percent of transit use is not likely to occur in a neo-traditional development's first 10-15 years of existence, unless already built. **Successes of neo-traditional community will depend on**: • Proximity and access to employment • Internal jobs-housing balance • Neo-traditional design characteristics, such as mixed land uses and quality of accommodations for alternative modes of travel (sidewalks, crosswalks) • Availability of free parking near nonresidential land uses • Quality of transit service to internal and external points

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Lund, Hollie **Title**: Testing the Claims of New Urbanism: Local Access, Pedestrian Travel, and Neighborhood Behaviors **Source**: Journal of the American Planning Association **Year**: 2003, 69(4): 414-429	**Dependent variables**: • *Pedestrian travel behavior*: frequency of strolling trips; frequency of destinations trips • *Neighboring behaviors*: frequency of unplanned interactions with one's neighbors; local social ties (# of acquaintances within close proximity of home); supportive acts of neighboring (frequency with which one gives / receives assistance to / from neighbors **Independent variables**: • *Personal variables*: socio-demographic (age group, gender, race, number and ages of children, homemaker); attitudinal (respondents' attitudes toward importance of walking to daily activities, interacting with one's neighbors, and feeling "at home" in neighborhood • *Neighborhood variables*: objective (defined by neighborhood selection criteria and include dichotomous variables for local access to retail only (no parks), local access to parks only (no retail), local access to parks and retail, location in the inner city; subjective (satisfaction with local parks, satisfaction with local shopping area, perception of walking in neighborhood • *Behavioral variables*: walking trip frequencies	**Data collection**: Mail-out / mail-back survey to all 494 households • 8 Portland metropolitan region neighborhoods defined by functional rather than political boundaries. • Included two with access to both a park and neighborhood shopping area, two with access to only a park, two with access to only a shopping area, and two with access to neither parks nor retail shops. • Within each neighborhood, all households were walking distance from the same park and / or shopping area • Variables such as route directness, quality of pedestrian environment, quality of local park / shopping area, neighborhood era age, and median property value used to pick neighborhoods. **Study sites**: • *New subdivisions*: Orenco Station, Bethany Village, Jones Farm, Arbor View • *Inner-city* (Pre-WWII): Ladd's Addition, Beaumont, Alameda-33rd Avenue, Alamada-Bryce	• Compared to neighborhoods with no local access, destination trips are significantly higher in neighborhoods with local access to retail shops, either alone or in combination with local access to parks. • Inner-city neighborhoods experienced higher amounts of destination trips (mean= 3.12) and number of local social ties (4.74) compared to subdivision neighborhoods (1.97 and 4.30, respectively) • Strolling trips freq do not vary significantly across groups. **Pedestrian travel**: • Destination trips linked most significantly to attitudinal factors and to objective environmental factors, primarily local access to retail shops. • Individual variables that correlated significantly with strolling trips were placing importance on walking to daily activities and identifying oneself as homemaker. Having "retail access only" was negatively correlated with strolling trips. **Neighboring behaviors**: • Frequency with which each respondent had unplanned encounters with neighbors is most explained by walking trip frequencies. • Interaction between inner-city neighborhoods and retail access only is significant; suggesting that local access to retail shops contributes positively to acts of neighboring in inner-city neighborhoods, but not in suburban developments. **Other findings**: • Findings support New Urbanist claim that local access contributes to increased levels of pedestrian travel. • Not strong support for relationship between local access and strolling trips. • Personal attitudes toward a particular behavior (e.g. walking to daily activities, interacting with neighbors) were more important in predicting that behavior than objective neighborhood variables.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Saelens, Brian E. **Title**: Neighborhood-Based Differences in Physical Activity: An Environment Scale Evaluation **Source**: American Journal of Public Health **Year**: 2003, 93(9): 1552-1558	**Activity Monitor** CSA activity monitor – objective measure of physical activity **Survey – scaled by respondents (1-4 for everything except residential density and land use mix)** **Environment**: • Residential density • Proximity to and ease of access to non-residential land uses (restaurants, retail) • Street connectivity • Walking/bicycling facilities • Aesthetics (tress along streets, trees cover or canopy sidewalks, interesting things to look at, litter free, attractive natural sights, attractive building/homes) • Traffic safety (heavy traffic along streets, slow speed posted, drivers exceed speed limit, crosswalks/pedestrian signal available, crosswalks feel safe, high exhaust fumes) • Crime safety (street well lit, walkers/bikers can be seen by people in their homes, see/speak with others, high crime rate, crime rate makes neighborhood unsafe during day/night) **Self-report walking assessment**: • To/from work/school • During breaks/lunch at work/school • Errands • For exercise • To/from transit stops Leisure time PA (Godin-Shephard Leisure Time Exercise Questionnaire) Demographic Information Height/weight (BMI calculated) *complete items available at: http://www.drjamessallis.sdsu.edu/NEWS.pdf	107 adults from neighborhoods in San Diego, CA selected to differ on walkability completed surveys (randomly selected from within neighborhoods) High walkable vs. low walkable community Physical activity assessed by self-report and accelerometer High-walkable neighborhoods defined as those with concentration of nonresidential land uses along main corridor of neighborhood. Mostly grid-like street pattern, with short block lengths and few cul-de-sacs, an indicator of greater street connectivity. Low-walkable neighborhoods defined as those with longer block lengths, mixture of grid-like and curvilinear street patterns, and more cul-de-sacs.	• Residents in high walkable neighborhoods perceived having higher residential density, land use mix diversity/access, street connectivity, aesthetics, and pedestrian/traffic safety than residents of low walkable neighborhoods ($p<0.003$). • Low walkable neighborhood residents reported greater numbers of walking/bicycling facilities ($p=0.003$). • No neighborhood differences in perceived crime. • Perceived environmental findings did not change substantially by inclusion of age/education. • Residents in high walkable community participated in approx. 52 more minutes of moderate intensity PA than low walkable residents ($p=0.016$). • Residents did not differ in amount of vigorous PA. • Percentage of residents walking for errands higher in high walkable community ($p=0.003$); after adjusting for age ($p=0.01$). • Neighborhood comparisons of BMI approached statistical significance; low walkable having higher BMI ($p=0.051$). • Greater percent of residents in low walkable neighborhood met criteria for overweight than high walkable neighborhood; remained significant after adjusting for age/education ($p=0.043$). • Findings strongly support test-retest reliability and validity of new self-report measure (NEWS). • Residents in high walkable neighborhood engaged in approx. 70 more minutes of moderate-vigorous PA per week, a difference = more than 3 miles more of walking; 15,000 kcal of energy expenditure (for 68 kg person) over 1 year; 1.8 kg weight loss per year.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Shriver, Katherine **Title**: Influence of Environmental Design on Pedestrian Travel Behavior in Four Austin Neighborhoods **Source**: Transportation Research Record 1578 **Year**: 1997, 1578: 64-75	**Traditional (TN) vs. modern neighborhoods (MN)** in terms of: **Transportation system**: number and type of blocks and intersections. Defined as local accessibility; involving directness and route options. • # intersections with boundary roads (TN>MN) • # 4-way intersect (TN>MN) • % blocks ≥ 90% sidewalk coverage (Varied) • Length of hike and bike trails (MN>TN) • # official bicycle routes (TN>MN) • # bus transit routes/# of stops (TN>MN) **Land use**: Potential for economic interaction. Measures defined as opportunity-accessibility. Includes number, variety, type, and location of destinations that may be comfortable reached by foot, as well as match with resident needs. • # commercial services, office sites, restaurants, gov't/community, school/day care/religious, parks and greenbelts (TN>MN) • Duration and distance to destination (MN>TN) **Urban design**: Potential of streets to encourage people to participate in street life. • Outdoor seats per residential dwelling (TN>MN) • Off-street parking spaces per dwelling (MN>TN) • Street trees per block (TN>MN) • Outdoor seats per commercial use (TN>MN) • Bike spaces per commercial use (TN>MN) • Parking spaces per commercial use (TN>MN) • News vending per commercial use (TN>MN)	32-item intercept survey of pedestrians. Survey sites selected to record activities at transition areas b/t either a park, commercial ctr, and/or a single or multifamily residential area. Same time during day, fall 1994. 