Update on Distance and Velocity Requirements for Community Ambulation

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ABSTRACT

Purpose: The purposes of this study were to provide an update to the ambulatory distance requirements for community ambulation and to update gait speed performance and requirements at intersections.

Methods: Distances were measured at 9 types of sites using a rolling measuring device in accordance with the protocol set forth by Lerner-Frankiel and associates. The 9 types of sites were supermarkets, drug stores, banks, department stores, post offices, medical offices, superstores, club warehouses, and hardware stores. Gait speed allotted by crosswalk signals as well as the gait speeds of individuals through crosswalks were recorded. Qualitative observations of the pedestrians' age (older ≥ 65 years; younger < 65 years) and sex were also noted.

Results: Distances were measured at 141 different establishments. The shortest mean distance requirement was found in the medical offices at 65.82 (32.28) m. Club warehouses had the longest mean distance requirement at 676.82 (159.36) m. The mean gait speed used by the pedestrians (N = 139) was 1.32 (0.31) m/s while the mean speed necessary as set by the crosswalk signals was 0.49 (0.20) m/s. All of the individuals observed were able to cross the street within the allotted time and with adequate speed. The gait speeds met the normative data established for age and sex as well as data reported for slower older adults and some with incomplete spinal cord injury.

Conclusions: Distance requirements for full community ambulation may need to be increased to 600 m or more. Gait speed requirements at crosswalks in the communities measured are set to accommodate the gait speed capabilities of older pedestrians who attempt crossing at controlled intersections.

Key Words: community ambulation, gait, gait speed

(J Geriatr Phys Ther 2010;33:128-134.)

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DOI:10.1097/JPT.0b013e3181eda321

INTRODUCTION

Community ambulation has been defined as "independent mobility outside the home," which includes the ability to confidently negotiate uneven terrain, private venues, shopping centers, and other public venues.[1] For older individuals, the ability to ambulate in the community as well as in the home is an important determinant in the ability to maintain an independent lifestyle.[2] In a survey of patients recently discharged from inpatient rehabilitation after sustaining a stroke, Lord et al[1] found that 74.6% of their survey participants considered the ability to get out to a setting in the community as either essential or very important to them. Patla and Shumway-Cook[3] have identified 8 environmental dimensions that are associated with independence in ambulation and mobility in a given community. Two of the 8 dimensions include minimum walking distance and time constraints to be able to perform in a community environment (ie, distance and gait speed).

According to the Functional Independence Measure,[4] a patient must be able to ambulate a minimum of 46 m (150 ft) before being designated as an independent ambulator. Lapointe et al[5] reviewed several clinical measurement scales of ambulation and they found that the furthest ambulatory distance required of patients in these tests was 62 m (200 ft). However, in studies conducted in the 1980s, several different investigators measured actual distances in retail and other establishments in the community.[6-8] Most of the distances measured were greater than 62 m. Lerner-Frankiel et al[6] found from their measurements that individuals ambulating in the community may have to traverse a distance of as much as 600 m when visiting 1 location. Cohen et al[7] found that the mean distances that people had to travel when visiting locations in the community were greatest at supermarkets (M [SD] = 293.5 [60.5] m) and department stores in shopping malls (M [SD] = 360.2 [66.5] m). They chose twice the farthest mean distance (720.4 m) as the point for determining community ambulation since they determined that an individual often goes to more than 1 destination on an outing. Robinett and Vondran[8] also found that distances required to ambulate in the community are often greater than distance benchmarks in clinical measurements such as the Functional Independence Measure. In their study, Robinett and Vondran found that individuals may have to ambulate as much as 480 m when visiting supermarkets. These measurements were taken, however, prior to passage of the Americans with Disabilities Act that forced retail establishments to provide handicapped-accessible parking.[9] Thus, the distances measured by these investigators may have been inflated by the fact that only about one-half of the establishments measured provided handicapped-accessible parking.[6-8]

