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Differences in Behavior, Time, Location, and Built Environment between Objectively Measured Utilitarian and Recreational Walking

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Abstract

Objectives—Utilitarian and recreational walking both contribute to physical activity. Yet walking for these two purposes may be different behaviors. We sought to provide operational definitions of utilitarian and recreational walking and to objectively measure their behavioral, spatial, and temporal differences in order to inform transportation and public health policies and interventions.

Methods—Data were collected 2008–2009 from 651 Seattle-King County residents, wearing an accelerometer and a GPS unit, and filling-in a travel diary for 7 days. Walking activity bouts were classified as utilitarian or recreational based on whether walking had a destination or not. Differences between the two walking purposes were analyzed, adjusting for the nested structure of walking activity within participants.

Results—Of the 4,905 observed walking bouts, 87.4% were utilitarian and 12.6% recreational walking. Utilitarian walking bouts were 45% shorter in duration (−12.1 min) and 9% faster in speed (+0.3km/h) than recreational walking bouts. Recreational walking occurred more frequently in the home neighborhood and was not associated with recreational land uses. Utilitarian walking occurred in areas having higher residential, employment, and street density, lower residential

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property value, higher area percentage of mixed-use neighborhood destinations, lower percentage of parks/trails, and lower average topographic slope than recreational walking.

Conclusion—Utilitarian and recreational walking are substantially different in terms of frequency, speed, duration, location, and related built environment. Policies that promote walking should adopt type-specific strategies. The high occurrence of recreational walking near home highlights the importance of the home neighborhood for this activity.

Keywords

GPS; accelerometer; home and non-home based walking; pedestrian; active transportation

1. Introduction

The recently published United States Surgeon General's *Call to Action to Promote Walking and Walkable Communities* identifies policy gaps and provides future strategies, recognizing the multipurpose nature of walking (U. S. Department of Health and Human Services, 2015). Walking is a complex behavior with diverse motivations including travel (utilitarian walking) and leisure and exercise (recreational walking) (Tudor-Locke et al., 2006). While most researchers have recognized that different mechanisms may trigger and influence walking for these different purposes (Giles-Corti et al., 2005b; Lovasi et al., 2008; Saelens and Handy, 2008; Sugiyama et al., 2012; Tudor-Locke et al., 2006), many studies have treated walking as single behavior (Millward et al., 2013; Owen et al., 2004; Saelens and Handy, 2008). One review of studies on environmental correlates of walking argued that the lack of specificity in distinguishing between utilitarian and recreational walking weakens the predictive power of walking behavior models (Giles-Corti et al., 2005b). Effective interventions and policies to promote walking require specific understanding of why and where people walk.

A major challenge in distinguishing purposes of walking is the lack of standardized, objective, and robust methods to define walking behavior (Heath et al., 2006; Saelens and Handy, 2008; Sugiyama et al., 2012). In most studies stratifying utilitarian and recreational walking, data come from transportation and physical activity surveys or time diaries, in which respondents were asked to record perceived purpose or context of walking activity. The characterization of walking is inconsistent across studies (Kang et al., 2013). Dog walking was considered as utilitarian walking in one study (Agrawal and Schimek, 2007), recreational walking in another (Cutt et al., 2008), and as an independent category separate from recreational walking in yet another study (Yang and Diez-Roux, 2012). Some studies classified walking to a fitness facility as recreational walking (Agrawal and Schimek, 2007; Yang and Diez-Roux, 2012). Yet it could be argued that walking to a fitness facility has explicit transportation utility, because it replaces a trip by car or transit which would not be classified as driving or riding transit for recreation. The ambiguity between trip purpose and destination was also found in another study that defined walking while visiting historic sites as recreational walking (Tudor-Locke et al., 2007). Furthermore, self-reported data being subjective (Sugiyama et al., 2012) may lead to inconsistencies between or even within participants. Reported walking duration estimates are inaccurate. Recall bias in transportation surveys typically leads to underestimating the number of short walking trips, and social desirability bias generates average overestimation of physical activity in surveys making it difficult to quantify walking overall or by purpose (Lee et al., 2011; Wolf et al., 2003).

