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How many walking and cycling trips made by elderly are beyond commonly used buffer sizes: Results from a GPS study

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ABSTRACT

In choosing appropriate buffer sizes to study environmental influences on physical activity, studies are hampered by insufficient insight into the distance elderly travel actively. This study aims at getting insight into the number of trips walked and cycled within various buffer sizes using GPS measures. Data were obtained from the Elderly And their Neighborhood study (Spijkenisse, the Netherlands (2011–2012)). Trip length and mode of transport were derived from the GPS data ($N=120$; total number of trips $=337$). Distance decay functions were fitted to estimate the percentage of trips to grocery stores within commonly used buffer sizes. Fifty percent of the trips walked had a distance of at least 729 m; for trips cycled this was 1665 m. Elderly aged under 75 years and those with functional limitations walked and cycled shorter distances than those over 75 years and those without functional limitations. Males cycled shorter distances than females. Distance decay functions may aid the selection of appropriate buffer sizes, which may be tailored to individual characteristics.

1. Introduction

In aging societies, health promotion among elderly increasingly focuses on aging in place (Farber et al., 2011; Zantinge et al., 2011). This focus covers both societal need to prevent further increases in costs for institutionalized care, as well as the desire of most elderly people to age in place (Cheek et al., 2005). Physical activity plays an important role in this respect. Being able to walk or cycle to grocery stores contributes substantially to independent living and to health and well-being of elderly (Matthews et al., 2007; Noda et al., 2005; Savela et al., 2010; Smith et al., 2007). It is recognized that physical activity depends on individual characteristics (e.g. age, physical conditions, cognitions towards physical activity) and environmental characteristics (Alfonzo, 2005; Kremers et al., 2006; Sallis et al., 2002) such as the presence of shops (Chaudhury et al., 2012; Van Cauwenberg et al., 2012). Various studies have explored the role of physical environmental factors for walking among elderly. A review of the literature reveals that evidence for such associations is mixed (Van Cauwenberg et al., 2011). These mixed results have been attributed to methodological limitations such as the way buffers to measure environmental characteristics were constructed (i.e. circular vs. road networks) (Oliver et al., 2007) and their size (i.e. "buffer sizes") (Brownson et al., 2009). Circular buffers become less accurate with the occurrence of physical barriers (e.g. rivers, highways). Therefore, road network buffers are often the preferred methods for constructing a buffer to study environmental correlates of physical activity behavior (Oliver et al., 2007). When choosing an appropriate buffer size to capture environmental characteristics, it is important to know how far people travel actively, which gives an indication of the environmental factors to which people are likely exposed. Auchincloss et al. concluded that there is still little knowledge regarding the relevant buffer size to study the impact of the environment on physical activity (Auchincloss et al., 2012). Some studies have investigated the importance of the size of buffers by studying correlates of physical activity within various buffer sizes (Dowda et al., 2009; Nagel et al., 2008; Prins et al., 2011), but little is known about the number of trips, made by means of active travel, within and beyond these buffers. Information on the relative number of trips made within and beyond these buffers provides insight into the exposure of elderly to their neighborhood environment. We therefore aimed to get insight into the number of trips made beyond various network buffer sizes using GPS measures. This knowledge may aid researchers in constructing appropriately sized network buffers.

A factor that complicates the determination of distances that elderly are willing to travel actively for their grocery shopping is that these distances may differ according to personal factors, such

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as age and gender (Perchoux et al., 2013). This may have consequences for relevant buffer sizes in which environmental influences on active transport behavior are studied. It has been shown that self-reported trip length decreases with increasing age (Yang and Diez-Roux, 2012) and that men seem to cycle less than women (Krizek et al., 2005). In a similar way it is likely that people with functional limitations are more bound to their residential environment and therefore travel shorter distances actively. Insight into how personal characteristics affect the distance people travel actively is needed to come closer towards the individualized buffer sizes where has been called upon (Diez Roux et al., 2007; Perchoux et al., 2013). Therefore, we also examined differences in distances traveled actively according to gender, age, and level of functional limitations.

In summary, it is the aim of this study to a) get insight into the number of trips walked and cycled beyond various buffer sizes using GPS measures and b) examine whether these differ according to gender, age, and level of functional limitations. We hypothesized that, given the high connectivity and relatively good infrastructure for walking and cycling in The Netherlands, most elderly will walk or cycle to get their groceries for distances well beyond 1000 m. In addition, we hypothesized that trip length decreases with increasing age and functional limitations.

