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Research Articles

The Role of the Built Environment in Individuals with Mobility Disabilities' Physical Activity

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Abstract: This study explored the relationship between the built environment and the health behaviors of individuals with mobility disabilities. The findings suggest that individuals with mobility disabilities are likely to participate in light recreation activities more often if there are opportunities to do so within convenient pedestrian distance of their residence.

Keywords: disability, health behavior, recreation, pedestrian

Introduction

There are strong demonstrated associations between physical activity and health. Community-scale urban design and land use policies and practices may increase physical activity through sidewalks, bicycle lanes, nearby parks and open space, mixed land uses, and the connectivity, aesthetic and safety aspects of the street-scale built environment (Taylor & Lou, 2011; Heath, Brownson, Kruger, Miler, Powell & Ramsey, 2006; Saelens & Handy, 2008; Mowen, 2010; Kaczynski & Henderson, 2007). The design of the built environment is an important factor in the health of the general population (Jackson, 2003).

The impact of the built environment on health behaviors appears to be different across various demographic subgroups (Kremmers, De Bruijn, Visscher, Mechelen, De Vries & Brug et al., 2006). Individuals with disabilities represent 12% of the total population of the United States (Census, 2010), yet research on the impact of the built environment on the health behaviors, particularly physical activity, of individuals with disabilities, is limited (Rimmer, Riley, Wang, Rauworth & Jukowski et al., 2004). Although limited, these studies suggest that the aspects of the built environment that increase physical activity among the general population may facilitate physical activity in disabled populations (Spivok, Gauvin, Riva & Brodeur et al., 2008). However, these studies have primarily assessed accessibility to recreation programs and fitness facilities (Rimmer et al., 2004; Christensen, Holt & Wilson et al., 2010; Rimmer, Riley, Wang & Rauworth et al., 2005), environmental supports that effect physical activity (Spivok, 2008; Spivok, Gauvin & Brodeur et al., 2007), and community mobility as influenced by the built environment (Shumway-Cook, Patla, Stewart, Ferrucci, Ciol & Guralmik et al., 2002).

There is a significant need to address the information gap which persists regarding the effects of the built environment on the physical activity of individuals with disabilities. Built environment characteristics such as pathway texture, disconnected pedestrian ways, signage, and slope become more influential on individuals with disabilities' participation in physical activity than they do for in comparison to individuals without disabilities (Spivok et al., 2007), in addition to chronically inaccessible built environments (Spivok et al., 2008).

disability during January and February 2012. The questionnaire was also available in Spanish, with one respondent completing the Spanish language version.

Environment and Physical Activity Questionnaire

The self-administered survey instrument is based on an existing validated instrument, the Physical Activity Scale for Individuals with Physical Disabilities (PASIPD) (Washburn, Zhu, McAuley, Frogley & Figoni et al., 2002). PASIPD has been shown to provide accurate and reliable information regarding the physical activity of individuals with disabilities, where greater flexibility in

These conditions may result in fewer opportunities to engage in beneficial health behaviors (Rimmer et al., 2004), contributing to an increased risk for sedentary behavior and the associated disparities which persist in nearly every aspect of health among individuals with disabilities (AHRQ, 2007). Only 36% of individuals with disabilities engage in physical activity with some demographics reporting only 8% (Rimmer, 1999) in comparison to 56% of individuals without disabilities who engage in physical activity (Rimmer et al., 2004). The prevalence of sedentary behaviors among individuals with disabilities increases their susceptibility to chronic diseases and secondary health conditions (Rimmer, Braddock & Pitetti et al., 1996; Dannenberg, Jackson, Frumkin, Schieber, Pratt, Kochtitzky & Tilson et al., 2003). There is a need to address the effects of the built environment on the physical activity of individuals with disabilities.

Research Objectives

The purpose of this pilot study is to explore the role the built environment plays in relation to the health behaviors of individuals with disabilities, specifically physical activity. To do so, three research questions were examined: To what extent the physical activity of individuals with disabilities are affected by (1) the presence of public park space; (2) the connectivity of pedestrian infrastructure; and (3) the diversity of land use in the community. These built environment factors are some of those which have been shown to be related to the physical activity rates of the general population.

