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The relations between walkable neighbourhoods and active participation in daily activities of people with disabilities[☆]

Naomi Schreuer^{a,*,1}, Pnina Plaut^b, Golan Lih^b, Sachs Dalia^{a,1}

^a Occupational Therapy Department, Faculty of Welfare & Health Sciences, University of Haifa, Israel

^b Faculty of Architecture and Town Planning, Technion- Israel Institute of Technology, Israel

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ABSTRACT

Introduction: Most research on the built environment and active travel focused on the general population or segments including children, adolescents and older adults. There is limited knowledge regarding the built environment and active participation of people with disabilities. This most vulnerable population is at risk of reduced engagement in physical and social activities and of developing secondary chronic health conditions. The present study examines the relationship between people with disabilities' participation in daily activities, self-reported environmental barriers and objective urban spatial walkability measurements.

Methods: A cross-sectional study was conducted among 137 adults with various disabilities. A self-reported questionnaire collected demographic, residential, disability characteristics, and participation in 41 daily activities data. The Craig Hospital Inventory of Environment Factors (CHIEF) examined perceived environmental barriers. Geographic Information Systems (GIS) analyzed participants' residential neighborhood (street connectivity, land use mix, slope, housing density and socioeconomic status).

Results: significant correlations were found between higher participation of people with physical disabilities and the following urban characteristics: (1) a larger total number of land uses in the neighborhood correlated with increased participation in leisure and cultural activities; (2) lower residential density correlated with a lack of accessible public transportation; and (3) lower slope correlated with increased total participation. Participants living in neighborhoods with low street connectivity perceived more barriers in their neighborhoods.

Conclusion: These urban characteristics are important for enabling engagement in active travel for out-of-home activities. Results may shed light on urban planning for vulnerable populations and on their considerations in choosing a neighborhood for residence.

1. Introduction

In recent years, the urban built environment has been examined as a means of promoting participation in an active life along the life span in the general population. Emphasis is put on walking around the home neighborhood and its spatial characteristics (Huang et al., 2019). However, little research has examined the effect of the urban built environment on participation in activities by people

[☆] The Urban Built Environment as a Barrier or Enabler for Participation in Daily Activities by People with Diverse Disabilities.

* Corresponding author.

E-mail addresses: nschreuer@univ.haifa.ac.il (N. Schreuer), arpnina@technion.ac.il (P. Plaut), lihigol@campus.technion.ac.il (L. Golan), dalia.sachs@research.haifa.ac.il (D. Sachs).

¹ These authors contributed equally to this work.

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with disabilities, those with physical mobility and non-physical disabilities such as sensory and mental disabilities (Evans, 2003; Helbich, 2018; Jeong et al., 2018; Stafford and Baldwin, 2018). In addition, almost no research has combined the analysis of urban environmental characteristics, such as street connectivity, land-use mix and residential density (measured by GIS) with the perceptions of people with diverse disabilities regarding the environmental barriers they experience in participation in active lifestyle. This is the focus of the current study.

1.1. Participation in daily activities

Participation in daily activities has a major positive impact on health and contributes to a sense of accomplishment, satisfaction, self-efficacy, and well-being (Berg et al., 2009; Rimmer et al., 2004). The World Health Organization (WHO, 2001) defines “participation” in its International Classification of Functioning, Disability, and Health (ICF) model as the involvement of a person in roles and activities in daily life, while interacting with their environment. However, the out-of-home environment contains barriers and enablers to participation in activities. Specifically, people with disabilities are at risk for losing the ability to adjust flexibly to environmental barriers and become more amenable to decreased participation (Wettstein et al., 2014, Sugiyama, 2005; Wahl et al., 2012). Furthermore, a barrier-free environment may also slow or even reverse the disablement process or prevent secondary chronic conditions (Clarke et al., 2008; Keysor et al., 2006; Whiteneck et al., 2004).

The importance of the urban environment in maintaining daily activities among people with disabilities is demonstrated in several studies. A study that investigated the role of the built environment in the disablement process found relations between two factors (land use and density) and the reduced activity of people with severe disabilities (Clarke and George, 2005). Few studies (Clarke et al., 2008; Rimmer et al., 2004; Quintas et al., 2014) looked at the built environment as facilitating or hindering an active life style for people with disabilities. Others examined the role of built environment appearing in urban sprawl in influencing the probability of mental illness (Garrido-Cumbrera et al., 2018).

Research shows that individuals who perceive their environment as having a high walkability level tend to maintain an active lifestyle (Timperio et al., 2004). Correspondingly, a correlation was found between the components of the actual built environment and the way that it is perceived (Nathan et al., 2013). This suggests that the relationship between the built environment and an active lifestyle is mediated through the perception of the environment, and thus perceived barriers are important.

