Journal of Planning Literature
27(1) 43-60

DOI: 10.1177/0885412211415283
http://jpl.sagepub.com
SAGE

The Role of the Built Environment in Healthy Aging: Community Design, Physical Activity, and Health among Older Adults

Jacqueline Kerr[1], Dori Rosenberg[2], and Lawrence Frank[1]

Abstract

Older adults are a large but very inactive population group. Physical activity, especially walking, has many important health benefits for older adults. This review describes the relationship between walking and health and reviews studies investigating the relationship between the built environment, walking, and health in older adults. Important features of community design for older adults are identified and suggestion for impacting walking behavior is made.

Keywords

urban form, quality of life, health, environment–behavior, neighborhood planning

Introduction

The number of Americans over the age of sixty-five is expected to increase from thirty-six million in 2003 to eighty-seven million by 2050 (Federal Interagency Forum on Aging-Related Statistics 2004). Health care costs increase with age and older adults who are inactive experience significantly greater health problems (CDC and the Merck Company Foundation 2007; Pratt, Macera, and Wang 2000). While evidence is mounting on the health relationships with place of residence (Kawachi and Berkman 2003; TRB Report 282 2005); little has been done to build environments that support the health and independence of older adults.

A key question facing planners, civil engineers, and other groups is how to design and develop new and redevelop existing communities to address the health, safety, and mobility of older adults. However, the contemporary community design practices that emerged during the first half of the twentieth century were based on facilitating automobile travel. Communities were developed with lower residential densities and disconnected street networks to prevent cars from traveling through neighborhoods and providing a hierarchical network of roads demarcated with wide high-speed arterial roads bordering residential enclaves. Residential areas were separated from other land uses such as employment, retail, and entertainment making walking difficult for many. Nearly a century later, it is clear that these land development practices originally conceived to promote public health, safety, and welfare have resulted in declining levels of active transportation (Frank, Engelke, and Schmid 2003).

One of the every five Americans will be sixty-five years or older by 2030 and currently 42 percent of those over sixty-five report having a health condition or disability (Lynott et al. 2009). This article examines the existing literature to better understand how community design affects the health and mobility of older adults as relatively little attention has been given to this subject to date. The first section of this review examines the health benefits of physical activity, particularly walking, for older adults. This is followed by an examination of the relationship between community design and physical activity and travel behavior among older adults. We conclude by discussing health implications of community design and evidence-based strategies to improve physical activity and health in older adults.

Health Benefits of Physical Activity and Walking for Older Adults

Benefits of Physical Activity for Older Adults

As we age our physical capacity declines. Each decade after age thirty, maximum oxygen uptake declines by about 8 percent to 16 percent, muscle strength declines by about 10 percent to 15 percent, and the risk from falls increases (Paterson, Jones, and Rice 2007). Physical activity has a plethora of health benefits for older adults in the domains of

[1] University of California, San Diego, CA, USA
[2] Group Health Research Institute, Seattle, WA, USA

Corresponding Author:
Jacqueline Kerr, University of California, 9500 Gilman Drive, 0811, San Diego, CA 92093, USA
Email: jkerr@ucsd.edu

physical, cognitive, and emotional health. Longitudinal epidemiological studies have shown that physical activity is related to reduced morbidity and mortality (Talbot et al. 2003; Paterson, Jones, and Rice 2007; Hollman et al. 2007). Physical activity is essential in the prevention and treatment of a range of health conditions including obesity, type 2 diabetes, cardiovascular disease (CVD), osteoporosis, some forms of chronic pain, chronic obstructive pulmonary disease, high cholesterol, high blood pressure, and some cancers (Nelson et al. 2007; US Department of Health and Human Services 1996, 2008). Physical activity is associated with decreased risk of falls and can help older adults recover from functional limitations, serving to assist older adults in living independently (Agency for Healthcare Research and Quality 2002; Lee and Park 2006). More active individuals are less depressed and anxious and have higher ratings of quality of life (Nelson et al. 2007). A recent review (Sjosten and Kivela 2006) found that exercise may reduce clinical depression and depressive symptoms in the short-term among the aged. A review of quality of life and independent living in older adults (Spirduso and Cronin 2001) found that active older adults report higher levels of well-being and physical function. There is also growing evidence that physical activity can improve cognitive function among healthy older adults (Angevaren et al. 2008) as well as those with mild cognitive impairment (Baker et al. 2010; Angevaran et al. 2008). In addition, physical activity may reduce Alzheimer's risk (Larson 2008).

In the 1980s exercise recommendations tended to emphasize vigorous intensity activities. By the mid-1990s, epidemiological studies had indicated a dose–response relationship between physical activity and health benefits, such that the more activity, the better, but also that moderate intensity exercise such as brisk walking was beneficial (Pate et al. 1995). These findings had important implications for older adults because they suggested that even inactive frail older adults could benefit from starting an exercise regime. Numerous studies have now reported on the health benefits of walking, which is the preferred form of exercise in older adults and can be designed into everyday living at a population level by appropriate neighborhood planning. The current, 2008 physical activity guidelines, underscore that doing any amount of activity is better than none and bouts of ten minutes of exercise count toward the recommendations (U.S. Department of Health and Human Services 2008). The recommendations for older adults are 150 minutes of moderate intensity physical activity or 75 minutes of vigorous physical activity per week in addition to strength and training. Older adults with chronic conditions who cannot meet this recommendation should do as much as they are able to.

Notably, sedentary behavior is also associated with several health concerns, independent of physical activity levels, including weight gain, metabolic syndrome, diabetes, and heart disease (Hamilton et al. 2007; Matthews et al. 2008; Owen et al. 2010). Older adults spend approximately eight to nine hours of their day engaging in sedentary behaviors such as watching television and sitting and are the most sedentary age group (Matthews et al. 2008). Reducing time spent sitting may also have important health consequences for older adults.

Benefits of Walking for Older Adults

Longitudinal epidemiological studies, cross-sectional studies and intervention trials have demonstrated the benefits of walking in older adults. The findings are similar as those for overall physical activity. Cross sectionally, more walking has been associated with lower body fat, more favorable cholesterol and glucose levels (Thompson et al. 2006), higher aerobic capacity (Wong et al. 2003), and less likelihood of metabolic syndrome (Strath et al. 2007).

Prospective studies have shown that older adults who walked at least one mile per day were 50 percent less likely to die from all causes (Smith et al. 2007) and less likely to die from some types of CVDs (Smith et al. 2007; Noda et al. 2006). Other prospective studies have shown decreases in the risk of coronary heart disease in men (Hakim et al. 1999) and women (Manson et al. 1999). Additionally, one study showed that older women who walked at least eight blocks per week had fewer depressive symptoms and CVD, improved gait speed and lung function, and less decline in walking speed and functional performance than women who walked less (Simonsick et al. 2005). Walking has been related to improvements in health or prevention of disease for older adults with a variety of health conditions including osteoarthritis (Ettinger et al. 1997; Kovar et al. 1992; Mangani et al. 2006; Talbot et al. 2003), diabetes (Smith et al. 2007), colon cancer (Takahashi et al. 2007), hypertension (Iwane et al. 2000; Hayashi et al. 1999; Tanaka, Reiling, and Seals 1998), and dementia (Abbott et al. 2004; Andel et al. 2008; Ravaglia et al. 2008).

Several intervention studies have shown that increases in walking can lead to increases in maximal oxygen capacity in older adults (Shin 1999; Pollock, Carroll, and Graves 1991). This is important as cardiovascular fitness declines with age and inactivity but is related to important health outcomes (Blair, Cheng, and Holder 2001, Dionne et al. 2003). Pollock, Carroll, and Graves (1991) studied seventy- to seventy-nine-year-old joggers and walkers observed that older adults who jogged, rather than walked, experienced high rates of injury, with 57 percent of joggers reporting an injury to their lower extremities during the exercise regimen, while only 5 percent of walkers did so.

Taylor et al. (2003) examined the health benefits attributable to a walking program introduced in an assisted living facility located in Atlanta, Georgia. The objective of the research was to determine if a nine-week resident-led "walking club" could enhance balance (Tinetti Assessment), agility (Functional Reach Test), and independence in daily activities (Barthel Index) among older adults. While the individual amounts of walking varied from 75 feet to 1 mile, the study found that the nine-week program significantly increased all of the measures. Posttest interviews found that participants enjoyed walking more than they had initially expected and that they felt more capable of independent living as a result of the program.

Tanaka, Reiling, and Seals (1998) examined the effects of a walking program on hypertensive adults, finding that after six months of participating in a walking program, participants reported a reduction in blood pressure, an increase in maximal oxygen consumption, and increases in calf and forearm blood flow. Kovar et al. (1992) examined the effects of a supervised walking program on patients suffering from osteoarthritis of the knee. Following an eight-week intervention that consisted of twenty-four 90-minute walking sessions, the experimental group reported significant reductions in arthritis-related pain, as well as in arthritis-medication use. Similarly, Ettinger et al. (1997) examined the effects of a home-based walking program on knee osteoarthritis among 439 adults aged sixty and older. Program participants reported lower arthritis-associated pain and disability following the intervention. Fitzpatrick et al. (2008) utilized pedometers, chair exercises, and self-monitoring to improve step counts, physical activity, and physical function among older adults at senior centers.

Other intervention studies have shown positive effects on amount of walking and additional health benefits for stroke risk, functional capacity, disability, hospitalization days, and physical function (Purser et al. 2005; Tully et al. 2005). A meta-analysis of walking interventions suggested that walking increased aerobic capacity, decreased body weight and body mass index (BMI) and body fat, and improved diastolic blood pressure among sedentary adults (Murphy et al. 2007).

Most exercise interventions exploring the health benefits of physical activity take place in laboratory settings. There have been some neighborhood-based walking studies, however, that demonstrate health benefits. Participants in the Shin study (1999) walked along an outdoor footpath for thirty to forty minutes and improved their maximal oxygen capacity. Another study assessed a six-month neighborhood group walking intervention in older adults and found improvements in neighborhood walking, physical functioning, and quality of life (Fisher and Li 2004). A neighborhood-based physical activity intervention consisting of six months of graduated walking activity resulted in significant increases in walking (Jancey et al. 2008). Intervention group participants increased their activity level by 2.25 hour per week compared to the control group where activity levels were stable (Jancey et al. 2008). Another study (Rosenberg et al. 2009) sought to improve walking among older adults in a retirement community by improving perceptions of living in an environment that supports walking. Maps highlighting walking routes on and off-site were utilized in conjunction with pedometers and individual health counseling. Step counts increased significantly at posttest (Rosenberg et al. 2009).

Collectively, the research indicates that regular walking may produce not only weight-related and cardiorespiratory health benefits, but that walking may also improve strength and flexibility, as well as relieve suffering from arthritis. Given that the loss of strength and flexibility often results in the need for assisted living, such findings further suggest that regular walking may also help prolong older adults' capacity for independent living.

Impact of Community Design on Older Adults

In the next section, we review the literature on physical activity, health, and the built and social environment. Two reviews on this topic were conducted over five years ago (Cunningham and Michael 2004; Glass and Balfour 2003). In 2004, Cunningham and Michael (2004) concluded that there were few senior-specific studies on built environment and physical activity. Common themes studied included safety, design elements, aesthetics, and convenience of facilities. Since these early reviews, the literature has grown significantly. Recent reviews include Clarke and Nieuwenhuijsen 2009, Saelens and Papadopoulos 2008, Yeom, Fleury, and Keller 2008, and Yen, Michael, and Perdue, 2009. These reviews, however, focused on a public health research audience and did not extend the conclusions to practical planning recommendations or place it within the context of the health benefits of activity for older adults to highlight the importance of these findings to nonhealth professionals.