4 total Austin, TX neighborhoods; 214 respondents to survey. 2 pairs of neighborhoods w/ contrasting transportation, land use, and design characteristics but similar density, housing, and population characteristics: traditional neighborhoods (TN) vs. modern neighborhoods (MN)	**Differences in walk activity patterns in TN and MN**: **Trip purpose**: • 3x more respondents walk to commute and 65% more walk on errands in TN compared to MN • 85% more respondents walked to exercise or to walk dog in MN compared to TN **Distance by walk purpose**: • Distances in TN < MN • Walks to shop 18% shorter in TN vs. MN; other errands and exercise walks third shorter; walks w/ dog ½ distance in TN **Duration by walk purpose**: • All walk durations lower in TN • Exercise walks 15 min shorter; walks w/ dog avg 24 min shorter in TN • In TN and MN, walk distances and duration for commuting, shopping, reaching transportation shorter then recreational walks for exercise, walking dog, and socializing. • Distance for shopping 60% shorter than exercise walks and commutes and 40% shorter than walks with dog in both neighborhoods.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Shriver, Katherine. **Title**: Influence of Environmental Design on Pedestrian Travel Behavior in Four Austin Neighborhoods **Source**: Transportation Research Record 1578 **Year**: 1997, 1578: 64-75	**Following use 5-pt Likert scale (5-strongly agree):** • *Importance of attributes while walking*: continuous sidewalk or trail; canopy of trees, shade, ground cover, good lighting, walk to shops/work/entertainment/transit, destinations w/in walking distance • *Importance of conditions for walking*: Enough time, feel safe, feel energetic, want to be outside • *Importance of walking as opportunity to*: maintain health, be outdoors, manage stress, observe/learn about surroundings, avoid polluting air, be around people in public place • *Constraints*: distance b/t destinations too far, not enough time, too many stops/destinations, inclement weather, insufficient lighting, too tired, too much traffic, don't want to cross major road • *Individual and household characteristics*: age, student status, household size, # household dependents, income, # household cars	Limitations: • % of people in these neighborhood who choose to walk is not available. Results based on intercept-survey data. • Data collection therefore not random.	**Attitudes and personal characteristics of pedestrians (all respondents):** **<u>Constraint rating</u>** • Long distances (3.21) and lack of time (2.75) • Too many stops or destinations (2.35), inclement weather (2.05) • Poor lighting (1.63), heavy traffic (1.34), crossing major roads (1.27) **<u>Attributes and benefits</u>** • In TN (49% walk for utilitarian purposes), 2 most important attributes are walkable distances to shops, work, and entertainment (4.26) and access to transit (4.09) • In MN (57.2% walk to exercise or socialize), walkway continuity (4.02) and trees, shade, and interesting things to look at (3.60) were most important environment attributes. Most important benefit of walking was to maintain health (4.51) **Other conclusions**: • TN characterized by more pedestrian-oriented features, and pedestrian walks tended to be short and frequent utilitarian trips with secondary trips. • MN had more automobile-oriented features and walks tended to be longer, less frequent recreational walks with less secondary trips. • All respondents feel important: feel safe, energetic, want to be outside. • Respondents in traditional community indifferent towards walking as opportunity to be around people in public place. • Neighborhood characteristics affect ease of movement and opportunities for economic/social interaction. However, personal factors mediate the influence of environmental design on pedestrian travel.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Southworth, Michael O. **Title**: The Evolving Metropolis **Source**: Journal of the American Planning Association **Year**: 1993, 59(3)	**Characteristics of communities that were compared:** • *Community level*: large patterns of streets, land use, and growth patterns over time. Area about 9 sq. miles or 6,000 acres. • *Neighborhood level*: intermediate patterns of blocks, streets, and intersections in primarily single-family neighborhoods. Area about 100 acres that would take less than 10 minutes to walk across. • *Individual street and house lot*: street cross-sections, lot configurations, and building types.	Case study of 8 study areas in counties of Alameda and Contra Costa, CA in San Francisco Bay region to formulate typologies of urban edge. Study areas picked based on urban edge growth characteristics: pattern, age, physiography, and growth process. **Study sites**: • *Richmond*: long urbanized area that grew primarily in first third of the 20th century • *San Lorenzo and Castro Valley*: primarily grew in middle of 20th century • *Fremont, Moraga, Dublin, and San Ramon*: developed primarily after 1960 • *Concord*: outlying community that has experienced growth throughout 20th century	**Community level**: • Patterns of street network identified: *speculative gridiron, interrupted parallels, incremental infill, and cul-de-sac and loop pattern* • <u>*Impact*</u>: Increasing focus on self-contained subdivision planning has eroded integrity of public street framework and severed connections between neighborhoods. • Patterns of growth identified: *concentric, 'instant,' scattered* • <u>*Impact*</u>: Trend toward large-scale instant growth and away from small-scale incremental pattern has led to development of increasingly controlled and monotonous urban fabric that offers little opportunity for adaptation to changing community needs. • Patterns of land use identified: *strip commercial/continuous residential, contained commercial/fragmented residential* • <u>*Impact*</u>: Development at urban edge has separated land uses. Finer grained separation of uses within buildings, neighborhoods, and communities can support more time-and energy-efficient lifestyle and create more diverse places to live. As residential density increases and land uses increasingly intermingled, opportunities to live and work in same space increase. **Neighborhood level**: • Street patterns that contribute to quality and character of a neighborhood: *length of streets and number of intersections, cul-de-sacs, and loops in each unit of land* • *Gridiron form*: Has more land devoted to streets, blocks, intersections, and points of access than other street designs. Maximizes infrastructure costs, but offers shortest trip lengths and largest number of route choices. Most pedestrian-friendly form. • <u>*Impact*</u>: Transition from open and interconnected street patterns to more closed and discontinuous ones have resulted in increased land development by allowing more land area for lots as opposed to street and infrastructure. Residential neighborhoods are suffering degradation of pedestrian accessibility and of perceptual coherence as a result of disconnected and closed street patterns.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Southworth, Michael O. **Title**: The Evolving Metropolis **Source**: Journal of the American Planning Association **Year**: 1993, 59(3).		**Limitations**: Sample of case studies small and confined to geographic region.	**Street, lot, and house level**: • Street widths have increased over time. Pre-WWII gridiron streets have 50-60 ft right-of-way, pavement widths of 32-36 ft, and adjacent planting strips and sidewalks on both sides. • In postwar suburbs, right-of-ways are 60 ft, pavement widths 40-50 ft, and often sidewalks on one side only. Tend to lack street trees, affecting scale and comfort of residential streets. • Before WWII, lot sizes ranged from 30-40 ft wide; after war ranged from 60-70 ft wide. • Wider lots dilute sense of street enclosure and less on-street parking, which can slow down traffic if present. • More controlled subdivision process has resulted in uniformly sized lots, weakening the spatial variety and visual interest of the street. • Persistent lack of sidewalks has undermined restoration of pedestrian-scaled neighborhood street. • As lots became bigger, houses have been set back farther from street, weakening the spatial edge of the street and dissolving sense of enclosure. • Garages have grown in size and stature. Migrated from along back alleyways to forward position next to house. • Front porch has moved from position of dominance on residential street into obsolescence. In older urban edge neighborhoods, porch contributed to form and function of human street scale. With front garages, porches reduced to symbolic form and often not directly connected by sidewalk to street.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Southworth, Michael O. **Title**: Walkable Suburbs. An Evaluation of Neo-Traditional Communities at the Urban Edge **Source**: Journal of the American Planning Association **Year**: 1997, 63(1): 28-44.	