Most studies that discuss the interaction between urban characteristics and people with disabilities usually focus on people with physical disabilities. It is assumed that the urban environment may pose greater difficulties and restrictions for this segment of the population because they have physical impairments for mobility. Differences in perceived barriers were found between people with physical mobility disability and non-physical disability (Barnea et al., 2006). The role of objective measures of the built environment for non-physical/mobility disabilities has not been studied. They are not physically restricted but might face other environmental barriers. In this study we wished to understand which urban features affect participation of both groups and which are unique for each group.

1.2. The urban built environment as a facilitator or barrier to participation

In the research literature, the term ‘walkability’ is often used to describe the extent to which walking and/or other non-motorized means of mobility are enabled by the surrounding built environment and so promote an active and healthier lifestyle.

Walkability is made achievable by compact urban planning that includes: mixed land uses, a suitable built density (to ensure that destinations are within walking distance of each other), high street connectivity, structural designs that encourage walking, pedestrian and bicycle infrastructure (Transportation Research Board, 2005).

Increased walkability offers benefits for people with mobility disabilities, especially people relying on wheel-chairs or crutches. In order to participate in out-of-home activities and use services, people have to walk directly, walk to and from the public transportation's stops or walk to their car parking.

The empirical literature identifies three major variables of the neighborhood's spatial layout that determine its walkability level, including: (1) Land uses composite. It is determined by the placement of shops, schools, work places, health and other public services. Walkability is improved when a variety of land uses are located in conjunction with one another. and with residential areas. Thus, creating proximity between different activities; (2) Density— high residential density increases the proximity of different destinations to each other and creates compact environment that improves walkability. (3) The street pattern— walkability is favored when streets are organized in a grid network, thus creating high levels of connectivity and continuity. This pattern provides short and direct routes between the different destinations.

Some research explored built environment design instruments for walkability relevant for people with disability (Gray et al., 2012). They identified pedestrian accessibility, public transportation, parking, recreation accessibility, signage and signal accessibility, and public amenities accessibility (e.g., accessible bathrooms or drinking fountains) as important features. Others (Jeong et al., 2018) developed a framework for pedestrian experience to help identify barriers for walking for people who are mobility challenged.

The novelty of the current study lies in its multidisciplinary examination of environmental barriers to adopting an active lifestyle by combining the objective urban built environment, as measured by GIS data, with the self-perceptions of people with diverse disabilities. Very few studies have engaged in such research to date (Chan et al., 2014; Botticello et al., 2014); and none have compared between groups by disability type, to the best of our knowledge. **The objectives** of this study are: (a) to examine the relationships between participation in daily activities of people with various disabilities, their self-reported environmental barriers and objective urban spatial measurements, as recorded by GIS; (b) to examine the differences between people with physical mobility

disability and people with non-physical disabilities regarding their participation, their perceived barriers and the objective spatial measurements.

2. Methods

The hypotheses tested in this study are:

- (a) Correlations will be found between participation in daily activities of people with various disabilities, self-reported environmental barriers and objective urban spatial measurements, as recorded by GIS.
- (b) Participation in out of home activities by people with physical mobility disability will be more affected by the structure of the urban built environment than for people with non-physical mobility disability.

2.1. Participants

A cross sectional study was conducted among 137 adults with disabilities. Participants were recruited through meetings with disability associations, calls published on social networks, through non-governmental organizations, and via snow ball recruiting. The inclusion criteria were: being of working-age; reporting having a physical, sensory, or mental disability; residing in an urban or suburban residential community; understanding the language of the consent letter and the questionnaires; and not having a significant communication disability. Participants were sought across a broad geographical distribution. The geographical areas were associated to the residence location of participants. It turned out that most participants lived in cities ($n = 128$; 93.4%) close to the main metropolitan area in the center of the country ($n = 116$; 83.4%).

2.2. Research tools

Demographic questionnaire: This self-reported questionnaire collected data concerning each participant's demographic, residential, and disability characteristics.