Methods

Population

The study setting corresponds with the U.S. Census designated Ogden-Clearfield metropolitan/micropolitan statistical area (MSA) in north central Utah, which encompasses 1,489 square miles of land area reflecting development and land use diversity patterns consistent with typical U.S. suburban/urban communities, a land use pattern assumed to be more likely to include the environmental factors of interest (public park space, pedestrian infrastructure, and diverse land uses in close proximity). The Ogden-Clearfield MSA has a population of 547,184 of which 49.8% are female, 88.1% are white, and 11.8% are Hispanic or Latino. Of the total population, 319,808 individuals are between 18 and 64 years of age, of which 8.1% (24,942) report being individuals with disabilities, and 3.4% (10,813) report having ambulatory difficulty.

The study focused on individuals with mobility/physical disabilities 18 years of age and older residing in the study setting. As there is wide variability in type and degree of disability, individuals with mobility/physical disabilities were included under the assumption that the physical activity of such would most likely be impacted by the built environment, and that the identified impacts may generalize to the larger population of individuals with disabilities. Participants self-identified themselves as individuals with a mobility/physical disability.

A self-administered Environment and Physical Activity Questionnaire was mailed to a sample population of 1040 individuals 18 years of age and older identified as having a physical reporting rate and intensity is required. The PASIPD was primarily modified to reflect a focus on the built environment. The resulting Environment and Physical Activity Questionnaire (EPAQ) is divided into eight short sections to assess basic demographics, the built environment context, and the major types of physical activity; stationary activities, non-leisure time pedestrian activities (activities of daily living), light recreational activities, moderate recreational activities, strenuous recreational activities, and muscle strengthening exercise activities.

The demographic section includes routine questions regarding age, gender, disability type, employment, and education. These questions were used to verify participant inclusion. Participants were also asked to rate their level of physical activity (Not active at all, Moderately active, Active, or Extremely active) and current health (Excellent, Good, Fair, or Poor).

The six physical activity sections were each a six part question differing only in the type of physical activity being assessed. Each section's questions include, for light recreational activities:The six questions are listed in Table 1.

Table 1
Sample physical activity questions.

During the past 7 days, how often did you engage in light sport or recreational activities such as bowling, golf with a cart, hunting or fishing, darts, billiards or pool, therapeutic exercise (physical or occupational therapy, stretching, use of a standing frame) or other similar activities?
Never (instructed to proceed to next section)
Seldom (1-2 days)
Sometimes (3-4 days)
Often (5-7 days)
On average, how many hours per day did you spend in these light sport or recreational activities?
Less than 1 hour
1-2 hours
2-4 hours

More than 4 hours
What was your primary activity?
Open-ended response
Are you able to do this activity within four blocks of your home?
Yes
No
Do you do this activity in a:
Public space or facility?
Private space or facility?
Do you require personal assistance to participate in your primary activity?
Yes
No