**Characteristics of communities compared**: • *Character*: architecture, trees, topography, garages, sidewalks • *Land use patterns*: housing type, architecture, lot sizes, densities • *Public open space*: parks, playing fields, water • *Street design and circulation patterns*: street patterns, # of blocks, intersections, access points, cul-de-sacs • *Pedestrian access*: sidewalks, connection to retail / services, bike paths	Qualitative case study of 2 neo-traditional neighborhoods (Kentlands and Laguna West), and a traditional turn-of-the-century streetcar suburb (Elmwood) **Study sites**: • *Kentlands, MD (K):* Begun 1989. Community of about 1600 units surrounded by conventional suburbs. Hills, trees and ponds retained. Includes several distinct neighborhoods. Mix of housing types, varied grain, and coherent pattern. Divided boulevard connecting school to recreation center. • *Laguna West, CA (LW):* Begun 1990. About 3x size of Kentlands, 2x as many residents. Includes town center. Light industrial space and Apple Computer plant nearby. Function as part of larger metro region. Formal axial layout, which converge on community center and lake. Built form more coarse, repetitive than Kentlands. • *Elmwood (E):* early 1900's. A Berkeley, CA streetcar suburb. Walkable neighborhood, many single family homes. Modified rectilinear grid of different sized blocks. Grain is fine and varied. No obvious formal design elements. Dense population (5000 residents in 225 acres).	**Character**: • K: Strong architectural references to the past, yet diverse. Mature trees and topographic features. Alleys for garage access. • LW: Sense of late 20th century suburb. Rows of single-family homes along barren curing streets. Garages on side or back. Less architectural variety. • E: Grown incrementally by various builders/architects. Diverse. Front porches, small, set back garages. Sidewalks line narrow streets. **Land use patterns**: • K: Housing types and architecture vary. Granny flats above garages. Lot sizes range from small town house lots to quarter-acre lots. Lot widths range from 44-66 ft. • LW: Housing types vary however dwelling types not mixed together. Lot widths range from 34-60 ft. • E: Houses vary in size. Lot widths 30-40 ft and 120-135 ft deep. Single-family housing predominant. • Density in du/acre: K 5-17, LW 1.28-25, E 6-10. **Public open space**: • K: Many, small, and varied (28% of site). Includes village greens, pond, and recreational park. • LW: Large and lack character (20% of site). Includes shallow lagoons,, 4 large and 3 smaller parks. • E: Little open space. Virtually no parks or playgrounds within district. Major regional and city parks lie within ½ mile.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Southworth, Michael O. Title: Walkable Suburbs. An Evaluation of Neo-Traditional Communities at the Urban Edge **Source**: Journal of the American Planning Association **Year**: 1997, 63(1): 28-44.			**Street design and circulation patterns**: • In neo-traditional and traditional study areas, local streets somewhat narrower, have more sidewalks, street trees than conventional development. • Street patterns contribute to quality and character of community. Total amount of land devoted to streets relates directly to infrastructure costs. Number of blocks, intersections, access points, and loops or cul-de-sacs per unit area affects number of route options and ease of moving about. • K: Many straight, parallel streets and right-angle intersections (similar to grid). Streets within 50 ft right-of-way. 36 ft pavement consists of two 10 foot driving lanes and two 8 ft parking lanes. 4-5 ft sidewalks and planting strip throughout. Alleys 26 ft wide with 12 ft paved lane and 7 ft grass strips on each side. • LW: Streets form axials radiating from center. Few streets are straight and cul-de-sacs plentiful. Street widths can accommodate fire trucks with some local streets narrower (30 ft). • E: Modified rectilinear grid with blocks of varying sizes. Street width 30-34 ft wide, which have parking and sidewalks with narrow planting strips on both sides. • # blocks: E 23, K 24, LW 16; # intersections: E & LW 20, K 41 **Pedestrian access**: • In these developments, destinations are too far for people to walk. Pedestrian facilities are mostly used for recreation, not functional needs. • LW: About half of homes are more than a ½ mile walk. • E: Works best for pedestrians and bike routes because it has had time to mature over time. **Transit**: • K: Shuttle bus to Metro station; • LW: Largely auto-dependent. Infrequent bus service. • E: Good transit access. Within ¼ mile of all residents.

WALKING BEHAVIOR SUMMARY TABLES

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Ball, Kylie **Title**: Perceived Environmental Aesthetics and Convenience and Company are Associated with Walking for Exercise Among Australian Adults **Source**: Preventive Medicine **Year**: 2001, 33: 434-440	**Perceived environment (5-pt Likert scale):** • *Aesthetics* based on the following items explained 36 – 64% of variance in latent factor. Categorized into high (3-5), moderate (6), and low (7-15), using tertiles: • Your neighborhood is friendly • Your local area is attractive • You find it pleasant walking near you home • *Convenience* scored based on the following items summed (explained 10 – 60% of the variance): • Shops are in walking distance • A park or beach is within distance • A cycle path is accessible • *Company* based on 1 item. Dichotomized agree/strong agree vs. disagree/strong disagree: • You have someone (or a pet) to walk with in the neighborhood	**Study design**: • Cross-sectional self-report data • 1996 Physical Activity Survey for the state of New South Wales, Australia **Study population**: • Australian adult aged 18 years or older **Sample size**: • 3,392 (64% response rate): 1,555 male, 1,837 female **Outcome**: • Walking for exercise (not transport) in the past 2 weeks. **Stratified on**: • Physical and mental health component scores (using SF-12 scores), dichotomized as good or poor (above or below the media) **Limitations:** • Inherent in cross-sectional studies: Alternative hypothesis: Adults who are active may be more likely to seek out or to find company if they are active. Also, categorization of exposure and outcome variables.	• Walking associated inversely with age, directly with education, aesthetics, convenience, and company, and female sex in unadjusted model. **Environmental influence** (OR results): • Aesthetics: High 1.00; Moderate 0.84; Low 0.59 • Convenience: High 1.00; Moderate 0.84; Low 0.64 • Company: Yes 1.00; No 0.69 Did not control for other environmental influences. Aesthetics, convenience, and company were entered individually. **Other conclusions**: • Reported walking for exercise was significantly associated with putative environmental influences. Similar between those with good and poor mental and physical health. • Longitudinal and experimental/quasi-experimental studies needed. • Significant interaction between company and sex suggests may reflect safety concerns for women and may be relevant for gender-specific interventions with emphasis on social aspects of PA aimed at women.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Cervero, Robert **Title**: Commuting in Transit Versus Automobile Neighborhoods **Source**: Journal of the American Planning Association **Year**: 1995, 61(2): 210-225	**Travel characteristics**: • Work trips by mode • Work trip generation rates by mode and occupancy	**Study design**: • Matched pair analyses of transit- and auto-oriented neighborhoods • Quasi-experimental design • Comparisons made for 2 California metropolitan areas: San Francisco Bay Area (7 matched pairs) and Los Angeles-Orange County area (6 matched pairs) • Transit neighborhood defined as built along a streetcar line or around rail station, primarily gridded (over 50% intersections four-way or "X" intersections), and laid out and built up before 1945. • Auto neighborhood defined as laid out w/o regard to transit, generally in areas w/o transit lines, primarily random street patterns (over 50% intersections 3-way, "T" intersections, or cul-de-sacs), and laid out and built up after 1945.	**San Francisco area**: • Transit neighborhoods have 35-40% more 4-way intersections and higher residential densities than auto-oriented neighborhoods. • Auto neighborhoods averaged more vehicles per household than did transit counterparts (in 4 of 7 pairs, differences less than 10%). • Pedestrian modal shares higher in all 7 pairs of transit neighborhoods than in auto neighborhoods (between 1.2 – 13.4% more walking trips). • Pedestrian trip generation rates higher in all 7 pairs of transit neighborhoods than in auto neighborhoods (between 23 to 142 work trips per 1000 housing units). • All transit neighborhoods had lower auto drive-alone modal shares and trip generation rates. • On average, Bay Area's transit-oriented neighborhoods generated around 120% more pedestrian/bicycle trips than nearby auto-oriented neighborhoods did. **Los Angeles area**: • Transit neighborhoods have 16-60% more 4-way intersections than auto neighborhoods. • All transit neighborhoods 1-30% higher denser than auto counterparts. • Auto neighborhoods averaged more vehicles per household than did transit neighborhoods. • Pedestrian modal shares higher in 5 of 6 transit neighborhoods than in auto neighborhoods (between 1.7 – 24.6% more walking trips). • Pedestrian trip generation rates higher in 5 of 6 transit neighborhood than in auto neighborhoods (between 8 – 179 work trips per 1000 housing units).