The Israeli Adults Assessment of Participation (IAASP), (Barnea et al., 2006). The IAASP measures the variety and frequency of participation by adults in 56 daily activities and the amount of satisfaction the participant derives from participating. The current study used the short form of the IAASP, which contains 41 activities divided into seven sub-domains by activity type (Cronbach's Alpha revealed in the current study noted per each): (1) instrumental activities of daily living (IADL) ($\alpha = 0.72$); (2) cultural and social activities ($\alpha = 0.73$); (3) care for others ($\alpha = 0.77$); (4) self-care ($\alpha = 0.31$); (5) leisure at home – low energy activities ($\alpha = 0.59$); (6) study and self-enrichment ($\alpha = 0.63$); and (7) sports – high energy activities ($\alpha = 0.31$). Individuals were asked to self-rate their participation pattern in each activity. The current study used two scales of the tool: the frequency of participation in each activity on a 0–8 ordinal scale; and the amount of satisfaction the participant derived from participating in each activity, on a 1–6 ordinal scale. The tool's validity has been established among older adults with and without disabilities (Barnea et al., 2006). The current study calculated the total mean participation scores for frequency ($\alpha = 0.82$) and satisfaction ($\alpha = 0.88$), and in each of the sub-domain, with a higher mean score indicating activities in which the participant engages more frequently or from which he or she derives greater satisfaction. Test-retest comparison for each of the 41 activities revealed significant and good reliability scores (ranging from 0.553 to 1.00), except for shopping and other out-of-home IADL activities. Factor analysis Varimax rotation revealed eight factors that explained 60% of the variance. Comparison between groups revealed differences between people with physical disabilities, mental disabilities and those without disabilities, mostly in out of home leisure activities, self-care and caring for others (Barnea et al., 2006).

The Craig Hospital Inventory of Environment Factors (CHIEF) (Craig Hospital, 2001). The CHIEF is a self-reported questionnaire that aims to quantify perceived environmental barriers that impede the participation of people with disabilities at home, at work, and in their community (Craig Hospital, 2001). It consists of 25 questions concerning specific barriers that may have posed a problem for participation during the previous 12 months. The questions were divided by authors into 5 domains: attitude and support barriers; services and assistance barriers; physical and structural barriers; policy barriers; and work and school barriers. A high discriminant validity and high test-retest ability have been established for the CHIEF (Craig Hospital, 2001).

Participants were asked to address each CHIEF question on two scales: frequency and magnitude. a) The frequency score was measured on a scale of 0–4 (the barrier is encountered: 0, ever; 1, less than monthly; 2, monthly; 3, weekly; or 4, daily). B) The magnitude score was rated on a scale of 0–2 (the barrier poses: 0, no problem; 1, a small problem; or 2, a big problem). The overall score for each item was calculated as the frequency multiplied by the magnitude to yield a continuous score of 0–8 for each barrier. A high score indicates that the participants perceived the barrier as severe and frequent. For the current study five items were added at the end of the questionnaire, representing lack of resources (e.g. money, time, information). A total barrier level score across the 30 items was calculated as the average frequency-magnitude product score across all completed items. Test-retest comparison revealed for the total score ICC reliability of 0.926. Across all disability sub-groups among 400 subjects, proxy interclass correlations ranged from 0.406 to 0.699 with a total scale of 0.618. Factor analysis revealed five factors accounting for 48% of the cumulative variance across the 25 items. Although people with and without disabilities reported experiencing environmental barriers, the CHIEF differentiated between research and control group and by disability groups (i.e. traumatic brain injury, spinal cord injuries and others) (Craig Hospital., 2001).

The current study revealed Total Cronbach's Alpha $\alpha = .90$.

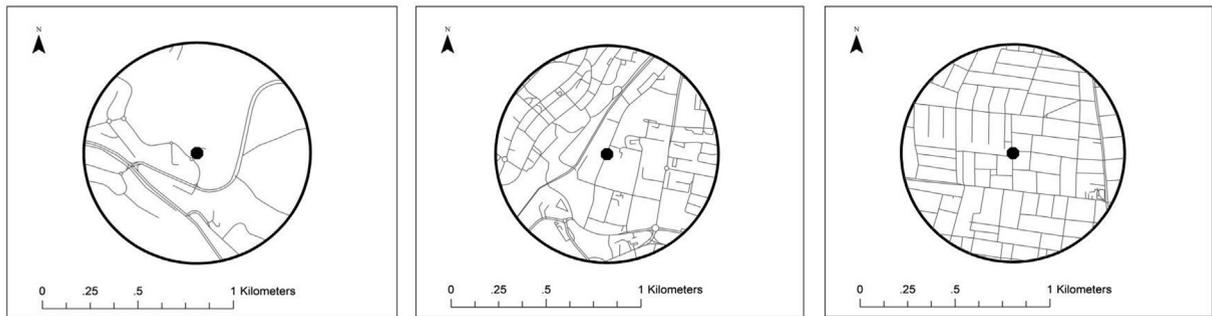


Fig. 1. Examples for classifications of street connectivity (500 m radius from participant street addresses): (a) Score 1 (low street connectivity; suburban); (b) Score 1 (medium street connectivity; suburban); and (c) Score 3 (high street connectivity; urban).

2.2.1. GIS measures of the neighborhood characteristics

GoogleMaps was used to locate the home addresses provided by the 137 individuals with disabilities, who lived in 27 municipalities in Israel.