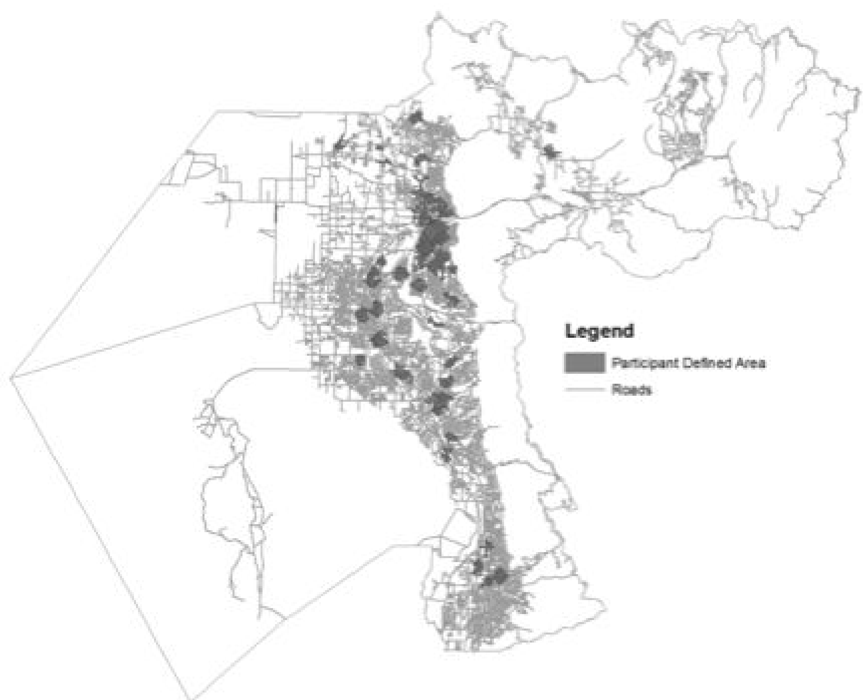
The built environment section asked participants to indicate the address of the street intersection nearest their home. This information was used to spatially model each respondent's immediate built environment, as was necessary to measure the built environment factors described below. Participants were also asked to assess the quality and ADA (Americans with Disabilities Act) accessibility of the sidewalks, public parks, and private recreation facilities within four blocks of their home (Excellent, Good, Fair, Poor, N/A). In addition, participants were asked whether their ability to participate in physical and recreational activities outside their home is affected by weather conditions.

Environment Factors

Based on the nearest street intersection for each respondent, a unique participant defined area (PDA) was calculated as a one kilometer network buffer using a geographic information system (GIS). One kilometer was selected to represent the distance an individual would be most likely to experience as a pedestrian (Lovasi, Moudon, Pearson, Hurvitz, Larson & Siscovick et al., 2008). Additionally, the distinction between perceived characteristics and objectively measured characteristics of the built environment breaks down beyond one kilometer (Lovasi et al., 2008). A network buffer, shown to provide more accurate representation than a circular area, with a 50 meter buffer depth was chosen to ensure that land use along the selected automobile/pedestrian network would be included, but that land not readily accessible from the automobile/pedestrian network would not be (Oliver, Schuuman & Hall et al., 2007). Each of the built environment factors was determined according to individual PDAs, which are shown in Figure 1. To be more easily understood by participants, the Environment and Physical Activity

Questionnaire described the one kilometer measure of the likely pedestrian environment, as the area within four blocks of the participant's home.

Figure 1. *Participant defined areas within the study setting*



Alternative text description – The image depicts all participant defined areas indicated within the study setting of Davis and Weber counties.