We conducted a comprehensive literature review using the terms employed by the Active Living Research Literature Database (http://www.activelivingresearch.org/resourcesearch/literaturedatabase). Studies included older adults, but not populations with specific health conditions. The review included studies published up to the end of 2010. Figure 1 outlines the concepts of the built and social environment included in this review and the expected relationships with three different types of physical activity. The solid lines indicate a strong relationship with the physical activity types, the dotted lines indicate a weaker or less consistent relationship. For example, transportation walking may occur out of necessity or cost and convenience, but easy access to destinations is key. Aesthetics and safety may play a secondary role and recreation facilities may be unrelated to transportation walking. On the other hand, for recreation walking, safety, aesthetics, and parks are important and destinations may be less related. For total activity, recreation facilities are likely the most important environmental feature. Additionally, there are relationships between the built and social environment features, for example, aesthetics may be greater in high-income neighborhoods. There is currently no clear relationship between neighborhood socioeconomic status (SES) and physical activity but studies have shown that it may relate directly to health indicators such as BMI and health outcomes such as quality of life, chronic conditions, and mortality.

Physical Activity and Walking

While the benefits of physical activity are convincing, older Americans are one of the least active segments of the population. Fewer than 10 percent of those over age eighty-five participate in light-to-moderate activity at least five times a week for thirty minutes or more (Schoenborn, Vickerie, and Powell-Griner 2006). In particular, retirement often introduces a reduction in physical activity from work-related transportation walking that is not compensated for by an increase in sports

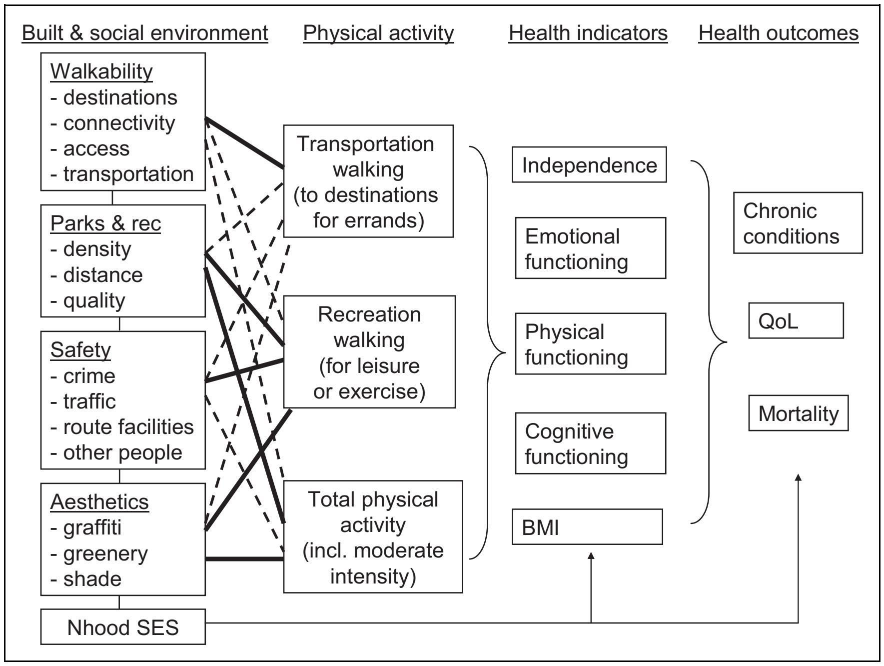

Figure 1. Theoretical model of environments and health outcomes.

participation or leisure time physical activity (Slingerland et al. 2007). A large national study using an objective measure of activity found less than 3 percent of older adults were meeting health guidelines (Troiano et al. 2008).

Walking in one's neighborhood is the most common type of physical activity in which individuals engage (Brownson et al. 2001; Giles-Corti and Donovan 2002). Older adults are often retired and spend more time in their home and community. Designing communities in ways that supports the ability to walk or bike to destinations and provides access to recreational amenities can play a strong role in influencing physical activity for older adults. Several studies have found that neighborhood features such as the availability of sidewalks, pleasant scenery and topography, and the presence of neighborhood footpaths are all strongly correlated with increased rates of walking and physical activity, as is the presence of nonresidential destination attractions within walking distance of one's place of residence (Saelens and Handy 2008; Booth et al. 2000; Brownson et al. 2001; Hoehner et al. 2005; Humpel et al. 2001; Frank et al. 2006; Lund 2003; Moudon et al. 2006).

Most research on physical activity and the built environment has focused on working-age adults; older adults have been the least studied age group (Sallis and Kerr 2006). Yet, due to the decline in functioning associated with aging, the environment may take on a more important role. A series of studies on mobility in older adults demonstrated that avoidance of certain environmental conditions (such as carrying loads, stairs, uneven surfaces, and stepping over obstacles) was related to disability (Shumway-Cook et al. 2005). The importance of activity for seniors outside the home is demonstrated by two studies which found that those who went out more often and walked were less functionally impaired and had fewer depressive symptoms (Kono et al. 2004; Simonsick et al. 2005). As older adults move into serviced residences, sources of activity other than housework and gardening, such as walking, become increasingly important (Chad 2005).

Several focus group studies with the purpose of obtaining senior reports of the hazards they contend with in their environment have been published. Such studies have found that traffic, poor pedestrian access to shopping stores, and falls hazards are particularly important in the decision to walk in the local area (Aronson and Oman 2004; Lockett, Willis, and Edwards 2005; Michael et al. 2006; Kealey et al. 2005). Interviewees in one study indicated that their choice of walking routes was influenced by length of route, sidewalk quality, people along the route, traffic, signaled cross walks, safety from crime, and scenery (Kealey et al. 2005). Michael et al. (2006) conducted focus groups with older adults over age fifty-five in order to develop a tool to assess features of street segments that could relate to older adults' walking (the Senior Environment Walkability Tool). Having access to nearby services in safe areas was important for older adults so they could walk and take care of daily activities (Michael et al. 2006). To get to such destinations, having close by traffic lights with sufficient crossing time were important. Gardens, interesting things to see, and attractive areas also added to walking enjoyment. Older adults also like having places to stop and rest while walking (Michael et al. 2006).

Most of the evidence for associations between the built environment and physical activity or walking have been in cross-sectional empirical studies. The findings from these studies have some similarities to the adult literature and some differences (Sallis and Kerr 2006; Yen, Michael, and Perdue 2009). The studies reviewed below have been grouped by

Table 1. Studies Relating Total Walking Behavior to Built Environment Variables

First author (Year)	Sample Characteristics	Type of Total Walking Measure	Self-Rreport Environment Variables	Objective Environment Variables (scale)	Results
Kemperman and Timmermans (2009)	*N* = 8,143; 65+ years; M/F	Travel diary	NA	Urbanization; land use (1,000 m buffer)	Urbanization +; recreation land use +
Lee et al. (2009)	*N* = 4,977; mean 70 years; M	Survey	NA	Sprawl index (county level)	Sprawl −
Michael et al. (2010)	*N* = 422; mean 74 years; M	Survey	NA	Park (400 m), trail (800 m), recreation facility proximity	NS overall; in high SES park +; trail +
King et al. (2005)	*N* = 158; mean 57 years; F	Pedometer steps	NA	Facility proximity (1,500 m buffer); home build date; census tract SES	*SES −; build date −;* golf course +; post office +; other facilities NS
Satariano et al. (2010)	*N* = 884; 65+ years; M/F	Survey	NEWS	Mixed land use; block length (400m buffer)	Mixed land use+; block length −; perceived safety +; others NS
Gomez et al. (2010)	*N* = 1,966, 60+ years; M/F	Survey	Safety, sidewalks	Land use, connectivity, parks (500 buffer)	Parks size +; safety +; *connectivity −;* sidewalks NS
Nagel et al. (2008)	*N* = 546; mean 74 years; M/F	Survey	Safety; neighborhood problems	Traffic volume, sidewalks, intersections, transport, and retail (400 m and 800 m buffers); distance to park	NS overall; for walking time destinations +; traffic volume −; problems −
Li et al. (2005)	*N* = 577; mean 74 years; M/F	Survey	Proximity and density recreation facility; safety	connectivity; green space (800 m buffer)	connectivity NS; green space NS; recreation facility density +; safety +; rec fac proximity NS
Mendes et al. (2009)	*N* = 4,317; mean 75 years; M/F	Survey	Neighborhood disorder	NA	Neighborhood disorder −
King et al. (2003)	*N* = 149; mean 74 years; F	Interview; pedometer steps	Walking distance to destinations	NA	# destinations +

Note: SES, socioeconomic status; NA, not applicable; NS, not significant, +, significant positive relationship; −, significant negative relationship, italics, result in unexpected direction; F, female; M, males; NEWS, Neighborhood Environment Walkability scale.

outcomes, walking for leisure or recreation, or physical activity, and further categorized by environment variables (1) proxies for walkability such as urban/rural split, (2) geographic information system- (GIS) based environment variables within a residential buffer, and (3) self-reported perceptions of the environment.

Studies of crude population estimates of walkability, usually at a large geographic area (e.g., zip code or even county), assessed by sprawl indices or designation of residential addresses into urban or rural, show an interesting pattern in older adults. In adults, early studies of these crude estimates of walkability indicated that both physical activity and walking were higher in urban areas (Ewing et al. 2003; Lopez et al. 2004). More fine-grained studies have tended to show that walking for transportation is a stronger correlate of walkability than physical activity, which makes sense, given the roots of walkability in transportation research (Frank et al. 2010a).

Tables 1 and 2 summarize the studies of walking in older adults. In the older adult literature, a clearer pattern emerges even at the cruder rural/urban split. Three studies indicate that walking is higher in urban environments (Kemperman et al. 2009; Lee et al. 2009; Patterson and Chapman 2004), and three studies found that recreational physical activity was not related to degree of urbanization (Armadottir et al. 2009; Chen and Fu 2008; Wilcox et al. 2000). One study found that physical activity in older adults was higher in rural environments (Lim 2005). In this study, the authors argued that infirm elders may move to the city for increased care. However, these relationships may vary by culture and other norms. A population survey of older adults in Switzerland revealed that elderly rural residents were more likely to be sedentary than urban residents (Meyer and Dumbaugh 2008).

There have now been several studies of walking and GIS-based built environment variables in older adults. Buffers around participants' homes range from 100 to 1,000 m in scale. Interestingly, more work has been done in smaller buffers in older adults than adults, reflecting the assumption that older adults are more influenced by their proximal environment and that they may not walk as far as adults. There is yet no consistent pattern across the buffers to indicate the best fit for older adults. Comparisons are difficult because the variables studied are often different and the outcomes across studies vary. At least five studies have found positive associations between GIS-based built environment features and walking. Within a 400 m buffer walking was higher in shorter block lengths and with mixed land uses (Satariano et al. 2010), and when a mall was present (Michael et al. 2006). Within an 800 m buffer, destinations and parks were related to total walking (Nagel et al. 2008) and within a 1,000 m buffer walking for transport was related to the walkability index (Frank et al. 2010b; King