Since these studies were conducted in the 1980s, no subsequent studies have been conducted in the United States even though significant changes have taken place in the layout of retail establishments, most notably the advent of "big-box" retail stores. Research at Columbia University characterized the general traits of big box retail as a single-story, rectangular building occupying more than 50 000 sq ft, typically ranging from 90 000 to 200 000 sq ft. The stores are isolated with acres of parking and little-to-no pedestrian amenities.[10]

Another important concern when determining the ability to ambulate in the community is gait speed.[11] Gait speed may be a measure that helps to discriminate between limited community ambulators and full community ambulators.[12-13] In community settings, gait is often measured at crosswalks, where speed is of utmost importance. As with ambulatory distance, studies have been conducted in the United States that examine gait speed at crosswalks, but they are not current.[8,14,15] The prior recommended walking speed to safely cross an intersection was 1.2 m/s.[16,17] However, more recently, there have been several recommendations to adjust the speed needed to be more representative of the population using those crosswalks. Now the recommendations range from 0.9 to 1.2 m/s.[17,18] However, it is unknown whether communities follow these recommendations.

As 2 determinants of independent community ambulation have exhibited major changes in their characteristics, the purposes of this study were to provide an update to the ambulatory distance requirements for community ambulation and to update gait speed performance and requirements at intersections with crosswalk signals.

METHODS

This study was approved by the Elon University Institutional Review Board. Individual consent was not required as no one was distinctly identified and because of the nature of the measurements as described later.

Measurements

Functional distances

In this study, 9 types of sites were measured using a Meter Man rolling measuring device (Model EW45, Winnebago, Minnesota) to determine mean distances traversed in common community settings. The 9 types of sites were supermarkets, drug stores, banks, department stores, post offices, medical offices, superstores (eg, Target, Wal-mart), club warehouses (eg, Costco, Sam's Club), and hardware stores (eg Lowe's, Home Depot).

Lerner-Frankiel et al[6] established a protocol for the distance measurements in Los Angeles County at supermarkets, large drug stores, banks, physicians' offices, post office, and department stores in a shopping mall. This study used the same protocol and similar equipment for distance measurements as presented. The only differences in methods used between the Lerner-Franiel study and this study were that we used the closest handicapped parking space, not the closest space if no handicapped parking was available, and we added the distances for superstores, club warehouses, and hardware stores.

All locations were measured from the closest available handicapped-accessible parking space and into the closest entrance. Measurement for supermarkets and large drug stores continued from this entrance, down half of the total number of aisles, through the closest exit checkout stand, and back to the same accessible parking space. Measurements for banks and post offices continued into the designated line and to the farthest teller, followed by exiting to the same accessible parking space. At physicians' offices, measurements continued to the elevator if more than one floor, from the elevator or directly to the waiting room, and return to the parking space. For department stores, measurements continued from the closest entrance on the ground floor, around the perimeter plus the distance from the main aisle to the passenger elevator, then back to the same parking space. For large hardware stores, measurements continued around the most outside aisle possible, plus up and down the center main aisle that goes from the front to the back of the store, out through a checkout, and back to the same parking space. For superstores, measurements continued from the front entrance (nongrocery entrance if available), around the most outside aisle possible (not including the garden/outside center), plus up and down the center main aisle that goes from the front to the back of the store, out through a checkout, and back to the same parking space. For club warehouses, measurements continued around the most outside aisle possible, plus up and down the center main aisle that goes from the front to the back of the store, out through a checkout, and back to the same parking space. At each location, the presence/availability of benches or motorized carts for the public to utilize was noted. The number of benches or motorized carts was not recorded.

Crosswalk measurements

Measurements taken included crosswalk distances, the time required for pedestrians to cross them, and the time allotted to cross. Data were collected from 2- to 6-lane crosswalks. "Lanes" included traditional traffic lanes as well as side-street parking and turning lanes. Distances from curb to curb (or between curb cutouts where applicable) were recorded in feet or meters using a rolling wheel; all data were then converted to meters.