2. Methods

2.1. Study design

This study used cross-sectional data derived from the ELANE (Elderly And their Neighborhood) study, which was conducted in Spijkenisse, a medium-sized city of 73,000 residents (Centraal Bureau voor de Statistiek, 2012) in The Netherlands in 2011–2012. The ELANE study aims at investigating associations between environmental characteristics and physical activity, functional loss, independent living and quality of life in two samples: 1) dismissed hospitalized elderly who participate in the Prevention and Reactivation Care Program (PreCAP) study (de Vos et al., 2012), and 2) randomly selected community-dwelling elderly. In this study we focused on the random sample. The medical ethical committee of the Erasmus Medical Center issued a declaration of no objection for this study.

2.2. Sampling and procedure

As part of the ELANE study, a sample of 2017 community-dwelling elderly (≥ 65 years) was randomly drawn from the municipal population registry of Spijkenisse in 2011. Based on their name and address their phone numbers were looked up in online phone number registries. Matched telephone numbers were found for 1190 persons, who received an invitation letter before they were called. In total, 1040 persons answered the phone within 5 attempts. Participants had to be non-institutionalized, not bedridden, community-dwelling, not dependent on a wheelchair and proficient in Dutch. Sixty-eight persons were excluded, as they did not match the above mentioned inclusion criteria. Of the 972 persons eligible for inclusion, 430 were willing to participate (response proportion 44.2%). Home interviews were carried out by trained research staff between September 2011 and July 2012, excluding the winter months of January to March, in which physical activity levels may be minimal.

The present study used data from a 36% subsample of the elderly ($n = 156$) who wore a GPS logger and accelerometer for one week. The subsample consisted of a higher percentage of higher educated individuals than the total sample. No differences were observed in terms of age, gender, weekly minutes spent walking, and weekly minutes spent cycling.

2.3. Measures

2.3.1. Measuring location: GPS receiver

Elderly in the subsample were instructed to wear a GPS receiver on their right hip (Travel recorder X, BT-Q1000X, QStarz International), from waking hours to bedtime for seven consecutive days. The elderly charged the GPS receiver during the night. A recent study which compared various GPS loggers showed that this GPS logger has a relatively good performance in terms of battery life and accuracy (Duncan et al., 2013). The GPS logger recorded at least every 10 s the x and y coordinates and time. From these parameters, distance and speed between two points were calculated (Kerr et al., 2012). The GPS data were downloaded by using Q-Travel software and projected as a layer in a GIS database containing street patterns and shops by using the URBIS III software package (TNO, 2012).

2.3.2. Determination of trips for shopping

To define the origin of the GPS track, the exact location of the home address was determined by using a center of gravity technique on the GPS signals at night hours (Maas et al., 2013). GPS points were projected in grid cells of 10 by 10 m. Grid cells that contained more than 99 points during night hours were analyzed. In an iterative process, the x-and y-positions of these grid cells and their 8 surrounding grid cells were averaged to obtain a first estimated location. Subsequently, points at a distance of more than 3 times the root-mean square were considered outliers and were excluded from the analyses. This process was iterated until the new estimated location was at a distance of at most 5 m from the previous estimated location.

Only trips that started from the home address and ended in the proximity of a grocery store were considered in this study. Data on the locations of grocery stores (i.e. supermarket, bakery, butcher, fish shop, greengrocery) were derived from the "National Information System Labour Organisations" (Landelijk Informatie System Arbeidsorganisaties). All trips that departed from the home address and entered a 30 m buffer around a grocery store were detected in the data. To be sure that the grocery store was the endpoint of the trip, the GPS signal had to be in the 30 m buffer for at least 80% of the time for a period of 2 min. The exact endpoint of a trip was determined by sequentially determining whether a data point (X) was closer to the grocery store than the previous data point ($X-1$). If this was the case, the data point was part of the trip. When a data point (X) was further than the previous data point ($X-1$) from the grocery store, the previous data point ($X-1$) was the endpoint of the trip. The same procedure was applied in the reverse direction towards the home location to find the starting point of the trip.

2.3.3. Outcome: trip length

For each trip classified as "grocery shopping", the one-way traveled distance (i.e. the length of the GPS track) between the first point of the track (i.e. the home) and the endpoint of the trip (i.e. the grocery store) was determined. In total 2740 potential trips were automatically identified in the data. Spurious trips were identified and deleted. Trips were considered spurious if all data points were in the cluster that defined the home location. In that case it is likely that the participant was living in the near proximity of a shop. This was the case for one respondent, who was responsible for 1800 "trips". A trip was also considered to be spurious if the average speed was over 150 km/h, if distances traveled were larger than 5 km, if time traveled was more than