Table 2. Studies Relating Walking Types to Built Environment Variables

First Author, Year	Sample	Self-Report Walking Type	Self-Report Environment Variables	Objective Environment Variables (Scale)	Result
Berke, Koepsell et al. 2007	*N* = 936; 65+ years; M/F	Survey: recreation walking	NA	Walkabilty score (100 m, 500 m, 1,000 m) if lived in location >2 years	Walkability + only in women at 100 m; others NS
Borst et al. 2009	*N* = 364; 55–80 years; M/F	Travel diary: transportation walking	NA	Street audit	Sidewalk +; front gardens +; shops; *block length +, parks −; traffic volume −;* stairs −; litter −
Fisher and Li 2004	*N* = 583; M/F	Survey: recreation walking	NA	Walking friendliness (neighborhood)	NS
Frank et al. 2010b	*N* = 1,970; 65+ years; M/F	Travel diary: Transportation walking	NA	Walkability (1,000 m)	Walkability +
Li et al. 2005	*N* = 577; mean 74 years; M/F	Survey: recreation walking	Proximity and density recreation facilities; safety	Connectivity; green space (800 m)	Connectivity NS; Proximity to recreation NS; Density recreation facilities +; *green space −;* safety +;
Mendes et al. 2009	*N* = 4,317; mean 75 years; M/F	Survey: Recreation and transportation walking	Neighborhood disorder	NA	Recreation Walk +; Transportation walk NS
Michael et al. 2006	*N* = 105; mean 75 years; M/F	Recreation walk	graffiti, sidewalks, parks, malls trails	Street audit (neighborhood); graffiti, sidewalks, parks, malls, trails	Mall + (audit and self-report); graffiti—(audit only); other NS
Shigematsu et al. 2009	*N* = 360; 65+ years; M/F	Survey: recreation and transportation walking	NEWS	NA	(66–75 years) Transportation walking: residential density +, land use mix +, walk facilities +, recreation facilities + ; others NS Recreation walking: land use mix +; others NS (76+ years)Transportation walking: land use mix +; recreation facilities +; parks +; others NS Recreation walking: all NS
Patterson and Chapman 2004	*N* = 372; 70+; F	Survey: recreation and transportation walking	NA	New Urbanism Index (neighborhood)	Transportation walking +; Recreation walking NS

Note: NA, not applicable; NS, not significant; +, significant positive relationship; −, significant negative relationship; italics, result in unexpected direction; F, female; M, males; NEWS, Neighborhood Environment Walkability scale.

et al. 2010). In adults, parks have been consistently related to walking and physical activity (Kaczynski and Henderson 2007), in older adults, they have been studied less often, but in at least four studies (Michael et al. 2006; Michael et al. 2010; Gomez et al. 2010; Li, Fisher, and Brownson 2005) park proximity or density was not related to walking. In two studies, there was an association with walking and parks (Nagel et al. 2008; Wilcox et al. 2000). In adults, street connectivity has been consistently related to walking, but in older adults there have been two studies that found walking was not related to street connectivity or inversely related (Gomez et al. 2010; Li, Fisher, and Brownson 2005). In one study, only women tended to walk more if the immediate environment around them (100 m) was walkable (Berke, Koepsell et al. 2007). Walkability at 500 and 1,000 m was not related to walking in either men or women in this population.

These findings indicate that built environment characteristics that are thought to be related to walkability, such as street connectivity (which is related to shorter block lengths and more crossings), may not be as important as other features among older adults. For example, even if with a plethora of street crossings available, many older adults may not feel comfortable negotiating street crossings due to problems such as unsignaled intersections and large crossing distances. Indeed, studies show increased risk of a motor vehicle collision with a pedestrian over age sixty-five at marked crosswalk with no traffic signal or stop sign (Koepsell et al. 2002). When asked, older adults have suggested that traffic control measures are one of the most important environment issues to address (Saelens et al. 2008; Lees et al. 2007; Strath et al. 2007).

Another finding is that many parks may not be an appropriate destination for older adults. Parks with safe paths and restrooms may be appealing to older adults, but in many instances older adults may feel vulnerable in an open public space where there are fewer people around. Recreation facilities have been related to walking for recreation (Fisher and

Table 3. Studies Relating Physical Activity Behavior to Built Environment Variables

First Author, Year	Sample	Type of PA Measure	Self-Report Environment Variable	Objective Environment Variables (Scale)	Result
Arnadottir et al. 2009	*N* = 186; 65+years; M/F	Survey: total PA; recreation PA	NA	Urban/rural (community)	Total PA NS; Rec PA +
Wilcox et al. 2000	*N* = 2,338; 60 percent 50+ years; F	Survey: recreation PA	NA	Urban/rural (Zipcode)	NS
Plotnikoff et al. 2004	*N* = 2,535; 60+ years; M/F	Survey: recreation PA	NA	Urban/rural (public health unit)	NS
Frank et al. 2010b	*N* = 1,970; 65+ years; M/F	Survey: total PA	NA	Walkability (1000 m buffer)	NS
Piro, Noss, and Claussen 2006	*N* = 3,499; 74-5 years; M/F	Survey: total PA	Perceived safety	Violence (neighborhood)	Violence–(M only); Safety + (F only)
Chen et al. 2008	*N* = 499; mean 70 years; M/F	Survey: Recreation PA	Urban/rural residence	NA	NS
Lim et al. 2005	*N* = 8,881; 65+ years; M/F	Survey: total PA	Urban/rural; safety	NA	*Rural* +; Safety NS
Bird et al. 2009	*N* = 72; 60+ years; F	Survey: Total PA	NEWS	NA	NS
Morris, McAuley, and R. W. Motl 2008	*N* = 136; mean 70 years; F	Accelerometer: MVPA	NEWS	NA	Street connectivity + ; all others NS
Shores et al. 2009	*N* = 464; 65+ years; M/F	Survey: total PA	NEWS	NA	Proximity to park +; safety +
Tucker et al. 2009	*N* = 18,370; 50+ years; M/F	Survey: recreation PA	Safety	NA	NS
Wilcox 2000	*N* = 102, mean 71 years; F	Survey: total PA	Safety, traffic, lights; sidewalks; proximity to park	NA	Safety +; traffic −; sidewalks +*;* proximity to park and lights NS
Mowen et al.	*N* = 1,515; 65+ years; M/F	Survey: total PA	Park proximity	NA	Park proximity +
Pericles 2009	*N* = 385; 60+ years; M/F	Survey: recreation PA	NEWS	NA	Proximity to destinations +; safety +; others NS

Note: NA, not applicable; NS, not significant; +, significant positive relationship; −, significant negative relationship; italics, result in unexpected direction; F, female; M, males; NEWS, Neighborhood Environment Walkability scale; PA, physical activity.

Li 2004; Berke et al. 2006) and these supervised environments may be more supportive for older adults' activity.

Studies of older adult participants who report their perceptions of the environment support some of the objective GIS-based findings. Table 3 summarized the studies of environments and physical activity. Perceived proximity and density of recreation facilities, and presence of malls and other destinations have been consistently related to total physical activity (Shores 2009; Chad 2005), recreation physical activity (Pericles et al. 2009), total walking (Li 2005a), and walking for recreation and transportation (Li 2005b; Nagel et al. 2008; Michael et al. 2006; Shigematsu et al. 2009). Recreation and total walking and physical activity have consistently been positively related to perceptions of neighbor safety and negatively related to neighborhood problems (Piro, Noss, and. Claussen 2006; Mendes et al. 2009; Li 2005a, 2005b; Nagel et al. 2008; Wilcox et al. 2000; Tucker 2009; Shores 2009). These findings again suggest that older adults may feel more comfortable recreating in settings where there is supervision or safety in numbers. In a survey in Scotland, older adults (over sixty-five years) without daily access to a car and who disliked going out alone or in the evening were more likely to be sedentary (Crombie et al. 2004). In a large study with older adults in Canada, physical activity was related to the presence of street lights and seeing other people (Chad 2005). Women over age fifty were more active when they reported more pleasant scenery and residential neighborhoods (compared to mixed-use neighborhoods; Sallis et al. 2007). Transportation walking has not been related to safety concerns in older adults (Mendes et al. 2009), perhaps because it is more likely to occur in walkable neighborhoods where there are more people around for support. This pattern appears more consistent and stronger than in the adult literature (Sallis and Kerr 2006; Yen, Michael, and Perdue 2009). A study compared relationships between built environment features and walking for both younger and older adults and showed that among older adults (over age seventy-five), the only significant relationships were between transportation walking and land use mix and proximity of shops, services, and recreational facilities near home. Younger adults (twenty to seventy-five years) showed many more relationships for both types of walking and various environmental features (Shigematsu et al. 2009). The authors noted that it is particularly important for older adults to have access to nearby destinations for accomplishing daily activities and recreational facilities in order for them to be able to get walking into their routine.

Most studies collect self-reported activity and walking levels through recall over a period of time. One study used self-reported household travel diary data collected over a two-day period a part of a major regional travel survey (Frank et al. 2010b). Two earlier studies, however, used pedometers. In older women, living within a twenty-minute walk of a park, trail, or store was related to walking (King et al. 2003). In postmenopausal overweight women, low neighborhood SES, older homes (representing more pedestrian friendly neighborhoods), and access to a post office and golf course were related to walking (King 2005; King et al. 2003). Only two known studies have employed accelerometers to objectively assess physical activity. One small study using accelerometers found neighborhood perceptions were not related to total activity counts per day (Morris, McAuley, and Motl 2008). Another larger study that recruited older adults from neighborhoods that varied in walkability and income found moderate–vigorous physical activity was not related to walkability (King et al. 2010).

Mental and Physical Health

Only a few studies have focused on relationships between community design and the mental and physical health of older adults (Brown et al. 2009; Yen, Michael, and Perdue 2009; Berke, Gottlieb et al. 2007). Research is building to suggest that the built environment impacts physical functioning and disability. Physical activity levels are strongly related to physical functioning and mobility in older adults—however, the direction of causation likely goes in both directions whereby more able bodied seniors are also likely to be more active. Individuals with lower physical functioning tend to be less active even though exercise can improve physical function and prevent disability. If older adults live in neighborhoods where their activity is restricted, physical function can worsen and disability can ensue (Beard et al. 2009).

Schootman et al. (2006) investigated risk of lower body functional limitations and found that poor neighborhood conditions (noise, street and road quality, air quality, sidewalk, and yard quality) were related to increased risk. Another study found that the environment was related to the disablement process (Clarke and George 2005). Older adults with declining physical functioning were less able to perform daily instrumental activities when they lived in a neighborhood with limited land use mixtures. In a large sample of adults over age fifty-five, Freedman et al. (2008) found that street connectivity was associated with a reduced risk of limitations in instrumental activities of daily living for men. Balfour and Kaplan (2002) found that older adults reporting more than two neighborhood problems had twice the risk of losing physical function. Most relevant neighborhood characteristics related to loss of function were excessive noise, inadequate lighting, traffic, and limited public transportation. Participants with severe and moderate mobility limitations have been found to have more barriers in their environment that keep them from exercising than those with no mobility limitations (Rasinaho et al. 2006). Among those over age forty-five, a longitudinal study showed that outdoor mobility was affected by poor street conditions (e.g., cracks and potholes) among those with severe mobility impairments while there was no effect for those with mild or no physical impairment (Clarke et al. 2008). Beard et al. (2009) found that objectively measured street characteristics including density of intersections, trees on streets, and access to public transportation were inversely related to physical disability and disability affecting leaving the home. A recent study showed that the two-year incidence of mobility difficulties was lower in less deprived neighborhoods (4.0 per 100) compared to the most deprived neighborhoods (13.6 per 100; Lang et al. 2008). Two large studies of older adults found that the association between walking and the built environment was moderated by physical functioning (Satariano et al. 2010; King et al. 2010). Interestingly, King et al. (2010) found that those living in walkable neighborhoods with the lowest levels of functioning still walked more than the most able in unwalkable neighborhoods. Yeom's brief review (2008) of the role of environmental factors in mobility limitation indicated that higher mobility is present when there are easily accessible indoor environments, availability and access to services in the local area, and safety. The review also noted that results are mixed regarding the impact of geographic location with mobility limitation.

Several studies have shown independent neighborhood SES associations with mortality or CVD, or interactions between individual and neighborhood SES and disease outcomes (Southern et al. 2005; Wen, Cagney, and Christakis 2005; Sundquist, Frank, and Sundquist 2004). For example, Diez Roux (2001), Diez Roux et al. (1997), and Diez Roux et al. (2004) geocoded participants of the Cardiovascular Health Study and the Atherosclerosis Risk in Communities Study, and found that neighborhood SES at the census block level was related to CVD death (but not other deaths) after controlling for individual SES.