The amount of time from the beginning of the "walk" signal to when the "don't walk" signal stopped flashing was recorded in seconds with a standard stopwatch to determine allotted time to cross the crosswalk safely. If no walking signal was present, the amount of time from the beginning of a green light at the cross street until the appearance of the yellow light was recorded consistent with the protocol of Lerner-Frankiel et al.[6] Individuals were then observed crossing the intersection. The amount of time required to go from curb to curb was recorded starting when the first foot entered the crosswalk and ending when both feet were out of the crosswalk. Qualitative observations of age (older ≥ 65 years; younger < 65 years) and sex were also noted in accordance with the methods utilized by Hoxie and Rubenstein.[14]

Data Analysis

The data collected for the crosswalk analysis (crosswalk distance, allotted time to cross, and actual pedestrian crossing times) were used to determine, in m/s, the average ambulation velocity of the pedestrians as well as the average velocity required to navigate the crosswalks safely. Data were further stratified by age group (young adult vs older adult) and sex.

Reliability of Distances Measured

To determine interrater reliability, the same grocery store, hardware store, superstore, and department store were measured by each member of the study group independently. Each group member measured these locations in the same manner that he or she had been collecting data based on the set protocol throughout the entire study.

RESULTS

Reliability

Distance measures were taken at 10 separate locations by 4 investigators. The intraclass correlation coefficient for agreement between the investigators was 0.977 with a 95% confidence interval (0.878, 0.999) with $P < .0001$ significance.

Geography/Demographics

Data were collected from late 2007 to December of 2008. Distances were measured at 141 different establishments in the 9 categories. These measurements were taken in 15 towns and cities in multiple regions of central and western North Carolina. If available, at least one of each type store was measured in the cities chosen. Cities included Raleigh, Durham, Elon, Burlington, Elkin, Boone, Greensboro, Mebane, Winston-Salem, Chapel Hill, Asheboro, Julian, Liberty, Lewisville, and Clemmons. The population in the towns and cities measured ranged from 2719 to 375 806 based upon the 2007 US government census.[19]

Crosswalk data were limited to 4 cities in the central part of the state as both a sample of convenience and because of more pedestrian traffic in those communities. In those areas, 139 people were observed. However, data on age or gender were missing for 11 people. These 11 people were omitted from the analysis bringing the final number of participants to 128: 32 older individuals (12 female, 20 male) and 96 younger individuals (44 females, 52 males).

Functional Distances

Table 1 presents the summary information for distances in the different categories. The shortest mean distance was found in the post offices at 52.0 (23.3) m, with the club warehouses at the highest at 676.8 (159.4) m. Figure 1 compares the mean distances (m) for the studied locations and the data from Lerner-Frankiel et al.[6] Figure 1 also includes the mean distances for the categories not available for study in Lerner-Frankiel et al's[6] work (ie, superstores, hardware stores, and club warehouses).

Table 1. Distances in Meters Required to Traverse Each Type of Establishment

Category	N	Mean (SD)	Minimum	Maximum
Post office	12	52.0 (23.3)	25.1	98.4
Bank	17	57.1 (20.9)	25.0	102.0
Medical	16	65.8 (32.2)	30.5	149.4
Pharmacy	18	206.3 (26.8)	153.9	255.1
Department store	20	345.9 (69.2)	241.3	512.0
Grocery	23	380.6 (86.3)	162.1	526.0
Hardware	14	565.5 (38.6)	499.2	626.7
Superstore	16	606.6 (101.2)	472.0	792.0
Club warehouse	5	676.8 (159.4)	506.3	922.0

Figure 2 presents the percentage of the locations in which some kind of power scooter or motorized mobility device was present and the percentage of the places that had benches available. Of the 3 largest establishments, all superstores, hardware stores, and club warehouses provided some type of motorized mobility device. Ninety-four percent of the superstores and 80% of the club warehouses had benches available for their customers. To the contrary, only 36% of the hardware stores provided benches for their customers to sit on.