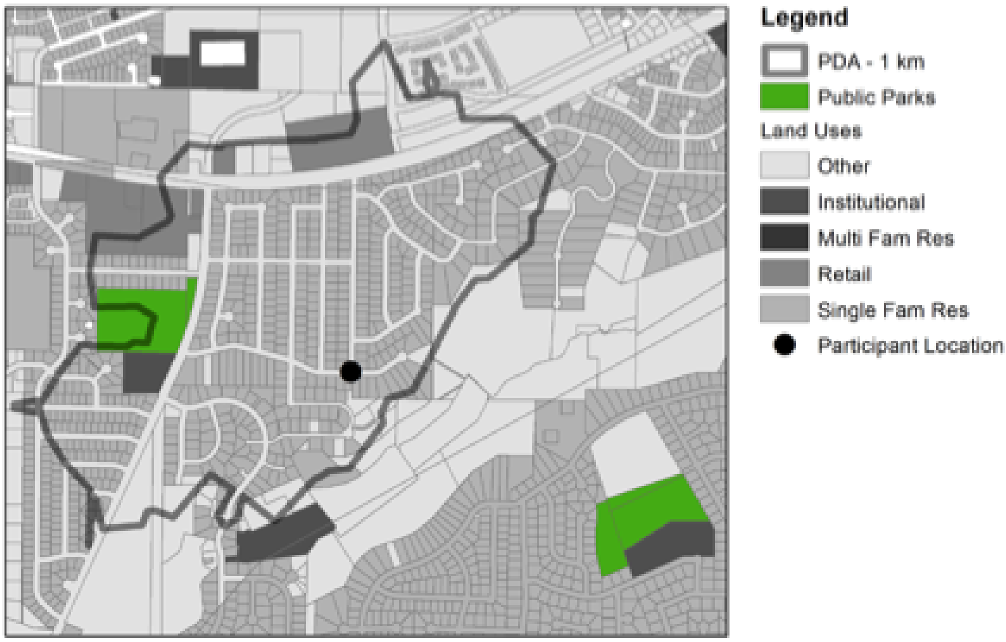
Land Use Diversity

The descriptive measure of pedestrian-oriented land use diversity is an entropy score describing the diversity of the distribution of four land use categories for each PDA determined according to the following equation;

$$\text{entropy} = - \{\sum_k [(pi)(\ln pi)]\} / (\ln k)$$

where is the percentage of each of the land uses and k is the number of land uses. The equation results in a normalized value between 0 and 1 (where each land use is 1/4th of the total), the larger value representing greater diversity of land use. The four land use types considered are single family residential, multi-family residential, retail and services, and institutional. These land use types, and their description by entropy score, have been found to be a significant predictor of pedestrian behaviors (Brown, Yore, Ham & Macera et al., 2005; Brown, Yamada, Smith, Zick, Kowaleski-Jones & Fan et al., 2009) in suburban/urban environments. An example of the land use diversity and distribution for one PDA may be seen in Figure 2, the entropy score for which is .4618 due to the predominance of single family residential land use.

Figure 2. *Environment factors for an example participant defined area*



Alternative text description – The image illustrates the public parks and various land uses within one participant defined area. The area is primarily comprised of single family residences, with some retail, multi-family residences and two public parks.

Public Parks

The descriptive measure of public park space is the percentage of each PDA's land area designated as public park space. The location and spatial configuration of over 200 public park spaces for the study setting were identified manually in the GIS system using each municipality's and county's addresses for public parks. An example of the public park distribution for one PDA may be seen in Figure 2, the percentage of which is 2.65.

Pedestrian Connectivity

The pedestrian network is defined as constructed pathways providing pedestrian circulation typical to the built environment (i.e. sidewalks, hiking trails, etc.). The location and spatial configuration of the pedestrian network were derived from roadways generally associated with pedestrian improvements (residential streets, collectors, etc.). The descriptive measure for pedestrian connectivity is the number of roadway intersections per PDA. This method has been shown to be an effective measure of pedestrian connectivity associated with physical activity (Saelens, Sallis & Frank et al., 2003) in suburban/urban environments.

Results

Ninety-four individuals returned questionnaires (9% overall response rate), only sixty four of which were completed sufficiently for inclusion in the study (6.2% effective response rate).

Of these, forty seven were completed by individuals who self-reported possessing a mobility/physical disability (17 were excluded; 4.5% inclusion rate). A general description of participant responses is presented in Table 21. Response Frequencies. Respondents' overall participation in stationary activity is high and, as was expected, participation in physical activity is low (see Table 32. Activity Participation Rates). Table 43 provides a synopsis of the study findings, the specifics of which are reported hereafter.

Table 2
Response Frequencies (%)

What is your age?	
18-34 years	10.6
35-51 years	25.5
52-64 years 65 years and over	31.9 31.9
What is your gender?	
Male	31.9
Female	68.1
Are you currently employed?	
No	80.9
Yes	19.1
Are you currently in school?	
No	89.4
Yes	10.6
How would you rate your level of physical activity?	
Not active at all	36.2
Moderately active	57.4
Active	4.3
Extremely active	2.1
How would you rate your current health?	