Shortcomings aside, prior studies pointed to many behavioral differences between utilitarian and recreational walking. In the U.S., utilitarian walking trips were consistently found to be shorter in time but more prevalent than recreational walking. In the 2001 and 2009 National Household Travel Survey (NHTS), the average duration of utilitarian walking trips was less than half that of recreational walking (Agrawal and Schimek, 2007; Yang and Diez-Roux, 2012). In the 2010 National Health Interview Survey (NHIS), the average utilitarian walking trip was 20% shorter than the average recreational walking trip (Paul et al., 2015). The 2003–2005 American Time Use Survey (ATUS) and the 2010 NHIS reported prevalence rates of walking for transportation or utilitarian walking to be 70%–160% higher than those of walking for exercise or recreational walking (Paul et al., 2015; Tudor-Locke and Ham, 2008). However, all of these estimates and thus differences between utilitarian versus recreational walking were based on self-report. Furthermore, the afore-mentioned national surveillance systems have different assessment techniques and construct definitions of walking measures, thus resulting in widely varying estimates (Whitfield et al., 2015).

The impact of built environment factors on walking may also differ by walking purpose (Owen et al., 2004; Saelens and Handy, 2008; Sugiyama et al., 2012). In one study, hilly terrain was a barrier to utilitarian walking but it was a facilitator for recreational walking, ostensibly because hills afforded enjoyable vistas that attracted recreational walkers (Lee and Moudon, 2006b). Another study showed that the presence of shops, or the availability of public transport were less important in predicting recreational walking than utilitarian walking (Pikora et al., 2006). Land use mix patterns differed in their association with utilitarian and recreational walking in one recent study (Christian et al., 2011). A review found consistent and significant associations between utilitarian walking and the presence of nearby routine destinations (e.g., shops, services, transit stops) in 25 of the 31 studies reviewed. For recreational walking, results were inconsistent; 17 studies had null associations and 2 had unexpected negative associations between recreational walking and nearby presence of recreation-specific destinations (e.g., parks, playgrounds, sports fields) (Sugiyama et al., 2012).

Associations between purpose-specific walking and the built environment could be inaccurate because of the spatial mismatch between where walking actually occurred and where built environment attributes were measured (Sugiyama et al., 2012). Because of a lack of information on where people actually walked, most prior studies examined associations between home neighborhood characteristics and walking outcomes (Perchoux et al., 2013). The spatial mismatch between walking activity and environment is beginning to be explored in studies tracking participants' GPS locations and accelerometer-based physical activity. In two studies, between 40% and 50% of moderate or vigorous physical activity (which may or may not include walking) occurred outside of participants' home neighborhoods, defined as buffers of 1,666 m-to-1,855 m radii from home locations (Hurvitz et al., 2014a; Troped et al., 2010). Notably, another study found that built environment features significantly differed between participants' home neighborhoods and their visited locations beyond home neighborhoods, in terms of neighborhood composition, utilitarian destinations, transportation infrastructure, and traffic conditions (Hurvitz and Moudon, 2012). The spatial mismatch between built environment and walking may be further confounded by walking purpose. However, studies with concurrent data on the location and purpose of walking are few (Spinney et al., 2012). To analyze the influence of the environment and inform interventions, it is important to identify the locations of walking activity by purpose.

The present study offers operational definitions and methods to classify the two walking purposes to address the issue of classification standardization. Second, the study explores the multidimensional properties of utilitarian and recreational walking regarding the duration, activity intensity, speed, and time and location distributions of the activity based on a large sample of participants living in a U.S. metropolitan area. Finally, it examines the built environment characteristics of where walking actually occurred.

2. Methods

2.1. Participants

Participants in the present study were from the 2008–2009 baseline sample of the Travel Assessment and Community study, which examined the effects on physical activity of a new light-rail system to be planned to open in King County, Washington (Saelens et al., 2014). Participants were selected who lived close to (≤1.6-km) or far from (>1.6 km) future light rail stops, and were matched for household income, ethnicity/race composition, residential property values, residential density, housing type, land use mix, and bus ridership (Moudon et al., 2009). Participants were asked to wear a uni-axial accelerometer (GT1M, Actigraph LLC, Fort Walton Beach, FL) on the hip, set to aggregate data to 30-second epochs, and to carry a GPS unit (DG-100 GPS data logger, GlobalSat, Taipei, Taiwan) also set to collect data at 30-second intervals, and to record travel within a place-based travel diary for 7 consecutive days. We matched accelerometer and GPS records by synchronizing the device time.

Participants completed surveys about their demographic information (sex, age, race, and ethnicity) and socioeconomic status (household income, education, and employment). They provided informed consent and the study was approved by the Institutional Review Board of the Seattle Children's Research Institute.