Other studies have examined CVD risk factors and urban form. Ewing et al. (2003) examined the relationship between health outcomes and a sprawl index for 448 US Counties. Obesity, physical activity, and hypertension were related to sprawl; diabetes and Coronary Heart Disease (CHD) were not. Sturm and Cohen (2004) found higher rates of age-adjusted chronic diseases in counties with high sprawl indices. Another study showed associations between living in a high walkable neighborhood and decreases in blood pressure over one year among adults between fifty and seventy-five years of age (Li et al. 2009). There may be relationships between walkability and healthy body weight among older adults as well. A study of older adults in Atlanta also found that those living in a more walkable neighborhood were 32 percent less likely to be overweight (Frank et al. 2010b). One study showed that middle-to-older aged adults living who increased their activity levels and lived in high walkable areas had less weight gain than those in lower-walkability neighborhoods (Li et al. 2009). Cognitive function has also been related to the built environment (Sheffield and Peek 2009).

The most studied environmental correlate of mental health among older adults has been neighborhood poverty but results are mixed. One study found that lower neighborhood poverty and living in areas with more older adults was related to fewer depressive symptoms in some populations (Kubzansky et al. 2005). Bierman (2009) found that neighborhood disorder (including noise, vandamlism, run-down buildings, trash, crime, drug/alcohol use, and traffic) was related to increased depression over two years but only among nonmarried individuals. Aneshensel et al. (2007) and Wight et al. (2009) found that individual-level characteristics were most related to depression while neighborhood socioeconomic disadvantage mattered only for some population segments and in particular those who are most impoverished. Fewer studies have looked at other neighborhood environment features and mental health. One study found that living in more walkable areas was related to fewer depressive symptoms among older men (Berke, Gottlieb et al. 2007). Researchers have suggested this may be via greater social connectedness (Berke, Gottlieb et al. 2007). Another study confirmed this suggestion, finding that built environment features that facilitated social interaction (e.g., having porches and stoops) had effects on social support which impacted anxiety and depression among low-income, Hispanic adults over age seventy (Brown et al. 2009). Overall, evidence is building to suggest that neighborhood environment factors are integrally related to older adults' ability to maintain physical health. More research is needed to better understand the nuances regarding built environment relationships with mental health.

Ability to "Age in Place"

A main concern among older adults is being able to "age in place" and maintain independence (Cheek, Nikpour, and Nowlin 2005). A concern when older adults wish to age at home is that in auto-dependent settings, they will become isolated and experience declining ability to function independently. Having a home and local environment that supports independent mobility for older adults' could be a key to helping them age at home healthfully (Frank in press). Even when older adults must move to assisted-living situations, the built environment of such sites and local areas remains important to prevent further declines in health and functioning. One study found that older adults living in retirement facilities walked more and had fewer falls than outside community dwelling residents despite lower levels of functioning (Wert et al. 2010). Like the King et al. results, supportive environments appear to negate the effects of functional decline. New types of housing opportunities are growing including Green Houses and senior cooperatives (http://www.seniorcoops.org) indicating the importance of finding home-like residences to age in. It is also important for communities to have a mix of housing types. Older adults who want to downsize may not have access to multifamily housing options, for example, apartments, in all communities.

When the local environment does not support older adults' walking or having access to public transportation, older adults are less social (Richard et al. 2009). This can lead to isolation and declining physical function (Beard et al. 2009). Places such as naturally occurring retirement communities (NORCs) may demonstrate ideal areas for seniors to age. These are areas where large numbers of seniors tend to reside and healthy features include: access to destinations/services by walking, seeing others being active, having walking paths that are well kept and safe, being low crime and safe, "senior-friendly" local governments. Therefore, satisfaction with aging in place may depend on the type of local neighborhood environment.

Many older adults inevitably do end up transitioning into some type of retirement community which can include independent living, assisted living, or skilled nursing. Such communities have varying types of environments that deter or support physical activity for residents. The Wert study indicated such environments can support activity more than current community designs (Wert et al. 2010). Researchers have developed an audit tool to objectively assess the supportiveness of retirement facilities and found that outside walking and exercise facilities were related to more minutes of moderate physical activity and fewer minutes of sitting. Indoor facilities, even those for exercise, tend to be associated with increased sitting time, suggesting they may not be optimally used (Kerr et al. in submission).

According to environmental theory, when the environment is too demanding, individuals are unable to use their environment. When the environment is not demanding enough, there is boredom and deconditioning. Important environmental characteristics of assisted-living-type facilities have been identified and include: appear residential, small in size, foster independence, maintain connections with the surrounding community, aesthetics/appearance, and meaningful activity. In addition, older adults spend far more time at home than working-age adults. Taken collectively, the design of neighborhoods in which older adults live, retirement communities and assisted-living facilities, and older adults' homes are vitally important.

Importance of Access to Transportation

While the empirical evidence suggests strong and consistent correlations between community design and recreational physical activity (Sallis and Kerr 2006), travel behavior is also related to overall levels of physical activity in the general population (Frank et al. 2006) and among older adults (Frank et al. 2010b). Often use of public transportation includes walking trips before and after transit use. Thus, it is important to not only consider correlations between community design and physical activity but also the specific travel behaviors of older adults. Perhaps, most important is how community design relates to specific health outcomes and how community design helps determine the basic ability of older adults to accomplish household-sustaining travel objectives, such as shopping for food or other household items. Because many older adults either do not or cannot drive (Rosenbloom 2004; Carr and Ott 2010), the design of a community has a profound effect on the availability of destinations that can be accessed by nondriving individuals, as well as the quality and availability of transit service. Thus, senior mobility is also an important consideration for community design. Loss of driving can lead to loss of independence, anxiety, and increased nursing home placement (Carr and Ott 2010). Loss of driving in a walkable community with high-transit access provides other mobility options and would be less likely to have an adverse impact.

A recent review noted several issues pertaining to the travel behavior of older adults (Dumbaugh 2008). Adults over age sixty-five drive less than their younger counterparts due to cessation of work, yet vehicle miles traveled have doubled among the older adult population since 1983 (Rosenbloom 2004) suggesting that older adults are hesitant to relinquish driving. This is likely because in many areas, older adults cannot reach necessary destinations without being able to drive and must rely on others, friends, and family members, to drive them if they become unable to drive (Dumbaugh 2008). While better access to transit could help link older adults to services, older adults with other options tend not to use public transportation services (Giuliano 2004).

Designing Communities to Support Healthy Aging

Local neighborhoods likely affect the healthy aging of older adults. Urban form characteristics are directly related to health outcomes such as CVD, depression, and injury. They are also related to healthy body weight and physical activity levels which in turn influence physical functioning, independence, quality of life, and overall health. It is therefore import to design communities that support recreational and utilitarian walking and transit use. Several key organizations have recognized the importance of community design on older adults' health. The World Health Organization recognizes "Age Friendly Cities," the Environment Protection Agency awards active communities under the Active Aging Initiative and the New York City design guidelines for activity include features for older adults. Several advocacy initiatives by older adults have also been successful, including those supported by the Robert Wood Johnson Foundation Active Living by Design program. The Environment Protection Agency scheme to reward excellence in building healthy communities for active aging (www.epa.gov/aging/bhc) includes affordable senior housing near stores and public transportation in Seattle, building sidewalks in Naples, Florida, and a new senior-friendly Village Center in Barrington, New Hampshire. The American Association of Retired Persons also published a review of planning complete streets for an aging America (ww.aarp.org).

Conventionally designed communities (see Dumbaugh 2008 for explanation of such designs in regards to older adults) are particularly unaccommodating to older adults who elect not to or cannot drive or experience personal mobility declines associated with aging. Further, these environments do not support physical activity which is important for maintaining functioning and health. Rather than focusing on senior-friendly design, most strategies currently aimed at addressing the health and mobility needs of nondriving older adults result in programs that further isolate this group from the broader community and lessen opportunities to be active. The current emphasis on assisted living facilities, senior-oriented paratransit and driver screening programs does not address larger issues with the built environment (Dumbaugh 2008). Built environment changes are needed that promote independence and physical activity for older adults by allowing them to walk to local services and connect with public transportation so they can access regional destinations and places for recreation. Providing opportunities to access destinations independently through walking would likely increase the feeling of connectedness with their community and creates opportunities for "unplanned" interactions with other members of their community. These types of encounters can create social capital and are especially important for an older adult who may otherwise feel isolated.

At present there are few studies of the influence of change to the built environment and subsequent change in physical activity in all age groups, and particularly seniors. This is because research into this issue has only been recently begun and has focused on understanding the barriers to behavior in cross-sectional studies. There are now a few prospective studies that add to the evidence base (Li et al. 2005; Michael et al. 2009) but few intervention studies. Due to the cost of environment level interventions, it has not been possible for researchers to lead such efforts using traditional designs like randomized control trials. Although there are now research studies underway that include advocacy efforts in seniors. Most data will likely come from evaluations of natural experiments, either changes in the environment due to new policies and allocation of funds to build projects or from seniors moving to different environments. In these types of studies, funds for evaluation are more frequently available as funding bodies also need health data to justify the expense of the build projects. Evaluation data in these circumstances is often post, rather than pre–post and may be limited to self-report data. The more researchers can be involved in such projects early on and advocate for more evaluation resources, the stronger the evidence base will be. In addition, the existing research on physical activity and walking can be used as baselines for future studies of built environment changes.

Assessing the impact of changes in the environment to seniors is further complicated by the lack of concentration of seniors in any one area—with the exception of assisted living and NORCs. Assessing changes in health-related outcomes before and after moving is often confounded by the fact that elderly often move due to a change or loss in physical functioning. Focusing on areas where elderly is spatially concentrated and also evaluating the comparative effect of programs to promote physical activity and in walkable and in unwalkable environments are promising options. Smaller scale more affordable improvements to the built environment may also have a disproportionate benefit for the elderly. Many audit-based studies are evaluating the presence of street trees, benches, shorter street crossing distances, even surface conditions for sidewalks and buffering of sidewalks from roadways (Michael et al. 2008; Healthy Aging Network [HAN]). Many of these features are modifiable and may greatly enhance the quality of the walking environment without large-scale investments. Further, the tools that have been developed may be helpful in assessing changes.

Our review suggests that older adults may benefit from: attention to decreased sensory and physical abilities, improved street connectivity and access to destinations, improved street crossings, traffic calming, and sidewalks that are in good condition. When designing communities for older adults, attention must be paid to the needs that arise due to declining functioning. The design of the environment must consider the declining visual, auditory, and kinesthetic senses to maintain mobility, autonomy, independence, and well-being (Crews 2005; Frank and Patla 2003). Impaired hearing and vision need to be compensated for by louder signals and increased lighting. Changes in gait and balance mean that hazards such as steps, uneven sidewalks, and obstacles may lead to falls and subsequent health problems. Loss of cognitive functioning may inhibit way finding and orientation, so clear signage is required. More resting places may also be required for older adults who have low stamina.

To improve community design for older adults macro- and micro-level changes may be required. A common criticism of conventional subdivision design is that the disconnected network design and segregated land uses within these developments increases distance to nonresidential destinations to levels that prohibit walking as a viable travel option, particularly for older adults (Duany, Plater-Zyberk, and Speck 2000). Neighborhoods need to be designed with short street blocks and intermixed land uses to encourage utilitarian walking in older adults. High-density neighborhoods should also support more viable transit options, but frequent service at off peak times are also necessary to support transit use in older adults. Communities designed for active living also tend to have lower crime rates, which is a frequently cited barrier for older adults (Loukaitou-Sideris 2004).