The neighborhood was defined as a circle with radius of 500 m (radial buffer) centered on each participant's home; The 500 m radius was chosen in line with other studies that defined as a typical walkable distances (Abildso et al., 2007; Van Lenthe, Brug & Mackenbach, 2005). The neighborhood was then examined via GIS in terms of street connectivity, non-residential land use, topographic slope, housing density and socioeconomic status.

Street connectivity. Street connectivity refers to typological distinctions between rectilinear, cul-de-sac and curvilinear layouts, which are evaluated by the street network and the number of intersections per unit-area (Ozbil et al., 2011).

In this study, the street pattern was scored as: 1 (streets with low connectivity within a suburban structure); 2 (streets with medium connectivity within a suburban structure); or 3 (streets with high connectivity, such as a grid layout, within an urban structure) (Fig. 1).

The inter-rated reliability of this classification of street connectivity was tested on-line by 19 professionals in urban and transportation planning, who were asked to rate 18 sets of round maps sampled from the data, similar to the examples in Fig. 1. Intra-correlation coefficient (ICC) analysis revealed very high inter-rated reliability (ICC 0.96, 95% confidence interval; range 0.93–0.98).

Non-residential land use. Mixed land use, especially for various public and commercial services affects accessibility and walkability for users. The GIS provided census data regarding the land uses for the study residential neighborhoods (Israel Census, 2008). All types of land uses other than residential were counted within a radius of 500 m from the identified participant's residence. These land uses contained various services, such as: health services, welfare services, public services, leisure, cultural, recreation, open space and commercial services. For example neighborhood in which many non-residential land uses ($n = 76$) were found, in contrast with another neighborhood in which only few (6) non-residential land uses were found. Fig. 2 demonstrates the results for a specific person. It shows 72 land uses in the close neighborhood around his/her residence.

Topographical slope. This was calculated by the difference between the maximal and the minimal height values within the same circular area (radius 500 m) around each participant's residence. Data for slope calculation was retrieved from GIS topographic maps (XX Census, 2014).

Housing density. This was calculated by dividing the number of households within a specific statistical zone (Israel Census, 2008) by the area of that zone, measured in Dunam (a Dunam is 1000 m^2 , i.e., 0.1 ha).

Socioeconomic status. Socioeconomic status is represented by an index calculated by the XX Central Bureau of Statistics. The level for calculating socio-economic status is "Statistical area" which is comparable to Census Block. The statistical areas are as small and homogeneous as possible, through which the unique characteristics of areas within the locality can be reflected. A statistical area designated for housing is usually between 3,000 and 4,000 persons.

The index includes the following characteristics of the population in the statistical area (Israel Census, 2008): the monetary resources of the population (e.g. salary, benefits); residence characteristics (e.g. property ownership, size of household); equipment in the residence (e.g. air-conditioning, computer, video); car ownership; employment status; education level; and demographic variables (e.g. age, ethnicity, place of birth). These data were available on a scale of 1–20, where 1 represents the lower socio economic status of a statistical zone and 20 represents the highest socio economic status.

2.3. Analyses

Participants who signed a consent form were visited by occupational therapists who administered the three questionnaires, for