2.2. Walking Bout Sample

Accelerometer, GPS, and travel diary data were merged based on common day and time stamps (Hurvitz et al., 2014b). Data were reduced to *bouts*, comprising sustained moderate physical activity that may or may not have been walking. A bout was defined as a time interval of accelerometer counts exceeding 500 counts per 30-second epoch (cpe) for 7 min or longer, allowing for up to 2 min of activity below the 500 cpe threshold so that a short break (e.g., traffic signal waiting) does not split one PA bout into multiple ones (Mâsse et al., 2005; Rodríguez et al., 2005). Among all activity bouts, *walking bouts* were identified based on either the GPS speed ranges and GPS point patterns consistent with walking or overlap with walking records in the travel diary. Details of the data processing and determination of whether a bout was walking or not were published elsewhere (Kang et al., 2013). The current study only included walking bouts with at least 1 GPS point within the study area, defined as King County Urban Growth Area (UGA, the 1,187 km^2 urbanized area around the City of Seattle) where complete built environment data are available.

2.3. Utilitarian and Recreational Walking

Utilitarian walking bouts were defined as having a *destination*; they originated and terminated at different locations (Figure 1 Walking A). In contrast, *recreational walking bouts* were defined as having *no destination*; they originated and terminated at the same location (Figure 1 Walking B). For example, if a participant started walking from home and walked around their neighborhood without making any stop to perform another activity, this would be defined as recreational walking. In contrast, walking stopped at a store > 2 min was defined as two utilitarian trips. To determine whether bouts had a destination or not, we used GPS data or travel diary data or both, depending on the data availability. When there were discrepancies between GPS and travel data, the more objective GPS data were used. Walking bouts whose first (assumed origin) and last (assumed destination) GPS points were ≤ 40.2 m of each other were classified as recreational. This GPS point *proximity cutoff* of 40.2 m was selected following an observational study reporting that 80%–90% of GPS points had locational errors of up to 20.1 m from their true location (Wu et al., 2010); therefore we accepted a location error of 40.2 m from two observed points from one true location. The selected distance is within the error range in various situations of the same GPS model (Rodriguez et al., 2013). For walking bouts with few GPS points (< 10 records), we did not use GPS data and used travel diary data instead. In the travel diary, participants were instructed to record all trips, even those that started and ended at the same location and had no intervening stops. Walking bouts were classified as recreational when they had any temporal overlap with the identified walking trip with no destination. All other walking bouts not classified as recreational were classified as utilitarian.

2.4. Behavior Characteristics of Walking Bouts

The duration of a walking bout was determined as the difference between the time stamps of the first and last accelerometer records in the bout. Physical activity intensity was measured as the average accelerometer count within the bout. The first record's time stamp was used for purposes of analysis of time-of-day and day-of-week distributions of walking bouts. A bout's speed was calculated as the mean of available GPS records' instantaneous speeds. GPS coverage was defined as the percentage of walking bout accelerometry records that had a time-matched GPS record. For example, Walking B in Figure 1 had 76 accelerometry records (a duration of 38 min) with 72 matched GPS records, yielding a GPS coverage of 94.7%.

2.5. Locations of Walking Bouts

We classified walking bouts as occurring within either *home-neighborhood* or *non-home-neighborhood*. Home-neighborhood walking bouts had more than 50% of their GPS points located within 833 m of the participant's home address point. The 833 m distance was selected to be equivalent to a 10-minute walk at 5 km/h, representing a comfortable walking distance by most adults (Hurvitz and Moudon, 2012; Sallis et al., 2004). The 50% threshold captured walking bouts which originated or terminated near home locations, but extended beyond the home neighborhood. For example, a 19.5-minute walking bout having 30 out of 39 GPS points (77%) located within 833 m of home, was considered as being home-neighborhood (Figure 1 Walking A). Walking bouts with >50% of their GPS points outside of the home neighborhood were defined as non-home-neighborhood (Figure 1 Walking B).

We tested whether each walking bout was spatially associated with recreational land uses or not. When a walking bout had one or more GPS points located within the boundaries of a public park or trail, it was considered to traverse recreational land uses, regardless of the walking bout's determined purpose. For example, a walking bout having 28 out of 72 GPS points (38.9%) located within parks or trails was determined to traverse recreational land uses (Figure 1 Walking B).