Further, even where destinations may be relatively accessible via walking, these trips often necessitate crossing an arterial roadway where signaled pedestrian crossings are regularly spaced at distances of a quarter mile or more to expedite vehicle through-movement (AASHTO 2001; Minnesota Department of Transportation 2002; Nevada Department of Transportation 1999). Such crossings are rarely timed with regard to the needs of older adults (Dorfman 1997; Owsley, Fildes, and Dewar 2004; U. S. Department of Transportation [USDOT], 2003). Thus, perhaps unsurprisingly, the need to cross a busy street has been identified as a major barrier to walking (Troped et al. 2001). More frequent cross walks are important for older adults, but the design also matters; cross walks without traffic lights are less safe for older adults (Koepsell et al. 2002). The timing of lights needs to be extended to safely accommodate older adults' walking speeds, and crossing times need to be indicated clearly with lights and noise signals (Retting, Ferguson, and McCartt 2003). Reduced crossing distances at intersections through "neckdowns" or widening sidewalks is also an important design solution.

From the perspective of older adults, the elimination of high-speed through-traffic is important (Dumbaugh 2008) Roadways in senior-friendly communities should be designed not to expedite through-moving automobile traffic but to encourage slower and more consistent operating speeds. This could be achieved by traffic calming design features such as narrower roads, more curves, street parking, and slower speed limits. Moreover, land use planning where older Americans and others can access shops and services and recreational destinations without crossing busy streets should be a priority. Traffic is also slower in grid pattern neighborhoods with frequent street intersections. This enhances not only the comfort and safety of older pedestrians but also addresses the safety needs of older drivers, who suffer from loss of depth perception. This can make it difficult to accurately estimate distance or time to impact when vehicles are traveling at high speeds. Further, as several authors have observed, permitted left-turns should be abandoned in favor of four-way stops and signalized turns to prevent the left-turn crashes prevalent among older adults (Dumbaugh 2008).

While evidence is limited, common sense dictates that well-maintained sidewalks with even surfaces are also important for older adults at greater risk for falls. Sidewalk maintenance needs to be a priority and should be included in road maintenance programs. Street curbs also need to be designed to make crossing easier for older adults who may be in wheel chairs or using other walking aids; curb cuts and bulb curbs can make crossing safer for older adults. Further, older adults, whether as pedestrians or as transit users, require safe and comfortable places to sit and rest. Transit stops intended for senior use should thus include comfortable places to sit, and preferably include shelter from inclement weather. Likewise, comfortable and attractive places to sit should be included at all destination attractions intended for use by older adults. Other amenities such as handrails on steep slopes can support walking for older populations. Such features are included in design guidelines for older adults (New York City [NYC] design).

Considered collectively, most of these recommendations are not new; these recommendations characterize most traditional communities in the United States, as well as many "neo-traditional" ones. It is worth observing that these communities emerged naturally as a means to effectively address the mobility needs of most Americans prior to the advent of the personal automobile and continue to perform better than conventional development in terms of health, safety, and mobility. Community designs that support activity in all population groups will increase the number of people walking and thus support safe walking in older adults. Improving the ability for older adults to walk to destinations where they live likely has many health benefits. However, care should be taken to develop walkable communities that protect the health of older adults (and others) by limiting exposure to air pollution (Peters et al. 2000). Concentrations of particulates decline quickly away from roads. One recent meta-analysis found "at least a 50% decrease in peak/edge-of-road concentration by 150 m, followed by consistent but gradual decay toward background (e.g., carbon monoxide, some ultrafine particulate matter number concentrations)" p. 37 (Karner, Eisinger, and Niemeier 2010). Research also suggests that elevation above street level is associated with reduced concentrations of harmful pollutants. For primary pollutants, concentrations aloft (>10–25 m, or three to five stories; Zhou and Levy 2008) can be several times lower than at ground level (Väkevä et al. 1999; Zoumakis 1995). Results suggest that this could more than compensate for the thirty percent to forty percent ground-level NO concentration difference found in the Marshall et al. (2009) study noted above (Pope et al. 2002; Marshall et al. 2009).

Even if better environments are built, individual motivational barriers to using them need to be addressed (Jilcott et al. 2007). The Guide to Community Preventive Services suggests that informational outreach should be used to promote enhanced access to supportive environments (Heath et al. 2006). When outreach is not used, supportive environments already in existence are not fully used by older adults. Increased awareness can be addressed via educational tools such as walking route maps (Rosenberg et al. 2009), maps of local recreation amenities (Reed et al. 2008) or prompts to use facilities (e.g., stairs; Kerr, Eves, and Carroll 2001). These strategies have been shown to be effective in increasing activity in older adults. Organized walking bus programs that have been successful in safe routes to school programs could be translated into a similar program to support walking in older adults.

Conclusions

This review presents evidence documenting the critical role the built environment has in promoting or inhibiting physical activity in older adults. Creating and preserving walkable communities is a means to reduce risk of chronic disease and maintain improved public health and quality of life. The design of the physical environment in which older adults live and level of access to transit service determines the level of accessibility they have to important destinations such as shops, services, and places to recreate. When supportive features are prominent in places where older adults live, they can remain active and independent. Older adults are an increasing proportion of the population and the demand for walkable places is likely to grow significantly among this age cohort. Planners should be prepared to respond with design solutions that will make destinations safely accessible on foot or by transit for this rapidly growing segment of the population.

References

AASHTO (American Association of State Highway and Transportation Officials). 2001. *A Policy on Geometric Design of Highways and Streets*, 4th ed. Washington, DC: AASHTO.

Abbott, R. D., L. R. White, G.W. Ross, K. H. Masaki, J. D. Curb, and H. Petrovitch. 2004. "Walking and Dementia in Physically Capable Elderly Men." *Journal of the American Medical Association* 292:1447–53.

Agency for Healthcare Research and Quality and the Centers for Disease Control. June 2002. *Physical Activity and Older Americans: Benefits and Strategies.* http://www.ahrq.gov/ppip/activity.htm

Andel, R., M. Crowe, N. L. Pedersen, L. Fratiglioni, B. Johansson, and M. Gatz. 2008. "Physical Exercise at Midlife and Risk of Dementia Three Decades Later: A Population-Based Study of Swedish Twins." *Journals of Gerontology A Biological Sciences and Medical Sciences* 63:62–6.

Aneshensel, C. S., R. G. Wight, D. Miller-Martinez, A. L. Botticello, A. S. Karlmangla, and T. E. Seeman. 2007. "Urban Neighborhoods and Depressive Symptoms among Older Adults." *Journals of Gerontology: Social Sciences* 62B:S52–9.

Angevaren, M., G., Aufdemkampe, H. J. Verhaar, A. Aleman, and L. Vanhees. 2008. "Physical Activity and Enhanced Fitness to Improve Cognitive Function in Older People Without Known Cognitive Impairment." *Cochrane Database of Systematic Reviews* 16:CD005381.

Armadottir, S. A., E. D. Gunnarsdottir, and L. Lundin-Olsson. 2009. "Are rural older Icelanders less physically active than those living in urban areas? A population-based study." *Scandinavian Journal of Public Health* 37:409–17.

Aronson, R. E., and R. F. Oman. 2004. "Views on Exercise and Physical Activity among Rural-Dwelling Senior Citizens." *Journal of Rural Health* 20:76–9.

Baker, L. D., L. L. Frank, K. Foster-Schubert, P. S. Green, C. W. Wilkinson, A. McTiernan, S. R. Plymate, M. A. Fishel, G. S. Watson, B. A. Cholerton, G. E. Duncan, P. D. Mehta, and S. Craft. 2010. "Effects of Aerobic Exercise on Mild Cognitive Impairment A Controlled Trial." *Archives of Neurology* 67:71–79.

Balfour, J. L., and Kaplan, G. A. 2002. "Neighborhood Environment and Loss of Physical Function in Older Adults: Evidence from the Alameda County Study." *American Journal of Epidemiology* 155: 507–15.

Beard, J. R., S. B. Blaney, M. Cerda, V. Frye, G. S. Lovasi, D. Ompad, A. Rundle, and D. Vlahov. 2009. "Neighborhood Characteristics and Disability in Older Adults." *Journal of Gerontology: Social Sciences* 64B:252–7.

Berke, E. M., R. T. Ackermann, E. H. Lin, P. H. Diehr, M. L. Maciejewski, B. Williams, M. B. Patrick, and J. P. LoGerfo. 2006. "Distance as a Barrier to Using a Fitness-Program Benefit for Managed Medicare Enrollees." *Journal of Aging and Physical Activity* 14:313–23.

Berke, E. M., T. D. Koepsell, A. V. Moudon, R. E. Hoskins, and E. B. Larson. 2007. "Association of the Built Environment with Physical Activity and Obesity in Older Persons." *American Journal of Public Health* 97:486–92.

Berke, E. M., L. M. Gottlieb, A. V. Moudon, and E. B. Larson. 2007. "Protective Association Between Neighborhood Walkability and Depression in Older Men." *Journal of American Geriatric Society* 55:526–33.

Bierman, A. 2009. "Marital Status as Contingency for the Effects of Neighborhood Disorder on Older Adults' Mental Health." *Journal of Gerontology: Social Sciences* 64B:425–34.

Bird, S., W. Kurowski, S. Feldman, C. Browning, R. Lau, H. Radermacher, S. Thomas, and J. Sims. 2009. "The Influence of the Built Environment and Other Factors on the Physical Activity of Older Women from Different Ethnic Communities." *Journal of Women and Aging* 21:33–47.

Blair, S. N., Y. Cheng, and J. S. Holder. 2001. "Is Physical Activity or Physical Fitness More Important in Defining Health Benefits?" *Medicine and Science in Sports and Exercise* 33:S379–99.

Booth, M. L., N. Owen, A. Bauman, O. Clavisi, and E. Leslie. 2000. "Social–Cognitive and Perceived Environment Influences Associated with Physical Activity in Older Australians." *Preventive Medicine* 31:15–22.

Borst, H. C., S. I. de Vries, J. M. A. Graham, J. E. F. van Dongen, I. Bakker, and H. M. E. Miedema. 2009. Influence of environmental street characteristics on walking route choice of elderly people. *Journal of Environmental Psychology* 29:477–84.

Brown, S. C., C. A. Mason, J. L. Lombard, F. Martinez, E. Plater-Zyberk, A. R. Spokane, F. L. Newman, H. Pantin, and J. Szapocznik. 2009. "The Relationship of Built Environment to Perceived Social Support and Psychological Distress In Hispanic Elders: The Role of "Eyes On The Street." *Journal of Gerontology: Social Sciences* 64B:234–46.

Brownson, R. C., E. A. Baker, R. A. Housemann, L. K. Brennan, and S. J. Bacak. 2001. "Environmental and Policy Determinants of Physical Activity in the United States." *American Journal of Public Health* 91:1995–2003.

Carr, D., and B. Ott. 2010. "The older adult driver with Cognitive Impairment: It's a Very Frustrating Life." *Journal of the American Medical Association* 303:1632–41.

CDC (Centers for Disease Control) and Prevention and The Merck Company Foundation. 2007. *The State of Aging and Health in America 2007*. Whitehouse Station, NJ: The Merck.

Chad, K. E., B. A. Reeder, E. L. Harrison, N. L. Ashworth, S. M. Sheppard, S. L. Schultz, B. G. Bruner, K. L. Fisher, and J. A. Lawson. 2005. "Profile of Physical Activity Levels in Community-Dwelling Older Adults." *Medicine & Science in Sports & Exercise* 37:1774–84.

Cheek, P., L. Nikpour, and H. D. Nowlin. (2005). "Aging Well with Smart Technology." *Nursing Administration Quarterly* 29:329–38.

Chen, S. Y., and Y. C. Fu. 2008. "Leisure Participation and Enjoyment among the Elderly: Individual Characteristics and Sociability." *Educational Gerontology* 34:871–89.

Clarke, P., and L. K. George. 2005. "The Role of the Built Environment in the Disablement Process." *American Journal of Public Health* 95:1933–9.

Clarke, P., J. A. Ailshire, M. Bader, J. D. Morenoff, and J. S. House. 2008. "Mobility Disability and the Urban Built Environment." *American Journal of Epidemiology* 168:506–13.