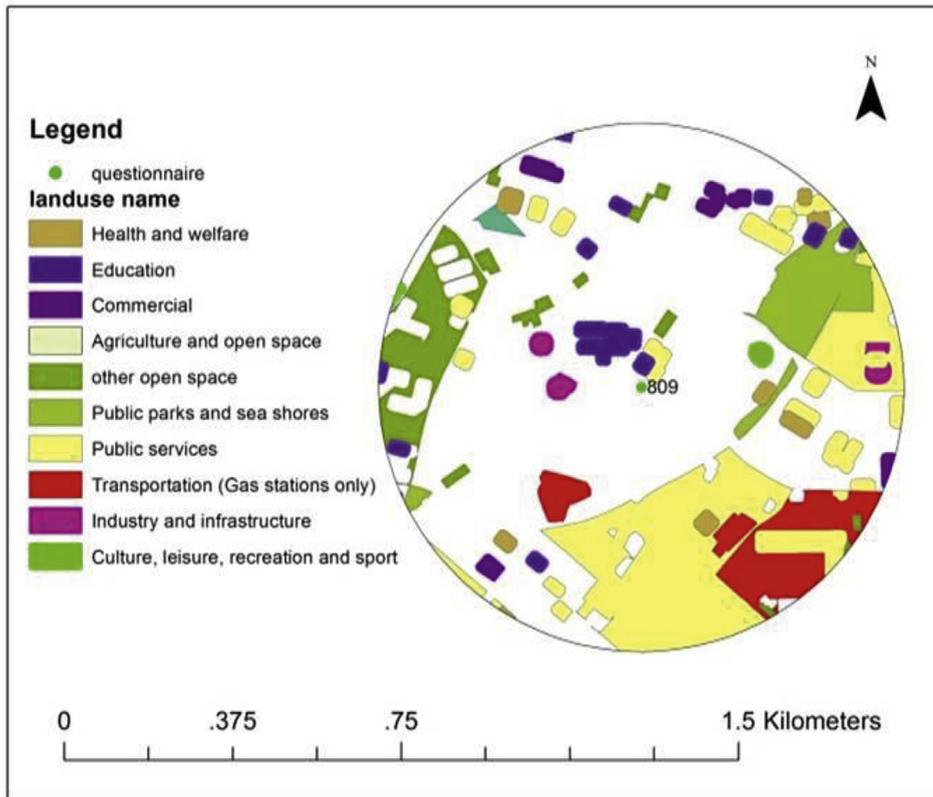


Fig. 2. An example for land use variety (500 m around participants' residence).

about 1.5 h, at their home or at any other preferred location. Each participant's residential address was then identified and analyzed using GIS and Israeli census data.

People with physical mobility disability may be more confined to their home than people with non-physical disability (e.g. sensory or mental disability), which further suggests that they may be more affected by outdoor barriers to participation. In this study we first examined correlations between participation in various activities and environmental barriers (perceived) and urban characteristics (objective measures) for the whole study population. Then, we analyzed data for the perceived (CHIEF) and objective (GIS) barriers with respect to two sub-groups, defined by their disability type. The physical mobility disability group ($n = 79$) comprised those participants with a limitation affecting physical functioning, mobility, dexterity, or stamina. The non-physical disability group ($n = 58$) comprised of participants with a visual disability, hearing disability, or mental disability.

Descriptive statistics were used to describe the population profile and the study variables. Pearson's and Spearman's analyses were employed to examine correlations between participation, perceived participation barriers, and the urban spatial measures (by GIS), according to the variable type. Multivariate Analysis of variance (MANOVA) was conducted to compare participation (the total IAASP scores) and perception of barriers (the total CHIEF scores) between two groups of adults with physical disability group and non-physical disability group; and a univariate ANOVA was used to identify the source of the differences. This study used a significance level of $p = .05$.

3. Results

3.1. Descriptive statistics

The consenting participants ($N = 137$) were aged 21–65 years (mean age = 42.39 years; $SD = 13.89$) and had physical (49%), sensory (9%), or mental health disabilities (42%). Among participants, 46.7% were males and 53.3% were females. The participants included a relatively high number of academic graduates ($n = 35$; 25.2%). A minority of participants were married ($n = 40$; 28.8%) and 27.7% ($n = 38$) had children (mean = 3 children; $SD = 1.3$). Self-reported disability severity level varied from moderate ($n = 44$; 37.8%) to severe or very severe ($n = 58$; 41.7%), while 12 (8.6%) participants did not report their disability severity level. Most participants lived in cities ($n = 128$; 93.4%) close to the main metropolitan area in the center of the country ($n = 116$; 83.4%), and were living by themselves (single, divorced or widowed) at the time of the study. Table 1 summarizes the study population's characteristics.

Table 1
Description of the study population (N = 137).

Variable	Category	N	Percentage
Gender	Male		46.7
	Female		53.3
Marital Status	Single/divorced/widowed		71.2
	Married		28.8
Had children			27.7
			72.3
Education level	Elementary school	12	8.7
	High-school	66	47.4
	Post-secondary	25	18
	Academic	35	25.2
Level of disability	Mild	25	18
	Moderate	44	31.7
	Severe	37	29.1
	Very severe	21	15.1
	Missing	12	8.6
Residence	City	128	92.8
	Village	7	5.0
	Hostel	3	2.2

3.2. Participation in activities by the whole sample

The current study used the IAASP tool to measure the self-reported frequency of participation and the self-reported amount of satisfaction derived from participating in 41 activities spread over seven activity sub-domains. With respect to frequency of participation, the mean sub-domain scores (out of 8, in ascending order) were (Fig. 3): the higher for leisure at home (M = 4.49, SD = 1.63) and self-care (M = 4.25, SD = 1.86) and the lower frequency for sports (M = 1.56, SD = 1.24) and care for others (M = 1.33, SD = 1.45).