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Cervero, Robert **Title**: Mixed Land-Uses and Commuting: Evidence from the American Housing Survey **Source**: Transportation Research A **Year**: 1996, 30(5): 361-377	**Land use variables**: • Single-family detached housing w/in 300 feet of unit (yes/no): ave 6-9 du/acre • Low-rise (1-2 story) multi-family buildings (row houses, duplexes) or single-family attached units w/in 300 feet of unit (yes/no): ave 10-24 du/acre • Mid-rise (3-6 story) multi-family buildings w/in 300 feet of unit (yes/no): 25-60 du/acre • High-rise multi-family buildings w/in 300 feet of unit (yes/no): ave 60+ du/acre • Commercial or other non-residential buildings w/in 300 feet of unit (yes/no): w/in walking distance • Grocery or drug store b/w 300 feet and 1 mile of unit (yes/no): in area, but beyond walking distance **Control variables**: • Residence in central city of MSA (yes/no) • # of private automobiles available in household • Annual household income • Four-lane highway, railroad, or airport w/in 300 feet of unit (yes/no) • Public transportation adequate in neighborhood (yes/no) • Distance from home to work, one way in miles	**Study design**: • Binomial discrete choice model used to estimate mode choice • Data from 1985 American Housing Survey (AHS) • AHS complied data from 42,200 housing units across 11 MSA's with population over 1 million: Boston-Lawrence-Lowell, MA-NH; Dallas, TX; Detroit, MI; Los Angeles-Long Beach, CA; Fort Worth-Arlington, TX; Minneapolis-St. Paul, MN; Philadelphia, PA-NJ; Phoenix, AZ; San Francisco-Oakland, CA; Tampa-St. Petersburg, FL; Washington, DC-MD-VA	• In 1985, commute modal splits were: auto- 85.5%, public transit- 9.4%, walking or bicycling- 4.2%, other- 0.9%. • 66.4% of households surrounded by single-family detached units. • 21.3% of households had non-residential buildings w/in 300 feet of home. 55% had grocery or drug store b/w 300 feet and 1 mile of residence. **Private automobile commuting model**: • Having single-family detached units w/in 300 feet of unit increases probability of auto-commuting (0.3718). • Having mid-rise multi-family units w/in 300 feet of unit decreases probability of auto-commuting (-0.7420). • Having retail or other non-residential uses w/in 300 feet of one's residence lowers probability of auto-commuting (-0.1512) • Having adequate public transit services in neighborhood decreases probability of auto-commuting (-0.8994). **Walking/bicycling commute model**: • Densities significantly influence whether someone walks or bicycles to work. • Living in neighborhood with single-family homes (-0.2203) or single-family or low-rise multi-family buildings (-0.0379) lowers probability of walking or bicycling to work. • Having a mid-rise multi-family building (0.2372) or high-rise building (0.1596) increase probability of non-motorized commute. • Having commercial and other non-residential land uses w/in 300 feet of one's home increases probability (0.3697). • For someone residing a quarter mile from their job, there is a 0.57 likelihood they will walk or bicycle to work if they live in a dense, mixed-use area; if they live in a neighborhood populated only by single-family homes, odds fall to 0.28. • Presence of mixed uses has strongest influence for journeys to work of 1 mile or less. • Presence or absence of neighborhood shops is better predictor of mode choice than residential densities for walking.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Cervero, Robert. **Title**: Walking, Bicycling, and Urban Landscapes: Evidence from the San Francisco Bay Area **Source**: American Journal of Public Health **Year**: 2003, 93(9): 1478-1483	**Pedestrian-/Bicycle-friendly factors**: • Street supply • City block sizes • Housing/employment characteristics within 1-mile radii of trip origins and destinations • Density and land use composition within 1-mile and 5-mile radii of origins and destinations • Street and urban design characteristics (# of 3-way and 4-way intersections, dead ends, lineal miles of local streets) **Other factors**: • Gender • Vehicle availability • Household income below $25,000 within 1-mile radius of trip origins and destinations as proxy for "neighborhood quality" • Neighborhood crime rates • Slope of land • # of trips after dark	**Study design**: • Data from 2000 Bay Area Travel Survey (BATS) of 15,066 randomly selected households in 9-county San Francisco Bay Area • Limited to trips that were unlikely to involve carrying significant amounts of items or goods (groceries) to test walkable or bikeable trips • Selected out-of-home activities: socialize / visit with friends; meals / eating; personal services ; recreation / entertainment; volunteer / civic / religious activities; shopping away from home (15-min limit as upper bound distance) • Also selected records of less than 5 minutes (a walkable distance) • Used discrete-choice logit modeling to estimate probability of walking or bicycling.	**Pedestrian-/Bicycle-friendly factors**: • Block size / intersection attributes of trip origins accounted for 21.5% of total variance in walking/bicycling trips. • Areas with large city blocks are not pedestrian-/bicycle-friendly. Neither were neighborhoods with large shares of 3-way intersections and dead-ends (signs of non-grid street patterns). • Areas with 4-way intersections (gridiron street patterns) and 5 or more converging streets (even higher levels of connectivity) positively associated with pedestrian-/bicycle-friendly factor. **Walking-Choice Model results**: • Walking constituted 12.5% of surveyed BATS trips that were 5 miles or less for trip purposes. 82.6% by automobile. • For trips under 1 mile, 60.7% by car; 34.3% walking. • Trip purpose weighted heavily in predictive powers of walking. Social purposes (0.886), recreation/entertainment (0.809), eating/meal purposes (0.688), and shopping purpose (0.623) on a 0-1 scale scored highest (p=0.000). • Personal attributes: After controlling for socioeconomic factors, African Americans (0.788) more likely to walk than Whites (-.310) and Asian Americans (-0.286). Males (0.161) tended walk more than females. • Impedance factors: Trip distance (-1.970), slope (-4.109), rainfall (-0.729), dark (-0.158), and neighborhood quality (-0.766) all decreased likelihood of walking. • Only built environment factor significant was land use diversity at trip origin (within 1-mile radius of person's residence). Balanced, mixed-use environs with retail services significantly induced walking. Land use diversity at destination encouraged walking; however relation was statistically weak. • Pedestrian-friendly designs at neither origin nor destination had much bearing on mode choice. Intersection configurations and block sizes exerted inconsequential influences on walking. **Other conclusions**: • Suggests that density (as reflected by employment accessibility) and land use diversity exert stronger pressures than urban design on decision to walk. • Suggests that greater public health benefits might accrue from designing walkable neighborhoods that appeal to niche-market characteristics of different demographic groups versus micro-designing places in hopes of swaying travel behavior.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Craig, Cora L. **Title**: Exploring the Effect of the Environment on Physical Activity: A Study Examining Walking to Work **Source**: American Journal of Preventative Medicine **Year**: 2002, 23(2S): 36-43	• *# of destinations*: # of schools, parks, recreation facilities, stores, libraries, businesses • *Variety of destinations*: mix of facilities listed above • Inclusive of *pedestrians: features making neighborhood* accessible by all ages and genders, people/ oriented buildings, signage, amenities) • *Exclusive of pedestrians*: inaccessible to certain ages or genders, not people oriented, factories, few crossing opportunities, lack of curb cuts, signs limiting access) • *Social dynamics*: potential to see people sitting, standing, moving (seating, porches, garages in front, commercial windows, outdoor cafes) • *Walking routes*: existence of accessible walking routes (sidewalks, paths) • *Meets pedestrian's needs*: continuity of routes, multiple route choices, crossing lights, ease of navigating topography, traffic, obstacles) • *Walking system*: continuous, uninterrupted walking routes • *Transportation system*: connection to other modes of transportation, benches at transit stops, secure bicycle parking) • *Complexity of stimulus*: amt and variety of visual and auditory stimuli (architectural detail, building variety, signage, traffic volume and sound, vegetation)	**Study design**: • Merged data from two Canadian sources, a neighborhood observational study and 1996 Canadian Census **Neighborhood study**: • Convenience sample of 27 neighborhoods with known diversity of urban design, social class, and economic status from Ontario, Quebec, and Alberta • In each province, an urban center (≥900,000 residents), a nearby suburban center, and a small urban center (≤50,000) selected • Neighborhood environment rated by observer on 10-pt Likert scale b/w 1999 and 2000	**Walking to work**: • Over all study neighborhoods, most employed adults commuted to work by car (70%), with few trips by public transportation (11%), walking (9%), and bicycling (2%). • Broken down by degree of urbanization, 56% of trips were by auto in urban areas, 81% in suburban, and 77% in small urban areas. • Walking trips to work highest in urban (13%) than small urban (8%) and suburban (3%). **Rating of environmental factors**: • Walking to work significantly related to environment score, with 1-unit increase in score being associated with a 25-percentage-point increase in the percentage walking to work • Environmental factor coefficients ranged from –1.82 to 2.20; each significant contributor to variation of environmental score except for visual interest and aesthetics. • Factors with greatest influence on walking to work: lack of obstacles (2.20), safety from crime (1.98), time and effort required (1.32), meet pedestrian's needs (1.19), walking routes (0.82), and walking system (0.78) • Factors reducing walking to work: exclusive of pedestrians (-1.82), inclusive of pedestrians (-1.76), potential "overload" of stimulus (-1.68), traffic threats (-1.42), potential for crime (-1.42), variety of destinations (-0.76) • Urban environments (5%) ranked higher than small urban (4.25%) and suburban (3.90%) neighborhoods in walking trips to work.