Excellent	6.4
Good	31.9
Fair	44.7
Poor	17.0
How ADA accessible are the sidewalks within four blocks of your home?	
Excellent	17.0
Good	29.8
Fair	31.9
Poor	21.3
How ADA accessible are the public parks or facilities within four block of your home?	
Excellent	17.4
Good	19.6
Fair	30.4
Poor Not Available	17.4 15.2
How ADA accessible are the private facilities within four blocks of your home?	
Excellent	4.4
Good	22.2
Fair	11.1
Poor Not Available	15.6 46.7
Is your ability to participate in physical and recreational activities outside your home affected by the weather? (Hot or cold temperatures, Ice/snow conditions, Rainy/wet weather, Sunny conditions)	
Yes	78.7
No	21.3

Alternative text description – Table 2 "Response Frequencies (%)" displays percentages of respondents' answers to questions including: Age, gender, employment status, school status, physical activity, current health, ADA accessibility near one's home (sidewalks, public parks, private facilities), and weather and how it might affect one's ability to participate in physical and recreational activities.

Table 3.
Activity Participation Rates (%)

	Never	Seldom (1-2 days)	Sometimes (3-4 days)	Often (5-7 days)
9. During the past 7 days how often did you engage in *stationary activities*?				
	4.3	12.8	12.8	70.2
10. During the past 7 days, how often did you *walk or wheel* outside your home other than specifically for exercise?				
	17.0	21.3	27.7	34.0
11. During the past 7 days, how often did you engage in *light sport* or *recreational activities*?				
	59.6	19.1	17.0	4.3
12. During the past 7 days, how often did you engage in *moderate sport* and *recreational activities*?				
	82.6	15.2	2.2	-
13. During the past 7 days, how often did you engage in *strenuous sport* and *recreational activities*?				
	89.4	8.5	2.1	-
14. During the past 7 days, how often did you do any exercise specifically to *increase muscle strength* and *endurance*?				
	52.2	13.0	19.6	15.2

Alternative text description – Table 3 "Activity Participation Rates (%)" displays percentages of respondents' answers to questions about physical activity.

Table 4
Activity Participation Correlation with Built Environment Factors

	Within 4 blocks	Public Parks	Pedestrian Connectivity	Land Use Diversity

	of home			
Stationary Activities				
Walk/Wheel outside the home				Negative
Light Sport or Recreation	Positive			Negative
Moderate Sport or Recreation				
Strenuous Sport or Recreation				
Muscle Strength or Endurance Exercise	Positive		Negative	

Alternative text description – Table 4 "Activity Participation Correlation with Built Environment Factors" provides a synopsis of the study findings, the specifics of which are reported hereafter.

Linear regression analysis conducted to predict physical activity participation levels from the built environment predictors (public parks, pedestrian connectivity, and land use diversity) did not indicate that the variables were linearly related, with the exception of muscle strengthening activity and pedestrian connectivity. The results indicate a moderate correlation (-.308) such that as the overall pedestrian connectivity increases participants engaged in muscle strengthening activity less. The regression line equation is:

$$\textit{Predicted Muscle Strengthening} = -0.13\ \textit{Pedestrian Connectivity} + 2.966$$

The 95% confidence interval for the slope is -.025 to -.001. Approximately 10% of the change in how often participants engaged in muscle strengthening activity was accounted for by its linear relationship with the surrounding pedestrian connectivity.

An independent-samples *t* test was conducted to evaluate whether individuals with mobility disabilities participate in physical activity more often if they have opportunities to do so within 4 blocks of their home, a convenient pedestrian distance. Each respondents' physical activity rate was grouped as either seldom (0-2 days per week) or regularly (3-7 days per week). The test was significant for light recreation ($t(19) = 2.85$, $p = .01$), as individuals who are able to do so within four blocks of their home engage in light recreation ($M = 1.60$, $SD = .507$) more often than those who do not ($M = 1.00$, $SD = .000$). This test also indicates that those who are unable to participate in light recreation within four blocks of their home do not participate at all. Participants reported that these light recreation activities included walking, shopping, and physical therapy performed at home.

The test was also significant for muscle strengthening activity ($t(18) = 2.65$, $p = .016$), as individuals who are able to do so within four blocks of their home engage in muscle strengthening activity ($M = 1.70$, $SD = .483$) more often than those who do not ($M = 1.18$, $SD = .405$). The majority of the activities participants reported as their primary activity were therapeutic in nature (resistance bands, stretching, walking, etc.). Further, the majority of participants reported engaging in these activities less than one hour daily (70.4%) in a private space or facility (72.7%), suggesting that these activities are taking place at home.