The mean scores for the amount of satisfaction participants derived from their participation (out of 6) were almost at the same level for all activities (Fig. 3). They ranged between leisure at home (M = 5.24, SD = 0.82) care for others (M = 4.99, SD = 1.02) and sports (M = 4.90, SD = 0.86); with the lowest score for self-care (M = 4.74, SD = 1.15) and IADL (M = 4.77, SD = 1.17). . Although these findings showed quite high satisfaction, lower scores for frequency of participation were reported in out-of- home activities. This is consistent with our hypothesis that participation in out of home activities by people with physical disabilities will be more affected by the structure of the urban built environment than for people with sensory and mental disability.

3.3. Participation (IAASP) by people with different types of disabilities

A MANOVA analysis of the participation patterns (as measured by the IAASP) of each group revealed significant between-group differences [F(7,129) = 5.06, p < .001, $\eta_p^2 = .22$]. A subsequent ANOVA clarified the differences (Table 2). People with physical

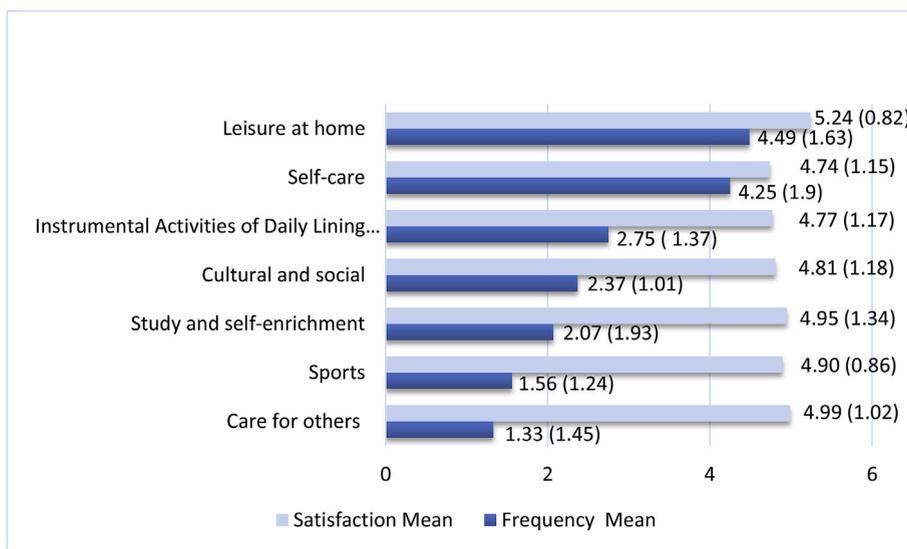


Fig. 3. Participation in activities: Frequency and satisfaction.

* Provided above mean scores (SD); The IAASP ranges for frequency from 0 to 8; and for satisfaction 1–6.

Table 2

Between-group differences in total IAASP participation scores for people with physical-mobility versus people with non-physical disabilities.

Activity Type	Groups by disability type	Mean	S.D.	F value
IADL	Physical-mobility disability	2.37	1.33	15.71***
	Non-physical mobility disability	3.27	1.28	
	Total	2.76	1.38	
Cultural & social	Physical-mobility disability	2.23	.86	4.74*
	Non-physical mobility disability	2.60	1.12	
	Total	2.39	1.00	
Care for others	Physical-mobility disability	1.14	1.27	3.08*
	Non-physical mobility disability	1.58	1.64	
	Total	1.33	1.45	
Self-care	Physical-mobility disability	4.40	1.89	1.18*
	Non-physical mobility disability	4.05	1.82	
	Total	4.25	1.86	
Leisure at home	Physical-mobility disability	4.82	1.57	7.58**
	Non-physical mobility disability	4.06	1.62	
	Total	4.49	1.63	
Study & self-enrichment	Physical-mobility disability	2.08	1.99	0.01
	Non-physical mobility disability	2.08	1.88	
	Total	2.08	1.94	
Sports & physical Activities	Physical-mobility disability	1.54	1.23	0.03
	Non-physical mobility disability	1.58	1.26	
	Total	1.56	1.24	

*p < .05; **p < .01; ***p < .001.

mobility disabilities engaged significantly less in IADL and in cultural and social activities that were mostly conducted out-of-the home, and they participated significantly more in self-care and leisure activities at home than people with non-physical mobility disabilities. There were no significant differences between the groups with respect to highly demanding activities, such as sports, study, and self-enrichment.

3.4. Perceived environmental barriers to participation (CHIEF)

Participants addressed the CHIEF questionnaire by reporting on barriers they faced, for example: “In the past 12 months, how often has the availability of transportation been a problem for you? How big was the problem?” The ten single items that got the highest-scoring barriers to participation for the whole sample (out of 8, in descending order) were (Table 3): lack of resources (M = 3.42, SD = 3.3); the natural environment (M = 3.11, SD = 3.23); lighting, noise, crowds; M = 2.72, SD = 3.07).