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Craig, Cora L. **Title**: Exploring the Effect of the Environment on Physical Activity: A Study Examining Walking to Work **Source**: American Journal of Preventative Medicine **Year**: 2002, 23(2S): 36-43	• *Potential "overload" of stimulus*: amt and variety of visual and auditory stimuli (architectural detail, building variety, signage, traffic volume and sound, vegetation) • *Visual interest*: type and variety of buildings, architectural interest, human scale, open vs. closed facades, property maintenance, water features, green spaces) • *Visual aesthetics*: color, texture, composition, relative proportions (sky to concrete) • *Time and effort required*: directness of routes, topography, obstacles, characteristics of intersections • *Traffic threats*: amt, speed, and separation from traffic • *Obstacles*: debris, construction, maintenance • *Safety from crime*: lighting, front porches, escape routes, # of people around, street type) • *Potential for crime*: graffiti, vandalism, disrepair, potential for lurking, street lighting, property maintenance		**Other conclusions**: • Positive association b/w environment score and walking to work, controlling for degree of urbanization supports development of integrated communities for housing, shops, workplaces, schools, and public spaces.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Frank, Lawrence D. **Title**: Impact of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, Walking **Source**: Transportation Research Record 1466 **Year**: 1994, 1466: 44-52	**Modal choice- dependent variables**: • SOV, transit, or walking (% of mode trips that originated or ended in a census tract) **Urban form- independent variables**: • Gross employment density: # of employees w/in a designated geographic areas divided by size of the designated area (census tract) • Gross population density: entire population or # of residents w/in designated geographic area divided by size of designate area • Land use mix: composition of uses w/in given geographic area. Includes single-family, multi-family, retail and services, office, entertainment, institutional, industrial uses. Measured using entropy index, which describes evenness of distribution of built square footage among 7 land use categories. Results in normalized value b/w 0 and log of the # of categories (7).	**Study design**: • Cross-sectional study using correlational research design • Data from: Puget Sound Transportation Panel (5-year longitudinal cohort study conducted b/w 1989-1994; US Census; Washington State Dept of Economic Security; Puget Sound Regional Council; King County BALD file • Statistical analysis valid cases range from 204 to 509	**Travel behavior**: • Employment density and mixed uses negatively correlated with % SOV work trips (-0.26 and –0.13, respectively). • % Transit trips to work positively correlated with employment density (0.59), pop density (0.19), and mix uses (0.15). • % Walk trips to work positively correlated with employment density (0.43), pop density (0.34), and mix uses (0.21). • % Walk trips for shopping positively correlated with employment density (0.24) and pop density (0.31). **Origin and destinations**: • Employment density increases origin % Walk work trips (0.38) and destination % Walk shopping trips (0.19). • Pop density increases origin and destination % Walk work trips (0.29) and origin and destination % Walk shopping trips (0.26). • Mix uses increases origin and destination % Walk work trips (0.15). **Other conclusions**: • Employment density significantly associated with SOV, transit use, and walking for both work and shop trips. • Pop density had greatest effect on walking trips for work and shop trips. Also associated with transit use and shop trips. • Mixed land uses only associated with walking for work trips.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Frank, Lawrence D. **Title**: Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ **Source**: American Journal of Preventative Medicine **Year**: 2005, 28(2S2): 117-125	**Net residential density**: • # of households per residential acre **Street connectivity**: • # of intersections per kilometer (within 1-km network-based street) **Land use mix**: • How evenly square footage of commercial, residential, and office floor area is distributed within household's 1-km street network buffer (Ranges from 0 to 1) **Walkability index**: • Integrates the 3 variables into formula with weights • Formula predicts variation in valid number of minutes of moderate activity per day • Avoids problem of having the 3 variables correlated and helps decrease estimation problems associated with interactive variables	**Study design**: • Study of 13-county metropolitan Atlanta region. • Random-digit telephone interview • Accelerometers deployed over 2-day period to capture objective levels of PA **Study population**: • 357 participants (response rate of 30.4%) • Urban form-based criteria developed to focus recruitment into neighborhoods in region that are more or less conducive for walking. • Areas considered more walkable had net residential density >6 du/acre and ≥30 intersections/km2 • Areas considered less walkable had net residential density < 4 du/acre and <30 intersections/km2	• Natural log of minutes of moderate physical activity (walking) per day significantly correlated with land use mix (0.145), net residential density (0.179), and intersection density (0.111). **Walkability index**: • Adding walkability index in regression model to demographic variables increases total amount of variance explained by 2.1%. • Walkability index correlated greater in its relationship with moderate PA (0.158) than each of demographic factors in model. • Increasing land use mix to a factor of 6, while holding density and connectivity constant, results in a slight increase in amount of explained variaition in minutes of moderate activity (R2 increased from 0.099 to 0.107). Additional increased in weight to mix measure had no effect. • Walkability index significant correlate for meeting ≥30-min PA recommendation. • Individuals on average 30% more likely to record these levels of PA with each increase in walkability index quartile. • 37% of respondents in highest walkability index quartile met this minimum recommendation, while only 18% did in lowest walkability quartile. • Odds of meeting recommended walking levels was 2.4 times greater for fourth quartile group than those in least walkable group. Those in third quartile twice as likely as those in first quartile.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Giles-Corti, Billie **Title**: Increasing Walking: How Important is Distance To, Attractiveness, and Size of Public Open Space? **Source**: American Journal of Preventative Medicine **Year**: 2005, 28(2S2): 169-176	**Environmental audit**: • *Activities*: type of usage (active-formal, active-informal, passive); specific activities for which space was designed (tennis, football, walking, etc) • *Environmental quality*: presence of features (birdlife, # and placement of trees, presence and placement of walking paths, presence of a water features, amt and quality of shade along paths, park contours, whether lawns were irrigated, whether dogs allowed, presence of graffiti • *Amenities*: presence of features (children's play equipment, barbecues, picnic tables, parking facilities, public toilets, public transport w/in 100 meters, seating, fencing w/in park, clubrooms / meeting rooms, trash cans, drinking fountains, kiosk, presence and height of boundary fencing, availability and amt of car parking • *Safety*: Presence of lighting, visibility of surroundings houses or roads, type of surrounding roads, presence of crossings **Survey of residents**: • *Use of POS* (in previous 2 weeks) • Sufficient PA (30 mins of moderate activity on most days of week) • *Walking as recommended* (5 or more walking sessions totaling ≥150 mins/week) • *High levels of walking* (6 or more sessions of walking/week, totaling ≥180 mins) • *Accessibility*: desire and ability of people to overcome distance or travel time to access a facility (based on gravity model)	**Study design**: • In 1995-1996, two studies conducted- an environmental audit of 516 public open spaces (POS) over 2 acres in size within a 408-km2 area of metropolitan Perth, Western Australia; and interviews with 1803 adults aged 18 to 59 years (n=1803; 52.9% response rate). • Data also from a 2002 observational study (n=772) • POS included parks with and without play equipment, recreational grounds, sports fields, commons, esplanades, and buffer strips (sports stadiums excluded).	• 28.8% of respondents had used POS for PA in previous 2 weeks. 23% had walked as recommended, 17.3% reported high level of walking. **Association b/w accessibility and use**: • Overall use of POS positively associated with accessibility. • Accounting for attractiveness and distance did not produce stronger trend with level of access. • When size taken into account, odds ratio increased for those with very good access. Compared with those with very poor access, those with very good access to large attractive POS were twice as likely to use POS. • Suggests that after distance to POS is taken into account, size is more important than attractiveness in encouraging use. **Association b/w use and achieving recommended levels of PA**: • Those who use POS were nearly three times as likely as others to achieve recommended levels of activity. • Odds of reaching 5 or more walking sessions / week (2.78). • Odds of reaching 6 or more walking sessions / week (2.82). **Association b/w access and achieving recommended levels of PA:** • Accessibility of POS was not significantly associated w/ achieving overall sufficient levels of activity or walking as recommended. • Those with very good access to attractive and large POS 50% more likely (1.50) to achieve high levels of walking (6 or more walking sessions / week). **Observational study results**: • 70% of those observed using POS were using high-scoring POS (high levels on environmental audit). • 70% of walkers observed were using high-scoring POS. • Suggest that high-scoring POS more likely to attract walkers. **Other conclusions**: • Access to proximate and large POS with attributes that make them attractive encourage higher levels of walking. • Having good access to larger POS associated w/ higher levels of walking.