2.6. Built Environment Characteristics around Walking Bouts

Seven built environment characteristics were considered as having an effect on walking based on the results of prior studies: (1) residential unit density; (2) job density (Ewing and Cervero, 2001, 2010; Frank et al., 2008; Frank and Pivo, 1994; Saelens and Handy, 2008); (3) residential property value (Gordon-Larsen et al., 2005; Moudon et al., 2011); (4) street intersection density (Ewing and Cervero, 2010; Frank et al., 2007); (5) combined areas of parks and trails (Bassett et al., 2008; Duncan and Mummery, 2005; Fitzhugh et al., 2010; Kaczynski et al., 2008); (6) areas of *Neighborhood Commercial Centers* (*NC*s)(Lee and Moudon, 2006a; Moudon et al., 2007; Sugiyama et al., 2012); and (7) slope (Lee and Moudon, 2006a). NCs were mixed-use routine commercial destinations, shown to be significantly associated with walking. In this study, we selected one specific type of NC ("NC2"), which showed the most significant association with walking (Lee and Moudon, 2006a; Moudon et al., 2007). An NC was delineated in GIS as a minimum convex polygon having at least one supermarket, one restaurant, and one retail outlet within 50m of each other; NC polygons typically contained many additional destinations (e.g., dry cleaners, hair dressers, banks, convenience stores, etc.) within their boundaries. To measure the seven built environment characteristics, we used GIS data from 2007, obtained from the King County GIS Center, the King County tax assessor, and the Urban Form Lab of the University of Washington.

To efficiently measure built environment characteristics for the large dataset of GPS points, we used the *SmartMap* method, which replaced the traditional buffer method with focal raster processing. SmartMap raster values were measured as focal means of built environment characteristics over an 833-meter-radius circle. The method has been described elsewhere (Hurvitz and Moudon, 2012; Hurvitz et al., 2014b).

Built environment characteristics were first captured for each GPS point in a walking bout and then averaged for each bout. In the case of a 10 GPS point walking bout for example, built environment characteristics were captured around each one of the 10 points; they were then summed and averaged for the individual bout.

2.7. Built Environment Characteristics around Home

The same set of built environment characteristics were captured around each participant's home address, thus defining each participant's home neighborhood. Home points were stored as the parcel centroids of home addresses reported in the survey using the King County, WA, address point GIS data. Home points were geocoded at the parcel centroids of home addresses reported in the survey. Home points of participants living in large parcels (≥ 0.8 ha), to find actual home locations, were estimated from the center of GPS coordinates recorded within the participant's home parcel.

2.8. Data Analysis

We compared the duration, intensity, speed, built environment characteristics (continuous) and location and time distributions (categorical) of walking bouts, stratified by utilitarian and recreational classes. For continuous variables, walking bouts were grouped within participants to account for their nested structure and to adjust for between-participant variance. Means and 95% confidence intervals (CIs) were estimated from fixed effects of linear mixed models fitted by restricted maximum likelihood. Mean differences between utilitarian and recreational walking bouts were tested using ANOVA models for linear mixed effects and their *P* values were reported. We calculated standardized effect size (Cohen's *d*) of mean differences between utilitarian and recreational walking. A Cohen's *d* value of 0.2 is considered a small effect, 0.5 a medium effect and 0.8 a large effect (Cohen, 1992). For categorical variables (e.g., time and location distributions), differences were examined with chi-squared tests. Statistical significance was set at $P < .05$.

To understand locations of non-home-neighborhood walking bouts, we compared built environment characteristics of them with those of the participant's home neighborhood. We calculated the difference D of built environment characteristic i and walking bout j as:

$D_{ij} = W_{ij} - H_i$, where

W_{ij} = built environment characteristic i for a walking bout j (described above) and

H_i = built environment characteristic i around the walker's home location (833-m buffer).

For example, if a walking bout occurred in a non-home-neighborhood location (Figure 1 Walking B), we calculated the difference in residential density between the bout location and the participant's home location. Means and 95% CIs of the differences (D) were also estimated using linear mixed models, to adjust for walking bouts being nested within participants. Next, we compared how D values differ by type (utilitarian vs. recreational), also using ANOVA models for linear mixed effects (*P* values reported) and standardized effect size (Cohen's *d* values reported).

We used R version 3.1.1 (R Foundation for Statistical Computing, Vienna, Austria) and R lme4 package version 1.1–7 for data processing and analysis and PostGIS version 2.0 (Refractions Research, Victoria, Canada) for spatial analysis.

3. Results

After excluding study participants who had either no GPS data or no travel diary data (n=3); who did not return the survey questionnaire (n=19); and whose accelerometer data did not show any physical activity bout during the 7-day assessment period (n=28), the final sample consisted of 651 participants with 4,288 person-days (mean = 6.6 days per person; SD = 1.7).