Independent-samples t tests were not conducted for moderate or strenuous physical activity participation as only one participant indicated participating often in moderate physical activity and one in strenuous physical activity.

A linear regression conducted to predict how often participants walked/wheeled outside their home from the environmental predictors (public parks, pedestrian connectivity, and land use diversity) indicated that land use diversity is moderately related (-.37) such that as overall land use diversity increases participants walk/wheel outside their home less. The regression equation is:

$$\textit{Predicted Walk/Wheel} = -1.971 \textit{ Land Use Diversity} + 4.068$$

The 95% confidence interval for the slope is -3.475 to -.468. Approximately 13% of the change in how often participants walked/wheeled outside their home was accounted for by its linear relationship with the surrounding land use diversity.

Binary logistic regression to predict participation in light recreation or muscle strengthening exercise, grouped as either seldom (0-2 days per week) or regularly (3-7 days per week), from the environmental predictors (public parks, pedestrian connectivity, and land use diversity) indicated that individuals with mobility disabilities residing in areas with more diverse land use decreased their odds for participating in light recreation by a factor of .008 ($p = .032$, 95% CI .000 and .649) (omnibus chi-square = 5.315, $df = 1$, $p = .021$). The model accounted for between 12.2% and 20.3% of the change in light recreation participation, with 100% of predictions for those seldom participating in light recreation and 14.3% of predictions for those participating regularly predicted successfully.

A linear regression conducted to predict participants' current health from the environmental predictors (public parks, pedestrian connectivity, and land use diversity) did not indicate a relationship.

Examining where individuals with disabilities are participating in physical activity, whether a public or private space or facility, indicates that the majority of individuals with mobility disabilities use private spaces to participate in light recreation (68.5%), strenuous activity (55.6%), and muscle strengthening exercise (72.7%). Whereas public spaces are used for moderate physical activity (66.7%). That individuals with mobility disabilities are seldom participating in moderate (97.5%) or strenuous (97.6%) physical activity, while higher percentages are participating regularly in light recreation (17.1%) and muscle strengthening exercise (31.7%), suggests that there are not appropriate opportunities available in public spaces or facilities.

Discussion

Given the low number of study participants, the results should be examined with some caution. This study, similar to prior studies (Rimmer, 1999), indicates that individuals with mobility disabilities' participation in almost every form of physical activity is very low. As a result, it is likely that the discernible effects of environmental factors is small. In addition, it is unlikely that a single factor can fully elucidate the complexities of an individual with disability's relationship with the built environment. As such, we would expect the role the built environment plays in relation to the health behaviors of individuals with disabilities to be difficult to identify.

Indeed, at first glance the hypotheses that the physical activity of individuals with mobility disabilities are affected by (1) the presence of public park space; (2) the connectivity of pedestrian infrastructure; and (3) the diversity of land use in the community appear to be false when examined through a straightforward linear regression analysis. Closer examination reveals nuances in this finding.

The results indicate that individuals with mobility disabilities are likely to participate in light recreation activities more often if they have opportunities to do so within four blocks of their place of residence. The Center for Disease Control and Prevention (CDC) has long suggested that adults participate in moderate-intensity physical activity, the equivalent of brisk walking at three to four miles per hour most days of the week (Haskell, Lee, Pate, Powell, Blair, Franklin & Macera et al., 2007). For individuals with mobility disabilities, doing so appears to be related to the environment available as a pedestrian from their place of residence. Further, those individuals with mobility disabilities who do not have opportunities to do so within four blocks of their place of residence do not participate in light recreation activities. Participants indicated that these light recreation activities are primarily pedestrian activities such as walking or shopping. Such findings support earlier findings that the aesthetics and safety aspects of the street-scale built environment, which support pedestrianism, may increase physical activity (Taylor and & Lou, 2011; Heath et al., 2006). For individuals with mobility disabilities, the accessibility characteristics of the street-scale built environment must be added to these qualities. The quality of the street/pedestrian environment, within a walkable distance, is important for the support of individuals with mobility disabilities' participation in light recreation activities.