Clarke, P., and E. R. Nieuwenhuijsen. 2009. "Environments for Healthy Ageing: A Critical Review." *Maturitas* 20:14–9.

Crews, D. 2005. "Artificial Environment Sand an Aging Population: Designing for Age-Related Functional Losses." *Journal of Physiological Anthropology and Applied Human Sciences* 24:103–9.

Crombie, I. K., L. Irvine, B. Williams, A. R. McGinnis, P. W. Slane, E. M. Alder, and M. E. McMurdo. 2004. "Why Older People do not Participate in Leisure Time Physical Activity: A Survey of Activity Levels, Beliefs and Deterrents." *Age Ageing* 33:287–92.

Cunningham, G. O., and Y. L. Michael. (2004). "Concepts Guiding the Study of the Impact of the Built Environment on Physical Activity for Older Adults: a Review of the Literature." *American Journal of Health Promotion* 18:435–43.

Diez Roux, A. V. 2001. "Investigating Neighborhood and Area Effects on Health." *American Journal of Public Health* 91:1783–9.

Diez Roux, A. V., L. N. Borrell, M. Haan, S. A. Jackson, and R. Schultz. 2004. "Neighbourhood Environments and Mortality in an Elderly Cohort: Results from the Cardiovascular Health Study." *Journal of Epidemiology and Community Health* 58:917–23.

Diez Roux, A.V., F. J. Nieto, C. Muntaner, H. A. Tyroler, G. W. Comstock, E. Shahar, L. S. Cooper, and R. L. Watson & M. Szklo. 1997. "Neighborhood Environments and Coronary Heart Disease: A Multilevel Analysis." *American Journal of Epidemiology* 146:48–63.

Dionne, I. J., P. A. Ades, and E. T. Poehlman. 2003. "Impact of Cardiovascular Fitness and Physical Activity Level on Health Outcomes in Older Persons." *Mechanisms of Ageing and Development* 124:259–67.

Dorfman, R. A. 1997. "Taking a Walk: No Longer Safe for Elders in Urban America and Asia." *Journal of Aging and Identity* 2:139–42.

Duany, A., E. Plater-Zyberk, and J. Speck. 2000. *Suburban Nation: The Rise of Sprawl and the Decline of the American Dream*. New York: North Point.

Dumbaugh, E. 2008. "Designing Communities to Enhance the Safety and Mobility of Older Adults: A Universal Approach." *Journal of Planning Literature* 23:17–36.

Ettinger, W. H., R. Burns, S. P. Mesier, W. Applegate, W. J. Rejeski, T. Morgan, S. Shumaker, M. J. Berry, M. O'Toole, J. Monu, and T. Craven. 1997. "A Randomized Clinical Trial Comparing Aerobic Exercise and Resistance Exercise with a Health Education Program in Older Adults with Knee Osteoarthritis." *Journal of the American Medical Association* 277:25–31.

Ewing, R., T. Schmid, R. Killingsworth, A. Zlot A, and S. Raudenbush. 2003. "Relationship between Urban Sprawl and Physical Activity, Obesity, and Morbidity." *American Journal of Health Promotion* 18:47–57.

Federal Interagency Forum on Aging-Related Statistics. (2004). *Older Americans 2004: Key Indicators of Well-Being*. Washington, DC: US Government Printing Office. Accessed from http://www.agingstats.gov/Agingstatsdotnet/Main_Site/Data/Data_2004.aspx.

Fisher, K. J., and F. Li. 2004. "A Community-Based Walking Trial to Improve Neighborhood Quality of Life in Older Adults: A Multilevel Analysis." *Annals of Behavioral Medicine* 28: 186–94.

Fitzpatrick, S. E., S. Reddy, T. S. Lommel, J. G. Fischer, E. M. Speer, H. Stephens, S. Park, and M. A. Johnson. 2008. "Physical Activity and Physical Function Improved Following a Community-Based Intervention in older Adults in Georgia Senior Centers." *Journal of Nutrition for the Elderly* 27:135–54.

Frank, J. S., and A. E. Patla. 2003. "Balance and Mobility Challenges in Older Adults: Implications for Preserving Community Mobility. *American Journal of Preventive Medicine* 25:157–63.

Frank, L., P. O. Engelke, and T. L. Schmid. 2003. *Health and Community Design*. Washington, DC: Island Press.

Frank, L. D., J. F. Sallis, T. Conway, J. Chapman, B. Saelens, and W. Bachman. 2006. "Many Pathways from Land Use to Health: Walkability Associations with Active Transportation, Body Mass Index, and Air Quality." *Journal of the American Planning Association* 72:75–87.

Frank, L. D., J. F. Sallis, B. E. Saelens, L. Leary, K. Cain, T. L. Conway, and P. M. Hess. 2010. "The Development of a Walkability Index: Application to the Neighborhood Quality of Life Study." *British Journal of Sports Medicine* 44:924–33.

Frank, L. D., J. Kerr, D. Rosenberg, and A. King. 2010. "Healthy Aging and Where You Live: "Community Design Relationships with Physical Activity and Body Weight in Older Americans." *Journal of Physical Activity and Health* 7:S82–90.

Freedman, V. A., I. B. Grafova, R. F. Schoeni, and J. Rogowski. 2008. "Neighborhoods and Disability in later life." *Social Science and Medicine* 66:2253–67.

Giles-Corti, B., and R. Donovan. 2002. "The Relative Influence of Individual, Social and Physical Environment Determinants of Physical Activity." *Social Science and Medicine* 54:1793–812.

Giuliano, Genevieve. 2004. "Land Use and Travel Patterns Among the Elderly." In *Transportation in an Aging Society: A Decade of Experience*, 192–212. Washington DC: The Transportation Research Board, ed.

Glass, T., and J. L. Balfour. (2003). Neighborhoods, aging and functional limitation. In I. Kawachi and L. F. Berkman (Eds.), Neighborhoods and health (pp. 303–334). New York: Oxford University Press.

Gomez, L. F., D. C. Parra, D. Buchner, R. Brownson, O. Sarmiento, J. Pinzón, M. Ardila, J. Moreno, M. Serrato, and F. Lobelo. 2010. "Built environment attributes and walking patterns among the elderly population in Bogotá." *American Journal of Preventive Medicine* 38:592–9.

Hakim, A. A., J. D. Curb, H. Petrovitch, B. L. Rodriguez, K. Yano, G. W. Ross, L. R. White, and R. D. Abbott. 1999. "Effects of walking on coronary heart disease in elderly men: the Honolulu Heart Program." *Circulation* 100:9–13.

Hamilton, M. T., D. G. Hamilton, and T. W. Zderic. 2007. "Role of Low Energy Expenditure and Sitting in Obesity, Metabolic Syndrome, Type 2 Diabetes, and Cardiovascular Disease." *Diabetes* 56:2655–67.

Humpel, N., N. Owen, and E. Leslie. 2002. "Environmental Factors Associated with Adults' Participation in Physical Activity: a Review." *American Journal of Preventive Medicine* 22:188–99.

Hayashi, T., K. Tsumura, C. Suematsu, K. Okada, S. Fujii, and G. Endo. 1999. "Walking to Work and the Risk for Hypertension in Men: The Osaka Health Survey." *Annals of Internal Medicine* 131:21–6.

Heath, G. W., R. C. Brownson, J. Kruger, R. Miles, K. E. Powell, and L. T. Ramsey. 2006. "The Effectiveness of Urban Design and Land Use and Transport Policies and Practices to Increase Physical Activity: A Systematic Review." *Journal of Aging and Physical Activity* 3:S55–76.

Hoehner, C. M., L. K. Brennan Ramirez, M. B. Elliott, S. L. Handy, and R. C. Brownson. 2005. "Perceived and Objective Environmental Measures and Physical Activity among Urban Adults." *American Journal of Preventive Medicine* 28:105–16.

Hollmann, W., H. K. Struder, C. Tagarakis, and G. King. 2007. "Physical Activity and the Elderly." *European Journal of Cardiovascular Prevention and Rehabilitation* 14:730–39.

Iwane, M., M. Arita, S. Tomimoto, O. Satani, M. Matsumoto, K. Miyashita, and I. Nishio. 2000. "Waling 10,000 Steps/Day or More Reduces Blood Pressure and Sympathetic Nerve Activity In Mild Essential Hypertension." *Hypertension Research* 23:573–80.

Jancey, J. M., A. H. Lee, P. A. Howat, A. Clarke, K. Wang, and T. Shilton. 2008. "The Effectiveness of a Physical Activity Intervention for Seniors." *American Journal of Health Promotion* 22:318–21.

Jilcott, S. B., B. A. Laraia, K. R. Evenson, L. M. Lowenstein, and A. S. Ammerman. 2007. "A Guide for Developing Intervention Tools Addressing Environmental Factors to Improve Diet and Physical Activity." *Health Promotion Practice* 8:192–204.

Kaczynski, A., and Henderson, K A. 2007. "Environmental Correlates of Physical Activity: A Review of Evidence about Parks and Recreation. *Leisure Sciences* 29:315–54.

Karner, A., D. Eisinger, and D. Niemeier. 2010. "Near-Roadway Air Quality: Synthesizing the Findings from Real-world Data." *Environmental Science and Technology* 44:5334–44.

Kawachi, I., and L. F. Berkman. 2003. *Neighbourhoods and Health*. New York, NY: Oxford University Press.

Kealey, M., J. Kruger, R. Hunter, S. Ivey, W. A. Satariano, C. Bayles, L. B. Ramirez, and L. Bryant. 2005. "Engaging Older Adults to be More Active where they Live: Audit Tool Development." *Preventing Chronic Disease* 2:1–2.

Kemperman, A., and H. Timmermans. 2009. "Influences of Built Environment on Walking and Cycling by Latent Segments of Aging Population." *Transportation Research Record: Journal of the Transportation Research Board* 2134:1–9.

Kerr, J., F. Eves, and D. Carroll. 2001. "Six-Month Observational Study of Prompted Stair Climbing." *Preventive Medicine* 33: 422–7.

King, W. C., J. S. Brach, S. Belle, R. Killingsworth, M. Fenton, and A. M. Kriska. 2003. "The Relationship between Convenience of Destinations and Walking Levels in Older Women." *American Journal of Health Promotion* 18:74–82.

King, A. C., J. F. Sallis, L. D. Frank, B. E. Saelens, K. Cain, T. L. Conway, J. E. Chapman, D. K. Ahn, J. Kerr. 2011. Aging in neighborhoods differing in walkability and income: Associations with physical activity and obesity in older adults. *Social Science & Medicine* 73(10):1525–33.

Koepsell, T., L. McCloskey, M. Wolf, A. V. Moudon, D. Buchner, J. Kraus, and M. Patterson. 2002. "Crosswalk Markings and the Risk of Pedestrian-Motor Vehicle Collisions in Older Pedestrians." *Journal of the American Medical Association* 288:2136–43.

Kono, A, I. Kai, C. Sakato, and L. Z. Rubenstein. 2004. "Frequency of Going Outdoors: A Predictor of Functional and Psychosocial Change among Ambulatory Frail Elders Living at Home." *Journal of Gerontology Series A: Biological Sciences and Medical Sciences* 59:275–80.

Kovar, P., J. Allegrante, C. Mackenzie, M. Peterson, B. Gutin, and M. Carlson. 1992. "Supervised Fitness Walking in Patients with Arthritis of the Knee: A Randomized, Controlled Trial." *Annals of Internal Medicine* 116:529–34.

Kubzansky, L. D., S. V. Subramanian, I. Kawachi, M. E. Fay, M. J. Soobader, and L. F. Berkman. 2005. "Neighborhood Contextual Influences on Depressive Symptoms in the Elderly." *American Journal of Epidemiology* 162:253–60.

Lang, I. A., D. J. Llewwellyn, K. M. Langa, R. B. Wallace, and D. Melzer. 2008. "Neighbourhood Deprivation and Incident Mobility Disability in Older Adults." *Age and Ageing* 37:403–10.