The sample characteristics and home built environments are provided in Table 1. The sample yielded a total of 6,528 raw walking bouts, of which 75.1% (4,905) were included because they had one or more GPS points in the King County UGA study area. The study sample had 4,285 (87.4%) utilitarian and 620 (12.6%) recreational walking bouts. We found that the 38% of the participants living close to (≤1.6-km) future light rail stops made 41% of the utilitarian and 32% of the recreational walking. A total of 591 walking bouts had < 10 GPS points and were classified only based on travel diary data, ignoring their GPS data. Of the recreational walking bouts, 240 (38.7%) were classified using GPS data only, 251 (40.5%) using travel diary data only, and 129 (20.8%) using both. Of the utilitarian walking bouts, 573 (13.4%) were classified using travel diary data only and 3,712 (86.6%) using both GPS and travel diary data.

Bout duration, accelerometer count mean (activity intensity), GPS coverage, and mean GPS speed were significantly different by walking purpose (Table 2). The group difference effect size was large for duration. On average, utilitarian walking bouts were 12.1 min (45.1%) shorter, less intense by 74.0 cpe (4.8%), but 0.3 km/h (8.5%) faster than recreational walking bouts. In terms of location, utilitarian walking was less likely to be located in the home-neighborhood (52.6%) than recreational walking (68.9%); and less likely to traverse recreational land uses. Utilitarian walking occurred in areas of higher residential density, lower property value, higher job density, higher street density, higher area percentage of NCs, lower area percentage of parks/trails, and lower average slope than recreational walking. Group differences had large effect sizes for residential, job, and street intersection densities and a medium effect size for area of parks/trails.

In terms of temporal distribution, utilitarian walking had a 4.6% higher occurrence rate on week days than did recreational walking (Table 3). Utilitarian walking bouts peaked at lunch time and in the late afternoon, while recreational walking peaked in mid-morning and early afternoon hours (Supplemental Figure).

Differences in the built environment characteristics of non-home-neighborhood walking bouts' locations and those of the walker's home neighborhoods were significant (Table 4). Focusing on the variables having significant differences (95% CIs not containing 0 difference values), relative to home neighborhood built environment, non-home-neighborhood utilitarian walking bouts occurred in areas with higher average property value and job density; and lower average slope than the walkers' home neighborhoods. Compared to home neighborhood built environment, non-home-neighborhood recreational walking occurred in areas with higher average property value and percentage of parks or trails; and with lower residential density, street intersection density, and percentage of NCs.

Differences in difference (differences between *D* of utilitarian walking and *D* of recreational walking bouts) were significant in the all built environment characteristics, with the largest difference being in the area of parks and trails (d=0.851).

4. Discussion

The present study clearly showed that walking is not a single behavior, and the observed walking bouts included two distinctively different types of walking. Differences between utilitarian (87.4% of walking bouts) versus recreational walking (12.6%) were largest in terms of walking duration (d=0.967) and built environment characteristics (densities of residential units, jobs, and street intersections; d ranging from 0.816 to 0.902). The different spatial and temporal distributions of utilitarian versus recreational walking confirmed their contextual differences. These results indicates that analyses combining the two different walking behaviors may yield inconsistent findings or reversed directions of association, suggesting that policies to promote walking should use type-specific strategies.

We provided an operational definition to classify utilitarian versus recreational walking based on an objectively distinguishable feature: whether the activity had a destination or not. This approach is different from that used by national survey tools, which rely on subjective self-reported trip purposes (e.g., the 2001 and 2009 NHTS) (Agrawal and Schimek, 2007; Yang and Diez-Roux, 2012). Previous studies proposed to classify trip purposes by using land use types at destination, which were identified by GPS data (Wolf et al., 2001) or machine learning approaches based on participants' survey, accelerometer, and GPS data (Montini et al., 2014). However, these studies considered all trips, did not focus on walking, and required contextual land use data or intensive computational processes. We showed that the objective activity feature (having a destination) may provide a more clear and simple classification methods. Although we implemented the classifier with an intensive dataset (accelerometer, GPS, and travel diary data), our approach may also be useful with simpler data (e.g., GPS and self-reported activity log) if they contain information on more objective activity features not self-reported activity purposes.

Another unique element of our study is its objective quantification of behavioral differences between two types of walking. We compared our objective estimates to self-reported data from large-scale studies. The mean duration of recreational walking of 26.8 min was close to survey-based estimates, which ranged from 25.3 min to 31.7 min in the 2000 Behavioral Risk Factor Surveillance System (Simpson et al., 2003), the 2003–2004 National Health and Nutrition Examination Survey (Ham et al., 2009), the 2001 NHTS (Agrawal and Schimek, 2007), and the 2010 NHIS (Paul et al., 2015). In contrast, this study's utilitarian walking duration mean of 14.7 min was similar to the 2001 NHTS estimate of 11.9–14.1 min (Agrawal and Schimek, 2007) but nearly half of the 2010 NHIS mean estimate of 26.3 min (Paul et al., 2015). For walking speed, there are few large-scale comparable studies. A Canadian study using GPS data reported that utilitarian walking was 12% faster (+0.5km/h) than recreational walking (Millward et al., 2013), which was consistent with our finding that utilitarian walking bouts were 8.5% faster (+0.3km/h) than recreational bouts.