3.5. GIS analysis of barriers in the outdoor Neighborhood's environments

A significant correlation was found between the socio-economic status of the neighborhood and total participation in daily activities ($r = 0.22$, $p < .01$).

Analyzing the outdoor built environment of the two disability groups by *t*-test comparison regarding the characteristics of their neighborhoods revealed no significant differences with respect to the three examined urban spatial measures (non-residential land use, topographical slope, housing density) (Table 4). This enabled us to examine barriers as perceived by both groups who live in similar built environments.

Table 3

Perceived environmental barriers to participation.

Type of Barrier	Mean score	SD
Lack of resources	3.42	3.3
Natural environment	3.11	3.23
Lighting, noise, crowds	2.72	3.07
Lack of information available in a useable and understandable format	2.64	2.99
Lack of access to information	2.46	2.8
Lack of information on support services	2.41	2.90
Prejudice or discrimination	2.33	3.00
Lack of time	2.29	2.93
Lack of accessible courses and structured recreation activities	2.23	2.76
Public transportation	2.2	2.89

Table 4
T-test comparison of the urban spatial measures for two disability sub-groups.

Total Sample N = 137	Group with Physical Mobility Disability N = 79			Group with Non-Physical Disability N = 58				
Urban spatial measures	Range ^a	Mean	S.D.	Mean	S.D.	t	P value	
Land use	6–90	52.04	19.63	54.59	18.56	−0.78	.325	
Number of households	0–2.7	1.41	.50	1.54	.51	−1.46	.955	
Residential density	0–17	4.86	3.8	5.32	5.55	−0.58	.075	
Topographic slope	.50–1.11	27.60	23.06	26.49	17.87	0.31	.134	
Socio-economic status	3–19	11.42	3.72	10.66	4.12	1.14	.462	

^a Range – total range of the specific measure for the whole sample.

3.6. Correlations between perceived (CHIEF) and objective outdoor (GIS) barriers for the whole sample

ANOVA analyses revealed that the GIS measure of street connectivity correlated with the total mean score for CHIEF perceived barriers [$F(2, 134) = 4.65$; $p = .011$, $\eta_p^2 = 0.065$], as well as with two specific barriers, namely: the natural environment [$F(2, 134) = 4.25$; $p = .02$, $\eta_p^2 = 0.060$] and accessibility of support services (e.g. health and welfare services) [$F(2, 134) = 6.46$; $p = .002$, $\eta_p^2 = 0.089$]. Specifically, people with disabilities living in neighborhoods with low street connectivity (pattern #a, Fig. 1), that is, in neighborhoods that offer fewer non-residential destinations and are characterized by longer distances and fewer alternative routes to a destination, perceived more barriers arising from the natural environment and greater lack of accessibility to public services than people with disabilities living in neighborhoods with greater street connectivity (pattern #c, Fig. 1).

3.7. Correlations between outdoor barriers (GIS) and participation (IAASP)

The participation findings (in section 3.3 above) suggested that people with a physical mobility disability may be more confined to their home than people with non-physical disability, which further suggests that they may be more affected by outdoor barriers to participation. For further analysis, we examined the correlation within each disability group between reported participation in various activities (IAASP) and objective urban environmental characteristics (GIS).

We found significant correlations only for people with a physical mobility disability, but not for people with non-physical disability, which is consistent with our hypothesis. Pearson's analysis revealed significant correlations between reported total participation in activities and topographic slope ($r = .22$, $p < .05$). Pearson's analysis also showed correlations between participation in cultural and social activities and the number of non-residential land uses in the neighborhood ($r = 0.33$, $p < .01$; and $r = 0.26$, $p < .05$, respectively). A significant correlation was found between reported lack of accessibility to public transportation and housing density (Pearson $r = .32$, $p < .05$; $n = 79$). Thus, these urban characteristics were found to be significant for the ability of people with disabilities to be engaged in out-of-home activities.

4. Discussion

This multidisciplinary study analyzed the interaction between the urban spatial measurements of neighborhoods and participation in out-of-home daily activities by people with physical mobility disabilities and people with non-physical disabilities, in relation to their perceived environmental barriers. The built and natural environment has been recognized as a potential barrier or facilitator for participation of people with disabilities.

Among the entire cohort, no significant differences were found between the residential urban characteristics of both groups. This enabled us to examine the barriers and participation reported by people with different disabilities who live in similar built environments. The studies that discuss the interaction between urban characteristics and people with disabilities usually focus on people with physical disabilities. It is assumed that the urban environment may pose greater difficulties and restrictions for this segment of the population due to their mobility impairments. Studies on the role of the built environment for non-physical mobility disabilities are limited (Jeong et al., 2018). They might face other barriers, such as orientation, social attitudes and anxiety from crowded places.