Larson, E. B. 2008. "Physical Activity for Older Adults at Risk for Alzheimer Disease. *Journal of the American Medical Association* 300:1077–9.

Lee, I. M., R. Ewing, and H. D. Sesso. 2009. "The Built Environment and Physical Activity Levels: The Harvard Alumni Health Study." *American Journal of Preventive Medicine* 37:293–8.

Lee, Y., and K. H. Park. 2006. "Health Practices that Predict Recovery from Functional Limitations in Older Adults." *American Journal of Preventive Medicine* 31:25–31.

Lees, E., W. C. Taylor, J. T. Hepworth, K. Feliz, A. Cassells, and J. N. Tobin. 2007. "Environmental Changes to Increase Physical

Activity: Perceptions of Older Urban Ethnic-Minority Women." *Journal of Aging and Physical Activity* 15:425–38.

Li, F., J. Fisher, and R. C. Brownson. 2005. "A Multilevel Analysis of Change in Neighborhood Walking Activity in Older Adults." *Journal of Aging and Physical Activity* 13:145–59.

Li, F., J. Fisher, R. C. Brownson, and M. Bosworth. 2005. "Multilevel Modeling of Built Environment Characteristics Related to Neighborhood Walking Activity in Older Adults." *Journal of Epidemiology and Community Health* 59:588–64.

Li, F., P. Harmer, B. J. Cardinal, and N. Vongjaturapat. 2009. "Built Environment and Changes in Blood Pressure in Middle Aged and Older Adults." *Preventive Medicine* 48:237–41.

Lockett, D., A. Willis, and N. Edwards. 2005. "Through Seniors' Eyes: An Exploratory Qualitative Study to Identify Environmental Barriers to and Facilitators of Walking." *Canadian Journal of Nursing Research* 37:48–65.

Lopez, R., 2004. "Urban Sprawl and Risk for Being Overweight or Obese." *American Journal of Public Health* 94:1574–9.

Loukaitou-Sideris, Anastasia. 2004. *Transportation, Land Use and Physical Activity: Safety and Security Considerations*. Paper prepared for the Transportation Research Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use. Washington DC: Transportation Research Board, Institute of Medicine.

Lund, H. 2003. "Testing the Claims of New Urbanism: Local Access, Pedestrian Travel and Neighboring Behaviors." *Journal of the American Planning Association* 69:414–29.

Lynott, J., J. Haase, K. Nelson, A. Taylor, H. Twaddell, J. Ulmer, B. McCann, and E. R. Stollof. 2009. *Planning Complete Streets for an Aging America*. Washington, DC: American Association of Retired Person.

Matthews, C., K. Chen, and P. Freedson, Buchowski MS, Beech BM, Pate RR, and Troiano RP. 2008. "Amount of Time Spent in Sedentary Behaviors in the United States, 2003-2004." *American Journal of Epidemiology* 167:875–81.

Mangani, I., M. Cesari, S. B. Kritchevsky, C. Maraldi, C. S. Carter, H. H. Atknson, B. Penninx, N. Marchionni, and M. Pahor. 2006. "Physical Exercise and Comorbidity. Results from the Fitness and Arthritis in Seniors Trial (FAST)." *Aging and Clinical Experimental Research* 18:374–80.

Manson, J. E., F. B. Hu, J. W. Rich-Edwards, G. A. Colditz, M. J. Stampfer, W. C. Willett, F. E. Speizer, and C. H. Hennekens. 1999. "A Prospective Study of Walking as Compared with Vigorous Exercise in the Prevention of Coronary Heart Disease in Women." *New England Journal of Medicine* 341:650–58.

Marshall, J. D., M. Brauer, and L. D. Frank. 2009. "Healthy Neighborhoods: Walkability and Air Pollution." *Environmental Health Perspectives* 117:1752–9.

Mendes de Leon, C. F., K. A. Cagney, J. L. Bienias, L. L. Barnes, K. A. Skarupski, P. A. Scherr, and D. A. Evans. 2009. "Neighborhood Social Cohesion and Disorder in Relation to Walking in Community-Dwelling Older Adults: a Multilevel Analysis." *Journal of Aging & Health* 21:155–71.

Meyer, M. D., and E. Dumbaugh. 2004. "Institutional and Regulatory Factors Related to Non-Motorized Travel and Walkable Communities." Report Commissioned by the Transportation Research Board and the Institute of Medicine, July. Incorporated in TRB Special Report 282: Does the Built Environment Influence Physical Activity? 2005. Transportation Research Board, National Research Council, Washington DC.

Michael, Y. L, M. K. Green, and S. A. Farquhar. 2006. "Neighborhood Design and Active Aging." *Health & Place* 12:34–40.

Michael, Y. L., L. A. Perdue, E. S. Orwoll, M. L. Stefanick, and L. M. Marshall. 2010. "Physical Activity Resources and Changes in Walking in a Cohort of Older Men." *American Journal of Public Health* 100:654–60.

Minnesota Department of Transportation. (2002). *Access Operations Study: Analysis of Traffic Signal Spacing on Four-Lane Arterials*. Minnesota: Minnesota Department of Transportation.

Morris, K. S., E. McAuley, and R. W. Motl. 2008. "Self-Efficacy and Environmental Correlates of Physical Activity among Older Women and Women with Multiple Sclerosis." *Health Education Research* 23:744–52.

Moudon, A. V, C. Lee, A. D. Cheadle, C. Garvin, D. Johnson, T. L. Schmid, R. D. Weathers, and L. Lin. 2006. "Operational Definitions of Walkable Neighborhood: Theoretical and Empirical Insights." *Journal of Physical Activity and Health* 3:S99–117.

Mowen, A., Orsega-Smith, E., Payne, L., Ainsworth, B., and Godbey, G. 2007. "The role of park proximity and social support in shaping park visitation, physical activity, and perceived health among older adults." *Journal of Physical Activity and Health* 42:167–79.

Murphy, M. H., A. M. Nevill, E. M. Murtagh, and R. L. Holder. 2007. "The Effect of Walking on Fitness, Fatness and Resting Blood Pressure: A Meta-Analysis of Randomized, Controlled Trials." *Preventive Medicine* 44:377–85.

Nagel, C. L., N. E. Carlson, M. Bosworth, and Y. L. Michael. 2008. "The Relation between Neighborhood Built Environment and Walking Activity among Older Adults." *American Journal of Epidemiology* 168:461–68.

Nelson, M.E., W. J. Rejeski, S. N. Blair, P. W. Duncan, J. O. Judge, A. C. King, C. A. Macera, and C. Castandeda-Sceppa. 2007. "Physical Activity and Public Health in Older Adults: Recommendation from the American College of Sports Medicine and the American Heart Association." *Medicine and Science in Sports and Exercise* 39:1435–45.

Nevada Department of Transportation (1999). *Access Management System and Standards*. Carson City: Nevada Department of Transportation. July.

Noda, H., H. Iso, H. Toyoshima, C. Date, A. Yamamoto, S. Kikuchi, A. Zoisumi, T. Kondo, Y. Watanabe, Y. Wada, Y. Inaba, A. Tamakoshi, and the JACC Study Group. 2006. "Walking and Sports Participation and Mortality from Coronary Heart Disease and Strong." *Journal of the American College of Cardiology* 4:220–1.

Owen, N., P. B. Sparling, G. N. Healy, D. W. Dunstan, and C. E. Matthews. 2010. "Sedentary Behavior: Emerging Evidence for a New Health Risk." *Mayo Clinic Proceedings* 85:1138–41.

Owsley, C. 2004. "Driver Capabilities." In *Transportation in an Aging Society: A Decade of Experience*, 44–55. Washington, DC: The Transportation Research Board, eds.

Owsley, J., B. N. Fildes, and R. E. Dewar. 2004. "Safety of Older Pedestrians." In *Transportation in an Aging Society: A Decade* *of Experience*, 167–91. Washington, DC: The Transportation Research Board, eds.

Pate, R., M. Pratt, S. Blair, W. Haskell, C. Macera, C. Bouchard, D. Buchner, Ettinger, G. W. Heath, A. King, A. Kriska, A. Leon, B. H. Marcus, J. M Morris, R. S. J. Paffenberger, K. Patrick, M. L. Pollock, J. M. Rippe, J. Sallis, and J. Wilmore. 1995. "Physical Activity and Public Health: A Recommendation from the Centers for Disease Control and Preventions and the American College of Sports Medicine." *Journal of the American Medical Association* 273:402–7.

Paterson, D. H., G. R. Jones, and C. L. Rice. 2007. "Ageing and Physical Activity: Evidence to Develop Exercise Recommendations for Older Adults." *Canadian Journal of Public Health*, 98, S69–108.

Patterson, P. K., and Chapman, N. J. (2004). "Urban Form and Older Residents' Service Use, Walking, Driving, Quality of Life and Neighborhood Satisfaction." *American Journal of Health Promotion* 19:45–52.

Piro, F. N., O. Noss, and B. Claussen. 2006. "Physical Activity among Elderly People in a City Population: The Influence of Neighbourhood Level Violence and Self Perceived Safety." *Journal of Epidemiology and Community Health* 60:626–32.

Plotnikoff, R., A. Mayhew, N. Birkett, C. Loucaides, and G. Fodor. 2004. "Age, Gender and Urban-Rural Differences in the Correlates of Physical Activity." *Preventive Medicine* 39:1115–25.

Pollock, M. L., J. F. Carroll, and J. E. Graves. 1991. "Injuries and Adherence to Walk/Jog and Resistance Training Programs in the Elderly." *Medicine and Science in Sports and Exercise* 23: 1194–200.

Peters, A, E. Liu, R. L. Verrier, J. Schwartz, D. R. Gold, and M. Mittleman, J. Baliff, A. Oh, G. Allen; K. Monahan, and D Dockery. 2000. "Air Pollution and Incidence of Cardiac Arrhythmia." *Epidemiology* 11:11–17.

Pope, C. A.III, R. T. Burnett, M. J. Thun, E. E. Calle, D. Krewski, and K. Ito, and G.D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-Term Exposure to Fine Particulate Air Pollution." *Journal of the American Medical Association* 287:1132–41.

Pratt, M., C. A. MAcera, and G. Wang. 2000. "Higher Direct Medical Costs Associated with Physical Inactivity." *The Physician and Sports Medicine* 28:63–70.

Purser, J. L., M. Weinberger, H. J. Cohen, C. F. Pieper, M. C. Morey, T. Li, G. R. Williams, and P. Lapuerta. 2005. "Walking Speed Predicts Health Status and Hospital Costs for Frail Elderly Male Veterans." *Journal of Rehabilitation Research and Development* 42: 535–46.

Rasinaho, M., M. Hirvensalo, R. Leinonen, T. Lintunen, and T. Rantanen. 2006. "Motives for and Barriers to Physical Activity among Older Adults with Mobility Limitations." *Journal of Aging and Physical Activity* 15:90–102.

Ravaglia, G., P. Forti, A. Lucicesare, N. Pisacane, E. Rietti, M. Bianchin, and E. Dalmonte. 2008. "Physical Activity and Dementia Risk in the Elderly: Findings from a Prospective Italian study." *Neurology* 70:1786–94.

Reed, J., L. Malvern, S. Muthukrishnan, R. Hardy, and L. King. 2008. "An Ecological Approach with Primary-Care Counseling to Promote Physical Activity." *Journal of Physical Activity and Health* 5:169–83.

Retting, R. A., S. A. Ferguson, and A. T. McCartt. 2003. "A Review of Evidence-Based Traffic Engineering Measures Designed to Reduce Pedestrian-Motor Vehicle Crashes." *American Journal of Public Health*. 93:1456–63.

Richard, L., L. Gauvin, C. Gosselin, and S. Laforest. 2009. "Staying Connected: Neighbourhood Correlates of Social Participation among Older Adults Living in an Urban Environmental in Montreal, Quebec." *Health Promotion International* 24:46–57.