The time-of-day distribution showed that utilitarian walking bouts had temporal patterns similar to those reported for all trips in the 2009 NHTS data (Santos et al., 2011), with peaks corresponding to morning (7–8 AM) and afternoon (5 PM) commutes and lunch-time trips (12 PM) (Supplemental Figure). In contrast, recreational walking bouts had two peaks, at 9 AM and 3 PM, respectively, which seemed less related to work-day activity patterns.

In the present study, park usage for recreational walking in home neighborhoods was not frequently observed. Previous studies found park proximity to be associated with recreational walking (Giles-Corti et al., 2005a; Sugiyama et al., 2010). The present study using GPS data showed that the majority (61.8%) of recreational walking occurred completely outside of such recreational land uses, although many participants lived close to parks or trails (the average distance between home and the closest park was 0.2 km). This finding was in line with the results of a large-scale study, which reported no relationships between recreational walking and neighborhood parks (Zlot and Schmid, 2005). Finding that most home-neighborhood recreational walking took place along streets may have important repercussions on the provision of transportation infrastructure. For example, it suggests that sidewalks may be as important as trails for encouraging recreational walking in residential neighborhoods. Overall, neighborhood street walkability may contribute more to recreational walking than park proximity.

The study has some limitations. Our classification did not consider participants' perceptions of trip purposes. Walking may be perceived to serve multiple purposes. For example, a participant begins to walk for exercise (recreational purpose), then encounters friends (social purpose), and finally has an incidental small shopping (utility purpose) before returning home. The walking journey may be classified as multiple utilitarian walking bouts if it involves recorded stops. In this scenario, utilitarian walking may be overestimated. However, other existing survey tools may not be able to appropriately classify the complex walking journey. More research is needed to understand walking trip chaining and multiple purposes of walking.

We defined home-neighborhood walking when more than half of the GPS points were located inside 833m from the participant's home location. Some of non-home-neighborhood walking may therefore originate and/or terminate in the participants' home neighborhoods, although the majority of their GPS points fell outside of home neighborhoods. Out of the 2,222 non-home-neighborhood walking bouts, 171 (7.7%) had a GPS points near home (distance < 40.2m, the accepted location error used in the current study). It should also be noted that our method is different from activity-based travel modeling, which defines "home-based" trips by their trip origin (Kitamura et al., 2000). A careful interpretation is needed when our definition of home-neighborhood walking is compared to home-based trips.

Current GPS technology has limitations which affect all studies, including this one. First, we assumed GPS data were missing at random and excluded walking bouts having no GPS data (24.9% of the total raw walking bouts identified). Comparing accelerometer data from walking bouts with and without GPS data showed negligible differences in bout duration (d=0.133) and activity intensity count (d=0.120). Second, because we used original GPS records without post-processing (e.g., outlier exclusion), errors may affect bout locations, especially in the case of bouts with few GPS points. Advances in location-aware technologies will likely improve GPS coverage in the future.

5. Conclusion

The present study introduced a new operational definition for classifying utilitarian and recreational walking, which focused on one objective activity feature, having a destination, but not on self-reported activity purpose. This approach may be useful for other studies even with relatively simple data. The findings clearly indicate that utilitarian and recreational walking are substantially different in terms of frequency, speed, duration, and location. Stratification by purpose, location and related built environment yielded insights that would be concealed if walking had been treated as a single, homogeneous activity. For policies to successfully promote walking, type-specific strategies should be adopted to generate increases in the activity, to identify supportive locations, or to appropriately modify the environment where the activity takes place. The high occurrence of recreational walking near home highlights the importance of the home neighborhood for this activity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Utilitarian and recreational walking are different behaviors
- Differ by duration, speed, temporal distribution, and location
- Utilitarian walking in high residential, job, street, and mixed-use density places
- Recreational walking in high property value and park density and more sloped places
- 52.6% of utilitarian and 68.9% of recreational walking classified as home-based

Figure 1. Examples of a participant's utilitarian walking bout (A) and recreational walking bout (B)

Walking A is classified as *utilitarian* (it has a destination); as *home-neighborhood* (more than 50% GPS points are located within the 833-meter-radius circle around the home point); and as having no location associated with recreational land uses (no GPS points within parks or trails).