Various studies define the built environment by different measures, including access to and movement within the building itself, such as doorways and front desk (Rimmer et al., 2004); street condition characterized by cracks, potholes, or broken curbs (Clarke et al., 2008; Jeong et al., 2018); or GIS built environment measures (Gray et al., 2012). Our study focuses on the built infrastructure by incorporating the perceived and objective measures. The comparison conducted revealed that people with physical mobility disability participate less than people with non-physical mobility disabilities in total participation out-of-home activities, in IADL, in cultural and social activities and participated more in self-care and leisure activities at home.

The current study provides evidence-based data regarding significant urban barriers to the participation in out-of-home activities merely among people with physical mobility disabilities. These include: (1) the urban infrastructure (street connectivity, mixed land uses, housing density and natural barriers particularly slope); (2) the urban surrounding (noise, light and crowds); and (3) transport services (insufficient access to public transportation).

Low street connectivity means longer walking distances and high slope demands enhanced endurance, which both pose extra burden on people with physical mobility disability and might increase fear of falling. On the other hand, high mix of land uses and high residential density foster high access to public transportation and improve walkability by creating proximity between people's residence and public services and activities (e.g. health care, shopping and community centers). Those urban attributes are particularly important for people that use crutches, canes or wheelchairs and for those with no car availability. Lack of access to public transportation restricts the activity space. In addition, the urban surrounding (e.g. lack of light, increased noise and crowding) might raise insecurity in public open spaces. All of these factors might reduce the participation in out-of-home activities and impact health and well-being.

In line with our results, empirical evidence has established a strong correlation between maintenance of an active lifestyle and density of land-use mixes within a neighborhood (Kerr et al., 2012). Walking in the home neighborhood of people with mobility disability was significantly associated with the GIS-derived measures of walk score, population density, and street density (Gell et al., 2015). Our findings suggest that the identified urban spatial measures are relevant to the participation of adults with physical disabilities in daily activities and might serve as moderators between their self-perception regarding the environmental barriers they face and their participation level.

The findings demonstrate the significance of social and urban spatial factors that facilitate equal opportunities for participation of adults with disabilities in activities in their community. The study is relevant to local and worldwide attempts to establish accessible and walkable environments under the Convention on the Rights of Persons with Disabilities (CRPD) that was signed and ratified by many states (United Nation Convention on the Rights of Persons with Disabilities (CRPD), 2006). It may also raise awareness of which environmental factors society should focus on when seeking to improve neighborhoods, being the most significant out-of-home environment, in order to reduce health risks that follow from decreased participation in daily activities. Taking these factors into consideration in urban planning and advising people with disabilities where to live may reduce their exclusion and enhance their active independence and their well-being. It still requires exploring whether these results may shed light on urban planning for children, older adults and other vulnerable populations, as they might have different needs in spatial terms. New accessible measures should be developed for these populations.

Study limitations and future research. A larger sample with smaller standard deviations from various countries may reveal more significant interactions between urban spatial measures and participation measures and may enhance generalization of the findings. People with cognitive impairments were not included in the current study and should be taken into account in future studies. Data obtained from GIS was lacking information on soft elements such as light, noise, signage and crowds. They were perceived barriers reported by study participants. Such soft barriers are important for addressing navigation and wayfinding of people with non-physical mobility disability, such as cognitive, sensory and mental disabilities.

Future studies should include more GIS-measurable aspects of urban living, for example proximity to bus stop, the presence of un-signalized pedestrian crosswalks, sidewalk availability and condition (Pecchini, and Giuliani, 2015; Rosenberg et al., 2013). Refining the "land use" measure to those uses of particular relevance to people with disabilities may improve its correlation with their participation.

5. Conclusions

This multidisciplinary study is a product of urban planning and health studies bodies of knowledge. It contributes to the understanding of the interaction between vulnerable populations and their residential neighborhood that may impede participation in daily activities and health.

Several urban spatial neighborhood walkability characteristics measured by GIS correlated significantly with the participation of people with physical mobility disabilities: (1) lower slope correlated with increased total participation in activities; (2) a larger total number of non-residential land uses correlated with increased participation in leisure and cultural activities; (3) lower housing density correlated with a lack of accessibility to public transportation; (4) increased street connectivity correlated with several measures of increased participation and with fewer total perceived barriers. By contrast, for people with non-physical disabilities—only street connectivity was found to correlate significantly with perceived barriers. Hence the urban characteristics are significant for enabling engagement in out-of-home activities.

It is worth noting that the perceived barriers measured by the CHIEF such as lack of resources (access to information, economic status), lack of accessible services and social attitudes should be addressed along with the urban spatial factors.

Conflicts of interest

The authors declare no conflict of interest.

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