Rosenberg, D. E., J. Kerr, J. F. Sallis, K. Patrick, D. J. Moore, and A. King. 2009. "Feasibility and Outcomes of a Multilevel Place-Based Walking Intervention for Seniors: A Pilot Study." *Health & Place* 15:173–9.

Rosenbloom, S. 2004. "Mobility of the Elderly: Good News and Bad News." In *Transportation in an Aging Society: A Decade of Experience*, 3–21. Washington, DC: The Transportation Research Board, eds.

Saelens, B. E., and Handy, S. L. (2008). "Built Environment Correlates of Walking: A Review." *Medicine and Science in Sports and Exercise* 40:S550–66.

Saelens, B. E., and C. Papadopoulos. 2008. "The Importance of the Built Environment in Older Adults' Physical Activity: A Review of the Literature." *Washington State Journal of Public Health Practice* 1:13–21.

Sallis, J. F., A. C. King, J. R. Sirard, and C. L. Albright. 2007. "Perceived Environmental Predictors of Physical Activity Over 6 Months in Adults: Activity Counseling Trial." *Health Psychology* 26:701–9.

Sallis, J. F., and J. Kerr. 2006. "Physical Activity and the Built Environment." *President's Council on Physical Fitness and Sports* 7:1–8.

Satariano, W. A., S. L. Ivey, and E. Kurtovich, Kealey M., Hubbard A.E., Bayles C.M., Bryant L.L., Hunter R.H., and Prohaska T.R. 2010. "Lower-Body Function, Neighborhoods, and Walking in an Older Population." *American Journal of Preventive Medicine* 38:419–28.

Schoenborn, C.A., J. L. Vickerie, and Powell-Griner, E. 2006. Health Characteristics of Adults 55 Years and Over: United States, 2000-2003. *Advance Data from Vital and Health Statistics, 370*. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics. Accessed from http://www.cdc.gov/nchs/data/ad/ad370.pdf.

Schootman, M., E. M. Andresen, F. D. Wolinsky, T. K. Malmstrom, J. P. Miller, and D. K. Miller. 2006. Neighborhood Conditions and Risk of Incident Lower-Body Functional Limitations among Middle-Aged African Americans. *American Journal of Epidemiology* 163, 450–8.

Sheffield, K. M., and M. K. Peek. 2009. "Neighborhood Context And Cognitive Decline In Older Mexican Americans: Results From The Hispanic Established Populations For Epidemiologic Studies Of The Elderly." *American Journal of Epidemiology* 169:1092–101.

Shigematsu, R., J. F. Sallis, T. L. Conway, B. E. Saelens, L. D. Frank, K. L. Cain, J. E. Chapman, and A. C. King. 2009. "Age Differences in the Relation of Perceived Neighborhood Environment to Walking. *Medicine & Science in Sports & Exercise* 41:314–21.

Shin, Y. 1999. "The Effects of a Walking Exercise Program on Physical Function and Emotional State of Elderly Korean Women." *Public Health Nursing* 16:146–54.

Shores, K. A., S. T. West, D. S. Theriault, and E. A. Davison. 2009. "Extra-Individual Correlates of Physical Activity Attainment in Rural Older Adults." *Journal of Rural Health* 25:211–8.

Shumway-Cook, A., A. Patla, A. L. Stewart, L. Ferrucci, M. A. Ciol, and J. M. Guralnik. 2005. "Assessing Environmentally Determined Mobility Disability: Self-Report Versus Observed Community Mobility." *Journal of the American Geriatrics Society* 53:700–4.

Simonsick, E. M., J. M. Guralnik, S. Volpato, J. Balfour, and L. P. Fried. 2005. "Just Get Out the Door! Importance of Walking Outside the Home for Maintaining Mobility: Findings from the Women's Health and Aging Study." *Journal of the American Geriatrics Society* 53:198–203.

Sjosten, N., and S. L. Kivela. 2006. "The Effects of Physical Exercise on Depressive Symptoms among the Aged: A Systematic Review." *International Journal of Geriatric Psychiatry* 21:410–18.

Slingerland, A. S., F. J. van Lenthe, J. W. Jukema, C. B. Kamphuis, C. Looman, K. Giskes, M. Huisman, K. M. Narayan, J. P. Mackenbach, and J. Brug. 2007. "Aging, Retirement, and Changes in Physical Activity: Prospective Cohort Findings from the GLOBE Study." *American Journal of Epidemiology* 165:1356–63.

Smith, T. C., D. L. Wingard, B. Smith, D. Kritz-Silverstein, and E. Barrett-Connor. 2007. "Walking Decreased Risk of Cardiovascular Disease Mortality in Older Adults with Diabetes." *Journal of Clinical Epidemiology* 60:309–17.

Southern, D. A., L. McLaren, P. Hawe, M. L. Knudtson, and W. A. Ghali. 2005. "Individual-Level and Neighborhood-Level Income Measures: Agreement and Association with Outcomes in a Cardiac Disease Cohort." *Medical Care* 45:1116–22.

Spirduso, W. W., and D. L. Cronin. 2001. "Exercise Dose-Response Effects on Quality of Life and Independent Living in Older Adults." *Medicine and Science in Sports and Exercise* 33:S598–608.

Strath, S., A. Swartz, S. Parker, N. Miller, and L. Cieslik. 2007. "Walking and Metabolic Syndrome in Older Adults." *Journal of Physical Activity and Health* 4:397–410.

Sturm, R., and D. A. Cohen. 2004. "Suburban Sprawl and Physical and Mental Health." *Public Health* 118:488–96.

Sundquist, K., G. Frank, and J. Sundquist. 2004. "Urbanisation and Incidence of Psychosis and Depression: Follow-Up Study of 4.4 Million Women and Men in Sweden." *British Journal of Psychiatry* 184:293–8.

Takahashi, H., S. Kuriyama, Y. Tsubono, N. Nakaya, K. Fujita, Y. Nishino, D. Shibuya, and I. Tsuji. 2007. "Time Spent Walking and Risk of Colorectal Cancer in Japan: The Miyagi Cohort Study." *European Journal of Cancer Prevention* 16:403–8.

Talbot, L. A., J. M. Gaines, T. N. Huynh, and E. J. Metter. 2003. "A Home-Based Pedometer-Driven Walking Program to Increase Physical Activity in Older Adults with Osteoarthritis of the Knee: A Preliminary Study." *Journal of the American Geriatrics Society* 51:387–92.

Tanaka, H., M. J. Reiling, and D. R. Seals. 1998. "Regular Walking Increases Peak Limb Vasodilatory Capacity of Older Hypertensive Humans: Implications for Arterial Structure." *Journal of Hypertension* 16:423–8.

Taylor, L., F. Whittington, C. Hollingsworth, M. Ball, S. King, V. Patterson, S. Diwan, C. Rosenbloom, and A. Neel. 2003. "Assessing the Effectiveness of a Walking Program on Physical Function of Residents Living in an Assisted Living Facility." *Journal of Community Health Nursing* 20:15–26.

Thompson, D. L., E. M. Krumm, O. L. Dessieux, and P. Andrews. 2006. "Pedometer-Measured Walking and Risk Factors for Disease." *Southern Medical Journal* 99:100–1.

Troiano, R. P., D. Berrigan, K. W. Dodd, L. C. Masse, T. Tilert, and M. McDowell. 2008. "Physical Activity in the United States Measured by Accelerometer." *Medicine & Science in Sports & Exercise* 40:181–8.

Troped, P. J., R. P. Saunders, R. R. Pate, B. Reininger, J. R. Ureda, and S. J. Thompson. 2001. "Associations between Self-Reported and Objective Physical Environment Factors and Use of a Community Rail-Trail." *Preventive Medicine* 32:191–200.

Tucker-Seeley, R. D., S.V. Subramanian, Y. Li, and G. Sorensen. 2009. "Neighborhood Safety, Socioeconomic Status, and Physical Activity in Older Adults." *American Journal of Preventive Medicine* 37:207–13.

Tully, M. A., M. E. Cupples, W. S. Chan, K. McGlade, and I. S. Young. 2005. "Brisk Walking, Fitness, and Cardiovascular Risk: A Randomized Controlled Trial in Primary Care." *Preventive Medicine* 41:622–8.

US Department of Health and Human Services. 1996. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services & Centers for Disease Control and Prevention.

US Department of Health and Human Services. 2008. Physical Activity Guidelines for Americans. http://www.health.gov/PAGuidelines/guidelines/.

US Department of Transportation. 2003. *Safe Mobility for a Maturing Society: Challenges and Opportunities*. Washington, DC: US Department of Transportation. November.

Väkevä, M., K. Hämeri, M. Kulmala, R. Lahdes, J. Ruuskanen, and T. Laitinen. 1999. "Street Level Versus Rooftop Concentrations of Submicron Aerosol Particles and Gaseous Pollutants in an Urban Street Canyon." *Atmospheric Environment* 33:1385–97.

Wen, M., K. A. Cagney, and N. A. Christakis. 2005. "Effect of Specific Aspects of Community Social Environment on the Mortality of Individuals Diagnosed with Serious Illness." *Social Science & Medicine* 61:1119–34.

Wert, D. M., J. B. Talkowski, J. Brach, and J. Van Swearingen. (2010). "Characteristics of Walking, Activity, Fear of Falling, and Falls in Community-Dwelling Older Adults by Residence." *Journal of Geriatric Physical Therapy* 33:41–5.

Wight, R. G., J. R. Cummings, A. S. Karlamangla, and C. S. Aneshensel. 2009. "Urban Neighborhood Context and Change in Depressive Symptoms in Late Life." *Journal of Gerontology: Social Sciences* 64B:247–51.

Wilcox, S., C. Castro, A. C. King, R. A. Houseman, and R. Brownson. 2000. "Determinants of Leisure Time Physical Activity in Rural Compared with Urban Older and Ethnically Diverse Women in the United States." *Journal of Epidemiology and Community Health* 54:667–72.

Wong, C. H., S. F. Wong, W. S. Pang, M. Y. Azizah, and M. J. Dass. 2003. "Habitual Walking and its Correlation to Better Physical Function: Implications for Prevention of Physical Disability in Older Persons." *Journals of Gerontology A Biological Sciences and Medical Sciences* 58:555–60.

Yen, I. H., Y. L. Michael, and L. Perdue. 2009. "Neighborhood Environment in Studies of Health of Older Adults: A

Systematic Review. *American Journal of Preventive Medicine* 37:455–63.

Yeom, H. A., J. Fleury, and C. Keller. 2008. "Risk Factors for Mobility Limitation in Community-Dwelling Older Adults: A Social Ecological Perspective." *Geriatric Nursing* 29:133–40.

Zhou, Y., and J. I. Levy. 2008. "The Impact of Urban Street Canyons on Population Exposure to Traffic-Related Primary Pollutants." *Atmospheric Environment* 42:3087–98.

Zoumakis, N. M. 1995. "A Note on Average Vertical Profiles of Vehicular Pollutant Concentrations in Urban Street Canyons." *Atmospheric Environment* 29:3719–372.

Bios

Jacqueline Kerr is an assistant professor at the University of California, San Diego in the department of Family and Preventive Medicine. Her research focuses on Ecological interventions to promote physical activity in older adults, and using technology to better assess behaviors and environments.

Dori Rosenberg is an assistant scientific investigator at the Group Health Research Institute in Seattle, WA. Her research focuses on physical activity promotion among older adults and better understanding built environment barriers to lifestyle activity and mobility in aging populations.

Lawrence Frank is a professor and the Bombardier Chairholder in Sustainable Transportation at the University of British Columbia and President of Urban Design 4 Health, Inc. He specializes in the interaction between land use, travel behavior, air quality; and health and the fuel consumption and climate change impacts of transportation and urban form policies.