Walking B is classified as *recreational* (it has *no* destination); as *non-home-neighborhood* (more than 50% GPS points are *not* located within the 833-meter-radius circle around the home point); and as having locations associated with recreational land uses (38.9% GPS points within parks or trails).

Table 1

Participant characteristics (n=651)

Variables		Measurements	
Demographic information		N	%
Sex	Female	406	62.4
	Male	245	37.6
Age	Age < 40	141	21.6
	Age 40–64	408	62.7
	Age ≥ 65	95	14.6
	NA[a]	7	1.1
Race/ethnicity	Non-Hispanic white	516	79.3
	Other ethnic	129	19.8
	NA[a]	6	0.9
Household income	<50K USD	238	36.5
	50K to <100K USD	259	39.8
	≥ 100K USD	136	20.9
	NA[a]	18	2.8
Education	Some college or below	182	28.0
	College graduate or higher	459	70.5
	NA[a]	10	1.5
Employment	Full-time	341	52.4
	Part-time	148	22.7
	Retired/unemployed	136	20.9
	NA[a]	26	4.0
Built environment characteristics in home neighborhood [b]		Mean	SD
Residential density [dwelling units/ha]		20.5	14.4
Average property value [1,000 USD/unit]		247.1	82.4
Job density [jobs/ha]		83.8	155.0
Street intersection density [count/km^2]		98.7	34.8
Area of *NC*s [c] [%]		9.7	10.1
Distance to the closest *NC* [c] [km]		0.5	0.5
Area of parks/trails [%]		5.1	5.3
Distance to the closest park or trail [km]		0.2	0.2
Average slope in degree [°]		4.3	1.3

[a] Missing for the variable coded as NA.

[b] Home neighborhood defined as a 833-meter-radius (a 10-minute walking distance) circle from the participant's home address point.

[c] Neighborhood Center (NC), mixed-use neighborhood destination, defined as a minimum convex polygon delineated by at least one of each supermarket(s), retail(s), and restaurant(s) parcels clustered within 50m of each other (Lee and Moudon, 2006a).

Table 2

Characteristics, locations, and built environment features of the walking bout sample (N=4,905)

	Utilitarian (n=4,285)		**Recreational (n=620)**				**All (n=4,905)**	
Characteristics	**Mean**	**95% CI**	**Mean**	**95% CI**	***p*** [a]	**Cohen's *d***	**Mean**	**95% CI**
Duration [min]	14.7	[14.1, 15.3]	26.8	[24.7, 28.8]	<.001	.967	16.3	[15.6, 17.0]
Accelerometer count mean [counts/30 s]	1,474.3	[1,440.7, 1,507.8]	1,548.3	[1,488.3, 1,608.3]	.016	.234	1,483.6	[1,451.7, 1,515.6]
GPS coverage [%]	80.5	[79.0, 82.0]	87.8	[85.4, 90.1]	<.001	.390	81.4	[80.0, 82.8]
GPS speed mean [km/h]	3.8	[3.7, 3.9]	3.5	[3.4, 3.6]	<.001	.254	3.7	[3.7, 3.8]
Location	Count	(%)	Count	(%)	*p* [b]		Count	(%)
Location								
Home-neighborhood	2,256	(52.6)	427	(68.9)	<.001		2,683	(54.7)
Non-home-neighborhood	2,029	(47.4)	193	(31.1)			2,222	(45.3)
Recreational land use								
Traversing	1,248	(29.1)	237	(38.2)	<.001		1,474	(30.1)
Not traversing	3,037	(70.9)	383	(61.8)			3,431	(69.9)
Built environment characteristics	Mean	95% CI	Mean	95% CI	*p* [a]	Cohen's *d*	Mean	95% CI
Residential density [dwelling units/ha]	23.2	[22.1, 24.3]	15.8	[14.3, 17.4]	<.001	.830	22.2	[21.1, 23.2]
Average property value [1,000 USD/unit]	255.2	[249.0, 261.4]	291.0	[275.0, 307.1]	<.001	.432	260.1	[253.5, 266.7]
Job density [jobs/ha]	147.4	[134.1, 160.6]	49.9	[36.0, 63.8]	<.001	.816	134.3	[121.9, 146.8]
Street intersection density [count/km^2]	105.2	[102.4, 108.1]	83.4	[79.3, 87.5]	<.001	.902	102.3	[99.5, 105.0]
Area of NCs [c] [%]	11.3	[10.5, 12.1]	8.0	[6.8, 9.2]	<.001	.388	10.8	[10.0, 11.5]
Area of parks/trails [%]	5.2	[4.7, 5.6]	9.4	[8.0, 10.7]	<.001	.598	5.6	[5.2, 6.1]
Average slope in degree [°]	3.9	[3.8, 3.9]	4.2	[4.0, 4.4]	<.001	.370	3.9	[3.8, 4.0]