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Giles-Corti, Billie **Title**: Relative Influences of Individual, Social Environmental, and Physical Environmental Correlates of Walking **Source**: American Journal of Public Health **Year**: 2003, 93(9): 1583-1589	**Individual cognitive variables**: • Attitude toward process of trying to exercise (unpleasant/pleasant, difficult/easy, bad/good) • Frequency of past attempts (# of times in past 3 months) • Perceived behavioral control (how likely to stick to routine) • Behavioral skills (# of days planned to be active in past month) • Intention (likelihood of trying to exercise in next 2 weeks) **Social environmental variables**: • Dog ownership • Club membership • Frequency of participation in PA by 5 significant others • Frequency of significant other doing PA w/ respondent **Physical environmental variables**: • Functional environment (sidewalk on one or both sides of street, shop visible on street) • Appeal of environment (cul-de-sac, minor local road, major local road, hwy or major thoroughfare; tree-lined street) • Overall spatial access to attractive public open space, river, beach, golf course **Level of walking**: • At level of recommended levels (yes/no)	**Study design**: • Randomly selected household telephone survey b/w August 1995 and March 1996 **Study population**: • 1,773 respondents of health homemakers and workers aged 18 to 59 years who reside in 277 districts of metropolitan Perth, Western Australia	• In previous 2 weeks, 72.1% of respondent had walked for transport, 68.5% for recreation. Only 17.2% received recommended levels of walking. • 13.1% of respondents did recreational walking only; 7.4% for transport only; 66.5% a combination of either **Individual cognitive variables**: • Odds of achieving recommended levels of walking 48% higher among respondent with a high level of perceived behavioral control than among those with low levels. • Odds nearly twice as high for individuals who were highly intent on being physically active in next 2 weeks as for those not intent. • Odds 43% higher among those who had attempted to be active during past 3 months. **Social environmental variables**: • Those who exercised with one or more significant others were more likely to walk at recommended levels. • Odds of walking at recommended levels were 58% higher among those who owned dogs than those who did not. **Physical environmental variables**: • Relative to respondents in bottom quartile of access to public open space, odds of walking at recommended levels were 47% higher among those in top quartile. • Those who lived on street with one or both of no major traffic and street trees were 50% more likely to reach recommended levels of walking. • In comparison to those who had no sidewalk and no shop on their street, those who had access to either or both were about 25% more likely to reach recommended levels of walking. • Weak evidence that those who achieved recommended levels were more likely to live on a street that was aesthetically pleasing, with minor traffic, trees, sidewalks, or local shop. **Relative influences of the 3 variable types**: • Relative to respondents in lowest determinant score categories, odds achieving recommended levels of walking were 3.10 times higher among those in high individual determinant score category, 2.79 times higher among those in high social environmental determent score category, and 2.13 times higher among those in high physical environmental determinant score category.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Handy, Susan L. **Title**: Understanding the Link Between Urban Form and Non-Work Travel Behavior **Source**: Journal of Planning Education and Research **Year**: 1996, 15(3): 183-198	**Objective**: • Point-to-point travel distance • Commercial uses in area • Location and distribution of commercial areas relative to residential areas **Street network stats**: • Area • Road mileage • Road mi/sq mi • Blocks/sq mil • Intersections/road mi • T-intersections/road mi • % T-intersection • % 4-way intersections • Cul-de-sacs/road mil • Arterial-collector intersections/road mi **Commercial uses**: • # of supermarkets, convenience stores, liquor stores, restaurants, take-out / fast food, deli / café, florists, health clubs, banks, etc • % of area w/in ¼ mile of destination **Accessibility measures**: • Ave # of supermarkets w/in 2, 5, or 10 min • Min time to supermarket • Regional centers w/in 5, 10, or 15 min • Dept stores w/in 5, 10, or 15 min • Min time to regional centers • Time-weighted # of centers	**Study design**: • Case studies of 1 traditional and 1 modern neighborhood w/in 2 areas of San Francisco Bay Area • Survey of residents w/ respect to their shopping and other non-work travel patterns **Traditional neighborhoods**: • *Silicon Valley neighborhood*: Mountain View (MV) • *Santa Rosa neighborhood*: Junior College (JC) • Turn-of-century towns built on rectilinear grid, which have since been surrounded by newer development and have evolved over time. **Modern neighborhoods**: • *Silicon Valley neighborhood*: Sunnyvale (SV) • *Santa Rosa neighborhood*: Rincon Valley (RC) • Post-WWII residential developments, with curvilinear street pattern and numerous cul-de-sacs	**Point-to-point travel distances**: • Traditional neighborhoods had more regular, rectilinear networks; modern neighborhoods had less regular, more curvilinear networks. • Traditional neighborhoods had commercial activity found w/in residential areas, away from boundary arterials. Modern neighborhoods had commercial activity concentrated almost solely at intersections and never found in residential areas. **Commercial use**: • Traditional neighborhoods had substantially higher numbers of uses per capita than modern neighborhoods • Greatest different in the number of supermarkets **% of area w/in ¼ mile of destination of commercial use**: • Any commercial: Traditional- 61% for MV, 90% for JC; Modern- 31% SV, 20% RV • Convenience store: Traditional- 44% MV, 59% JC; Modern- 18% SV, 13% RV • No difference in supermarket coverage **Qualitative characteristics**: • *Traditional neighborhoods*: In general, had more narrow streets, shaded sidewalks, variation in housing design, and size, shallow setbacks, front porches, detached garages (which increase quality of walking environment and interaction b/w neighbors). Commercial activity concentrated along a traditional Main St. redesigned in last few decades to enhance pedestrian environment, linked to residential areas. Small shops/centers imbedded w/in residential area, strip malls less integral to neighborhood than pedestrian-oriented areas. • *Modern neighborhoods*: Wider right-of-ways, missing / less shaded sidewalks, relatively homogenous housing, and domination of driveways in streetscape (considered indifferent to pedestrians and destructive to sense of community). Commercial areas designed almost entirely for auto access. Located at intersections of major arterials, expansive parking garaged, individual commercial areas haphazardly organized and linked, hostile to pedestrians, walls and buffers separate residential / commercial areas.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Handy, Susan L. **Title**: Understanding the Link Between Urban Form and Non-Work Travel Behavior **Source**: Journal of Planning Education and Research Year: 1996, 15: 183-198	**Qualitative**: • How people perceive distances • Desirability of driving or walking • Set of possible destinations • Sidewalk widths • Garages that dominate streetscape • Width of right-of-ways • Size of trees along street • Building setbacks • Variations in buildings to street • Design of buildings • Amount and nature of human activity • Parking lots • Walls and buffers b/w residential and commercial areas **Survey**: • Travel choices • Reasons for travel choices • Destination choice • Mode choice • Trip frequency		**Survey results relevant to walking**: • % walk to usual supermarket: Traditional- 3% MV, 8% JC; Modern- 4% SV, 0% RV • Ave walking strolling frequency (trips/mo): Traditional- 10.1% MV, 12.6% JC; Modern- 11.6% SV, 10.8% RV • % strolling at least monthly: Traditional- 78% MV, 85% JC; Modern- 78% SV, 78% RV • Ave freq of walks to commercial areas (trips/mo): Traditional- 4.8% MV, 5.7% JC; Modern- 2.8% SV, 1.0% RV • % walking to commercial at least monthly: Traditional- 56% MV, 64% JC; Modern- 48% SV, 33% RV • % usually walking to downtown: Traditional- 53% MV, 26% JC; Modern- N/A SV, N/A RV • % usually walking to regional center: Traditional- 2% MV, 9% JC; Modern- 3% SV, 1% RV

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Hoehner, Christine M. **Title**: Perceived and Objective Environmental Measures and Physical Activity Among Urban Adults **Source**: Transportation Research Record 1466 **Year**: 1994, 1466: 63-70	**Physical activity behavior**: • Transportation- and recreation-based PA (minutes of walking and bicycling) **Land use**: • # of non-residential destinations w/in walking distance (≤ 5 mins) **Recreational facilities**: • # of places to exercise (parks w/ walking trails, sports fields, playgrounds) • Presence of at least one park, walking trail, indoor fitness facilities (yes/no) **Transportation environment**: • Presence of sidewalks (% of street segments w/ sidewalks) • Bike lane present • Public transit available (% of street segments w/ a bus or other transit stop) • Feel safe from traffic **Aesthetics**: • Neighborhood pleasant (% of street segments w/ some or lot of attractive features- architectural design, building variety, vegetation) • Trees along neighborhood streets (% of street segments w/ comfort features- shade trees, benches) • Neighborhood free of garbage (% of street segments w/ no or little garbage) • Neighborhood maintained	**Study design**: • Cross-sectional study of 4.5 sq mile areas in St. Louis, MO and Savannah, GA • Telephone survey of 1068 adults aged 18 to 96 years in 2002 • Environmental audits of all street segments (n=1158) performed in 2003 • St. Louis represents low-walkable city (LW) • Savannah represents high-walkable city (HW)	**Physical activity behavior**: • Respondents from lower-income study areas (71% LW; 82% HW) engaged in more transportation activity than those from higher-income areas (57.4%; 55.4% HW). • High-walkable city respondents (50.2%) more likely to meet recommendations for PA through transportation activity than low-walkable city (36.3%). • High-walkable city respondents (73.4%) more likely to meet recommendations for PA through recreational activity than low-walkable city (54.4%). **Land use**: • Transportation activity positively associated with having more destinations within walking distance of one's home. • People in highest quartile for total number of non-residential destinations (15-37 destinations) were 2 to 3 times more likely to engage in any transportation activity or meet recommendations than respondents in lowest quartile (0-4 destinations). **Recreational facilities**: • People who reported more facilities within a 5-min walk were slightly more likely to meet PA recommendations. • Results indicate that people who live within ¼ mile to a park or trail use the facility more frequently (8 and 6 times/month, respectively), on average, than people who live farther from these facilities (4.75 and 2.25 times/month, respectively). • Use of facilities associated with meeting recommendations through recreational activity. Respondents in highest quartile for use per month of park or trail were 4 and 3 times, respectively, more likely to achieve recommendations than those in the lowest-quartile.