Similarly, individuals engaging in muscle strengthening activities are more likely to do so within four blocks of their home. Further, participants' reported activities, such as stretching, resistance bands, and walking, emphasize the importance of an individual's home and the immediate pedestrian environment.

Individuals with mobility disabilities indicated that public parks are used for moderate physical activity, however very few participate in moderate physical activity. As the findings suggest that there is not a significant difference in the presence of public parks between participants, it may be that there are not opportunities for physical activity which that are accessible to individuals with mobility disabilities in these parks. Where there are public parks with accessible recreation opportunities within convenient pedestrian distance, individuals with mobility disabilities may be more likely to participate in moderate recreation activities. Future research should examine the impact of public parks more closely.

As the poverty rate among individuals with mobility disabilities is disproportionately high (Erickson, Lee & von Schrader et al., 2012), these opportunities need to occur in close enough proximity as to not require additional transportation costs. Similarly, the results indicate that the majority of individuals with mobility disabilities do not use private recreation facilities, which may be the result of the cost of membership associated with these facilities. These findings underscore the importance of public opportunities within convenient pedestrian distance for individuals with mobility disabilities to engage in recreation activities, particularly those which cannot occur at the individual's residence.

It is likely that the lower socioeconomic level of individuals with mobility disabilities is a major factor in their physical activity opportunities and behavior. Socioeconomic status affects access to and safety for physical activity because of fewer facilities, poorer condition of these facilities, and unsafe environments due to criminal activity, etc. (Wilson, Kirtland, Ainsworth & Addy et al., 2004). As discussed previously, this condition likely resulted in the absence of an association between the presence of public park space or the diversity of land use and physical activity patterns.

The results suggest that land use diversity, or mixed land uses, are correlated with a decrease in participants walking or wheeling outside their home. While mixed land use areas have been shown to be related to the physical activity rates of the general population (Brown et al., 2009), mixed land use areas characterized by lower income generally lack features that support walking, such as well-maintained sidewalks and an aesthetic and safe street-scale environment characterized by trees, pedestrian amenities, and less traffic (Owen, Schuuman & Hall et al., 2004; Humpel, Owen & Leslie et al., 2002). The lack of these features may counter the effect of mixed land use to support pedestrian and physical activity. Similarly, a lack of aesthetic and safe public parks and open spaces, may limit the effects of these environments seen with less vulnerable populations. Future research should examine the relationship between individuals with disabilities, the quality of the built environment, and socioeconomic levels on physical activity as the sample population of this study was too small to examine socioeconomic and other demographic factors.

Future Research

Future research should examine the relationship between individuals with disabilities, the quality of the built environment, and socioeconomic levels on physical activity as the sample population of this study was too small to examine socioeconomic and other demographic factors. This study suggests ample opportunities for future examination, particularly with a larger sample size. Although difficult to acquire, an increased sample size is strongly suggested as individuals with disabilities' participation in physical activity is generally very low, and the complexity of their participation is quite high. For example, this study indicates that over 78% of individuals with mobility disabilities' participation in physical and recreational activities was affected by the weather. Unfortunately, no additional information regarding the impact of weather was collected during this study. Further examination in light of built environment characteristics which may mitigate the effects of weather conditions is warranted. Likewise, the role of social support in mediating participation was not assessed, and is recommended for future study.

An examination of participants' open ended responses to the types of activities in which they participated revealed a great deal of overlap between light, moderate, strenuous, and muscle strengthening physical activity categories, although each survey question included specific examples of each type. Walking, in particular, was noted across every activity, which also highlights the importance of walking as physical activity for individuals with disabilities. Future research involving a similar survey instrument should seek for increased validity of the measure, particularly for light and moderate recreation

Conclusion

While it is unlikely that a single factor can fully explain the complexities of an individual with disability's relationship with the built environment, there is a significant need to address the information gap which persists regarding the effects of the built environment on the physical activity of individuals with disabilities. This study suggests that individuals with mobility disabilities are likely to participate in light recreation activities more often if they have opportunities to do so within a convenient pedestrian distance of their place of residence.

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