[a] *P*-value of fixed effect of being recreational vs. utilitarian in linear mixed effect models adjusting a nested structure of walking bouts within participants

[b] *P*-value from chi-square test of utilitarian and recreational walking bout contingency table

[c] Neighborhood Center (NC), mixed-use neighborhood destination, is defined as a minimum convex hull polygon delineated by at least one of each grocery/supermarket(s), retail(s), and restaurant(s) parcels clustered within 50m of each other (Lee and Moudon, 2006a).

Table 3

Characteristics and temporal distribution of utilitarian and recreational walking bouts (N=4,905)

	Utilitarian (n=4,285)		Recreational (n=620)		*P* [a]	All (n=4,905)	
	Count	**(%)**	**Count**	**(%)**		**Count**	**(%)**
Day of week (walking bout start time)					.013		
- Week days	3,265	(76.2)	444	(71.6)		3,709	(75.6)
- Weekend days	1,020	(23.8)	176	(28.4)		1,196	(24.4)
Time of day (walking bout start time)					<.001		
- 4:00am - 6:59am (early morning)	126	(2.9)	27	(4.4)		153	(3.0)
- 7:00am - 10:59am (morning)	1,024	(23.9)	166	(26.8)		1,190	(24.3)
- 11:00am - 1:59pm (lunch)	1,077	(25.1)	114	(18.4)		1,191	(24.3)
- 2:00pm - 3:59pm (afternoon)	599	(14.1)	110	(17.7)		709	(14.5)
- 4:00pm - 6:59pm (late afternoon)	973	(22.7)	134	(21.6)		1,107	(22.6)
- after 7:00pm & before 3:59am (evening and before morning)	486	(11.3)	69	(11.1)		555	(11.3)

[a] *P*-value from chi-square test of utilitarian and recreational walking bout contingency table

Table 4

Built environment characteristics of non-home-neighborhood walking bouts (N=2,222) compared to those of the walkers' home neighborhoods (subtraction of built environment characteristic values of non-home-neighborhood walking bouts from those of the walker's home neighborhood)

Non-home-neighborhood walking bouts	**Utilitarian (n=2,029)**		**Recreational (n=193)**				**All (n=2,222)**	
	Mean	**95% CI**	**Mean**	**95% CI**	***p*** [a]	**Cohen's *d***	**Mean**	**95% CI**
Residential density [dwelling units/ha]	+0.3	[−1.2, +1.8]	**−4.9**	**[−7.3, −2.4]**	<.001	.502	−0.2	[−1.6, +1.2]
Average property value [1,000 USD/unit]	**+15.8**	**[+5.2, +26.4]**	**+75.2**	**[+48.1, +102.4]**	<.001	.519	+21.5	[+11.2, +31.9]
Job density [jobs/ha]	**+87.6**	**[+67.4, +107.8]**	+22.0	[−6.2, +50.3]	<.001	.520	+79.1	[+60.3, +98.0]
Street intersection density [count/km^2]	+3.0	[−1.2, +7.3]	**−15.0**	**[−22.3, −7.6]**	<.001	.613	+1.1	[−2.9, +5.1]
Area of *NCs* [b] [%]	+0.2	[−1.1, +1.6]	**−2.9**	**[−5.3, −0.5]**	<.001	.330	+0.0	[−1.3, +1.3]
Area of parks/trails [%]	+0.7	[−0.1, +1.6]	**+8.3**	**[+5.3, +11.4]**	<.001	.851	+1.4	[+0.5, +2.2]
Average slope in degree [°]	**−0.6**	**[−0.8, −0.5]**	−0.2	[−0.5, +0.1]	.005	.392	−0.6	[−0.7, −0.5]

[a] *P*-value of the group difference between the subtractions of utilitarian walking bouts and the subtractions of recreational walking bouts, after adjusting a nested structure of walking bouts within participants.

[b] Neighborhood Center (NC), mixed-use areas with routine destination, defined as a minimum convex hull polygon delineated by at least one of each grocery/supermarket(s), retail(s), and restaurant(s) parcels clustered within 50m of each other (Lee and Moudon, 2006a).

[*] 95%CI's not containing 0's are shown in bold.