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead** Author: Hoehner, Christine M. **Title**: Perceived and Objective Environmental Measures and Physical Activity Among Urban Adults **Source**: Transportation Research Record 1466 **Year**: 1994, 1466: 63-70	**Social environment**: • Feel safe from crime (count of crime watch signs) • Neighbors physically active (count of people engaging in active behaviors)		**Transportation environment**: • Perceived presence of sidewalks along neighborhood streets indicated slightly positive (1.3), but non-significant association with engaging in any transportation activity. Likely a function of high prevalence of sidewalks in study areas. • Levelness of sidewalks showed significant negative association with engaging in any transportation and with meeting recommendations through transportation activity. Suggest that respondents with fewer cracks on sidewalks in their neighborhood were less likely to report walking for transportation. • No association b/w sidewalk measures and recreational activity observed. • Having public transit stops associated with engaging in transportation activity. Highest quartile (25-53% segments with bus stops) 50% more likely to have transportation activity than lowest quartile (0-13% segments). • Traffic safety not clearly associated with PA. **Aesthetics**: • Compared to respondents in lowest quartile for no attractive features (0-7% segments w/in ¼ mile), those in second and third quartiles about 50-70% more likely to engage in recommended recreational activity. • Minimal garbage, maintenance, and physical disorder showed strong, inverse relationships with transportation activity. • Respondents in highest quartile of street trees (26-60% segments with trees) about 60% more likely to perform any transportation than those in lowest quartile (0-2%). Only 30% more likely to meet recommended levels of PA through recreational activity. **Social environment**: • Neither measure correlated with recreational activity. • Respondents with greater than 92 active people observed within ¼ mile of home (highest quartile) were about 2 or 3 times more likely to engage in any or recommended levels of activity through transportation compared to those in the lowest quartile (<47 active people).

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Humpel, Nancy **Title**: Changes in Neighborhood Walking Are Related to Changes in Perceptions of Environmental Attributes **Source**: Annals of Behavioral Medicine **Year**: 2004, 27(1): 60-67	• *Neighborhood walking*: frequency and time spent (minutes) per week. • *Perceived environment attributes* (Graded on a 10-point scale, 10 = very favorable): aesthetics, convenience of walking opportunities in neighborhood, access to destinations (by walking distance), traffic levels • *Relative change in perceptions of environment*: relative change variable (proportional change scores) for the four categories of perceived environment. • *Location by postal code*: Identifying whether respondents lived along the Austrian coastline. • *Dose of intervention*: receipt and use of an intervention.	**Study design**: Carried out within context of a physical activity intervention trial designed to test efficacy of a website-delivered self-help physical activity program in a workplace setting. Sample selected from the academic and general staff of a medium-sized Australian university. Baseline data collected for 800 individuals by telephone interview. Of those, 512 participants had a follow-up 10 weeks later.	• Women's perception of aesthetics and access to services significantly higher than those of men. • Participants with high (more positive) self-reported perceptions at baseline for aesthetics, convenience, and access did not significantly alter their walking behavior. Participants with high scores at baseline for traffic did report an increase in walking. • Men who increased their perception of aesthetics were 2.25 times more likely to have increased walking and twice as likely to increase walking more than 30 min compared with men who did not favorably change their perceptions of aesthetics. • Men who reported improved perception of convenience had almost twice the likelihood of increasing their walking. • Men who perceived traffic as being less a problem were found to be less likely to have increased their walking. • Women whose perceptions about convenience become more positive were twice as likely to report an increase in walking. • Increases in perception that traffic was not a problem was associated with women being 1.76 times more likely to have an increase in walking of 30 min or more. • Results indicated excellent test-retest reliability for perceived environmental attribute categories.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Jacobsen, Peter L. **Title**: Safety in Numbers: More walkers and Bicyclists, Safer Walking and Bicycling **Source**: Injury Prevention **Year**: 2003, 9: 205-209	• Injuries per capita • Fatalities per capita • Exposure measure: journey to work trips on foot, journey to work trips on bicycle, distance walked per capita per day, # of trips on foot per capita per day	**Study design**: • Five data sets (three population level and two time series) to compare amount of walking or bicycling and the injuries incurring in collisions with motor vehicles • Population level data: 68 California cities from year 2000; 47 Danish towns for years 1993-1996; 14 European counties for year 1998. • Time series data: Bicycling in United Kingdom, 1950-1999; Bicycling in Netherlands, 1980-1998 • For each data set, measure of injuries to people walking or bicycling compared to measure of walking and bicycling to determine relationship	• Exponential change in number of injuries in population in response to changes in walking and bicycling. **Calculated walking results**: • Portion journey to work trips on foot: 0.41 • Kilometers walked / capita / day: 0.36 • Trips on foot / capita / day: 0.58 **Walking in California cities**: • Per capita injury rates to pedestrians varied four-fold among the 68 cities. • Portion of journey to work trips made by foot varied more than 15-fold. • Likelihood of an injury decreased as walking increases. **Walking in Danish cities**: • Per capita injury rates to pedestrians varied two-fold among the 47 towns. • Number of trips made by foot varied more than four-fold. • Pedestrians are safer in towns with greater walking. **Walking in European countries**: • Number of trips on foot varied three-fold. • Per capita fatality rates by daily foot trip indicates nearly five-fold range of risk of death. • Risk decreases with increases of trips on foot. **Other conclusions**: • Total number of pedestrians struck by motorist varies with the 0.4 power of the amount of walking. Consistent across geographic areas from specific intersections to cities and countries. • For example, community doubling its walking can expect a 32% increase in injuries (20.4 = 1.32). Taking into account amount of walking, the probability that a motorist will strike an individual person walking declines with roughly –0.6 power of the number of persons walking. An individual's risk while walking in a community with twice as much walking will reduce to 66% (20.4 /2 = 2=0.6 = 0.66). • Adaptation in motorist behavior when they expect or experience people walking appears to be most plausible reason for why injuries decrease as the number of walkers increase. • Efforts to enhance pedestrian safety need to be examined for their ability to modify motorist behavior.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: King, Wendy C. **Title**: The Relationship Between Convenience of Destinations and Walking Levels in Older Women **Source**: American Journal of Health Promotion **Year**: 1994, 18(1): 74-82	**Physical activity variables**: • Walking and total leisure-time PA levels (frequency, duration of walking and other leisure-time activities) • Walking for exercise, transportation, or pleasure (# of months per year, # of times per week, average time per session spent participating each activity) • Estimates of kilocalories expended per week • Pedometer readings **Neighborhood environment variables**: • Convenience of walking to different types of destinations in neighborhood (time spent walking from home to 13 destinations: biking/walking trail, bus stop, coffee shop, church, community center, convenience or grocery store, department or hardware store, doctor's office, library, park, post office, restaurant, work) • Frequency with which respondents made waling trips to each destination • Ranking of overall quality of neighborhood surroundings for walking (poor, fair, good, excellent) as global neighborhood walkability rating	**Study design**: • Cross sectional analysis using data from 1999-2000 follow-up assessment of randomized controlled trial of walking intervention that took place in Pittsburgh, Pennsylvania from 1982 to 1985 • Follow-up consisted of evaluation at clinic, with measures of health status, functional status, and physical activity levels (both by questionnaire and PA monitor), and telephone survey **Study population**: • Original cohort of 1982-1985 walking intervention was 229 Caucasian postmenopausal women from Pittsburgh area (aged 50-65) • 188 (82% of original cohort) participated in 1999 follow-up • 149 (79% of 1999 cohort) who completed PY questionnaire, PA monitor, and environmental questionnaire included in present analysis • Destinations w/in 20 mins walk considered w/in walking distance	• Average age of participant was 74.2 years. **Physical activity**: • Median of 5285 steps/day from pedometer • 77.9% reported walking in last year. Average of 55.5% total kcals expended in PA attributed to walking. **Neighborhood environment**: • The number of women living within walking distance of each destination ranged from 20% (department/hardware store) to 78% (bus stop). • Other destinations within close proximity: grocery store (59.7%), coffee shop (55%), restaurant (52.4%), and park (46.3%) • Most popular destinations for respondents to walk to (of those that were w/in walking distance): grocery store (25.5%), park (20.1%), restaurant (17.5%), and church (14.1%). Any above destination: 59.1%. Suggests a mix of land uses increased walking trips. • Women living within walking distance of a park, biking or walking trail, or department store had significantly higher pedometer readings than women who did not. **Convenience score and PA**: • Significant trend b/w grouped convenience score (0, 1, 2+ destinations) and activity levels. Median walking and total PA levels measured by pedometer and questionnaire more than doubled as participants reported being able to walk from 0 to 2 or more destinations from home. **Neighborhood rating, PA, and convenience score**: • As neighborhood walkability rating improved, pedometer readings were higher, and walking and total PA levels measured by questionnaire were higher. • Neighborhood walkability ratings increased as number of destinations within walking distance of home increased.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Moudon, A.V. **Title**: Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments **Source**: Transportation Research Record 1578 **Year**: 1997, 1578: 48-55	**Pedestrian network connectivity**: • Measure of how well pedestrian network connects land use parcels or locations within an area. • # of blocks; size of blocks; size of street right of way; landscaping by sidewalks; traffic volume **Route directness**: • Measure of typical directness of pedestrian paths b/w origins and destinations • Ratio of actual route directness traveled to a straight line distance (reflects size of blocks, compactness of area); Walking distance contour (plots area from which pedestrian can reach center with a ½ mile walk or less); Effective residential density (# units w/in ½ mile straight line distance from each center to actual # units w/in ½ mile walking distance contour	**Study design**: • Quasi-experimental in which sites matched to control **Study population**: • 12 neighborhood centers or sites in Puget Sound area. Matched on pop. density, income, land use type and mix, and ½ mile radius area within which all of above var's are spatially contained. • All contain neighborhood and regional commercial centers surrounded by med-density residential development. • Sites differ in connectivity and safety of pedestrian facilities. • 4 matched groups. **High potential for supporting pedestrian travel (walkability):** • Density range (>7 du/acre or gross density of ≥ 10 people / acre) • Land use mix and intensity • Walkable distance b/w residential and commercial land uses (<½ mile or 10-15 min walk)	• Matched sites have similar population densities, median incomes, levels of car ownership, and intensities and mixes of commercial development. **Pedestrian volumes per site (per hour per 1000 residents):** • Queen Anne (U): 52 • Ballard (U): 50 • Madison Park (U): 42 • Wallingford (U): 36 • Proctor (U): 24 • West Seattle (U): 22 • Crossroads (S): 16 • Mariner (2): 16 • Oakbrook (S): 14 • Kent (S): 12 • Kingsgate (S): 9 • Juanita (S): 8 **Summary site design measures and pedestrian volumes**: • Block size (ha): U=1.1; S=12.8; ratio= 1:12.2 • Street system length: U=48; S=15.9; ratio= 1:0.33 • Sidewalk system length: U=60.5; S=12.6; ratio= 1:0.21 • Sidewalk system completeness: U=1:0.97; S=1:0.55; ratio= 1:0.57 • Population density (people/ha): U=34.3; S=31.5; ratio= 1:0.92 • Pedestrians/hr/1000 residents: U=38; S=12; ratio= 1:0.33 • Pedestrians/hr: U=217; S= 68; ratio: 1:0.30

Citation	Indicators Evaluated	Methods	Conclusions
Continued: **Lead Author**: Moudon, A.V. **Title**: Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments **Source**: Transportation Research Record 1578 **Year**: 1997, 1578: 48-55	**Completeness of pedestrian facilities**: • Refers to extent and distribution of pathways that are protected from vehicular traffic and primarily dedicated to pedestrians AND physical facilities that constitute these pathways. • Formal continuous sidewalks increase completeness where informal network links decrease. • Spatial distance measures; time-distance measures; safety mix (narrow sidewalk along res. st. vs. narrow sidewalk along arterial); route-quality mix (smooth vs cracked); # of sidewalks • Completeness mix (total length of sidewalk system / total length of block or street frontage; System fragmentation (# and length of sidewalk segment per block front	**Two categories, based on connectivity, route directness, and completeness of ped facilities**: • Urban sites (U): highly supportive of ped travel (mean block size= 2.7 acres, complete and continuous public sidewalk systems on both sides of all streets, buildings toward and next to streets) • Suburban sites (S): less supportive of ped travel (mean block size= 32 acres, incomplete and discontinuous sidewalk systems that on averaged lined < ½ of the streets in the sites, buildings set back from streets and toward parking lots)	**Other conclusions**: • Given sample size, preliminary analyses showed that no single variable explained pedestrian volumes. • Results suggest that density, land use mix, and income as accepted land us measures affecting pedestrian travel are not sufficient to predict pedestrian volumes. • Suggests that given appropriate land use conditions, pedestrian facilities improvement programs in suburban areas can have significant impact on mode choice and pedestrian travel.

Citation	Indicators Evaluated	Methods	Conclusions
Lead Author: Powell, K.E. **Title**: Places to Walk: Convenience and Regular Physical Activity **Source**: American Journal of Public Health **Year**: 2003, 93(9): 1519-1521	**Safety variables**: • Presence of a place where one could walk safely for exercise or recreation. **Convenience variables (based on time and mode of travel):** • Less than 10 minutes walking • Less than 10 minutes not walking • 10 minutes or greater regardless of mode **Walking places**: • No place to walk • Some place to walk • Not home based: Public park, school track, gym or fitness center, walking or jogging trail, shopping mall, other place • Home based: Neighborhood streets or roads, neighborhood sidewalk, treadmill at home	**Study design**: • Random-digit-dialed telephone survey of health-related behaviors • From 2001 Georgia BRFSS **Study population**: • 4,532 respondents • Georgia adults aged 18 years and older • Questions concerned with individual's convenience and safety to physical activity opportunities, not whether or not they actually use them.	• 91.8% of Georgians have place where they feel safe walking for exercise or recreation • Most commonly reported place was neighborhood streets or sidewalks (32%) • Public parks (26.8%), school track (10.2%), gym or fitness center (7.8%), walking or jogging trail (6.6%), treadmill at home (4.1%), shopping mall (2.9%) • 47.1% of persons could walk within their neighborhood to a physical activity location in less than 10 minutes. • Fewer than 15% of people whose place was a public park, school track, gym or fitness center, shopping mall could walk to their place in less than 10 minutes. • 41.5% of persons reporting a place to walk significantly more likely to meet current PA recommendations than those reporting no place to walk (27.4%). • Direct relation b/w convenience of walking place and proportion of respondents meeting current PA recommendations. **Other conclusions**: • Data suggests that proximity is important factor in identification of safe and convenient place to walk.