Crosswalk Measurements

The individual gait speeds and the times allotted by the signals varied across the communities measured. The mean gait speed used by the individuals observed to cross the street was 1.32 (0.31) m/s while the mean speed necessary as set by the signals was 0.49 (0.20; see Table 2) m/s. Figure 3 presents the means and standard deviations of the gait speed utilized by the participants when age and sex were considered. The speeds were within the confidence intervals for age group and sex as established in previous studies examining normative values for gait speed.[20,21] All of the individuals observed were able to cross the street within the allotted time and with adequate speed. The slowest speed by an individual was 0.48 m/s, whereas the fastest was 1.89 m/s. The speed allotted by the intersection ranged from 0.21 to 0.89 m/s. Interestingly, the crosswalk requiring the fastest speed to cross was in the smallest town recorded, whereas the crosswalk with the lowest speed requirement was in the largest city recorded.

DISCUSSION

Community Ambulation Distances

The mean distances for all categories of locations in the study by Lerner-Frankiel et al[6] fell within the 95% confi-

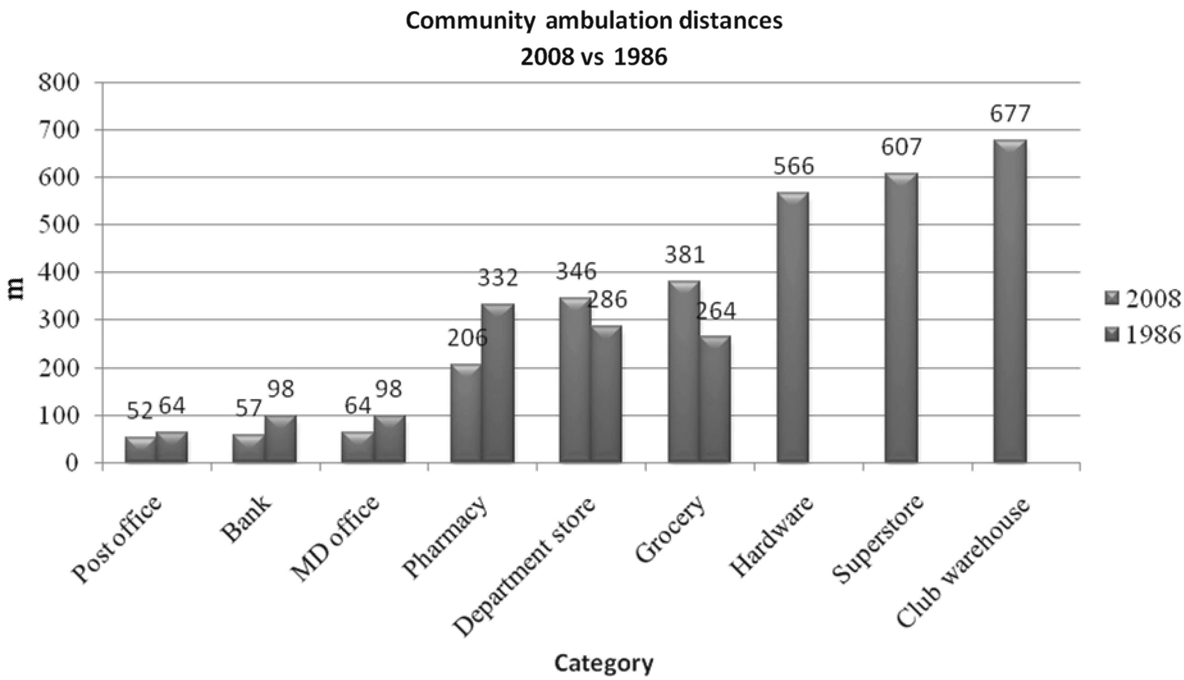

Figure 1. Mean community ambulation distances by category for this study compared to the study by Lerner-Frankiel et al.[6]

dence interval for the same category in this study with the exception of pharmacy. Thus, with the exception of the pharmacy category, the mean distances as measured using the same methods as those of Lerner-Frankiel et al[6] do not appear to have changed appreciably in the last 2 decades. Distances to pharmacies may have decreased over the last 2

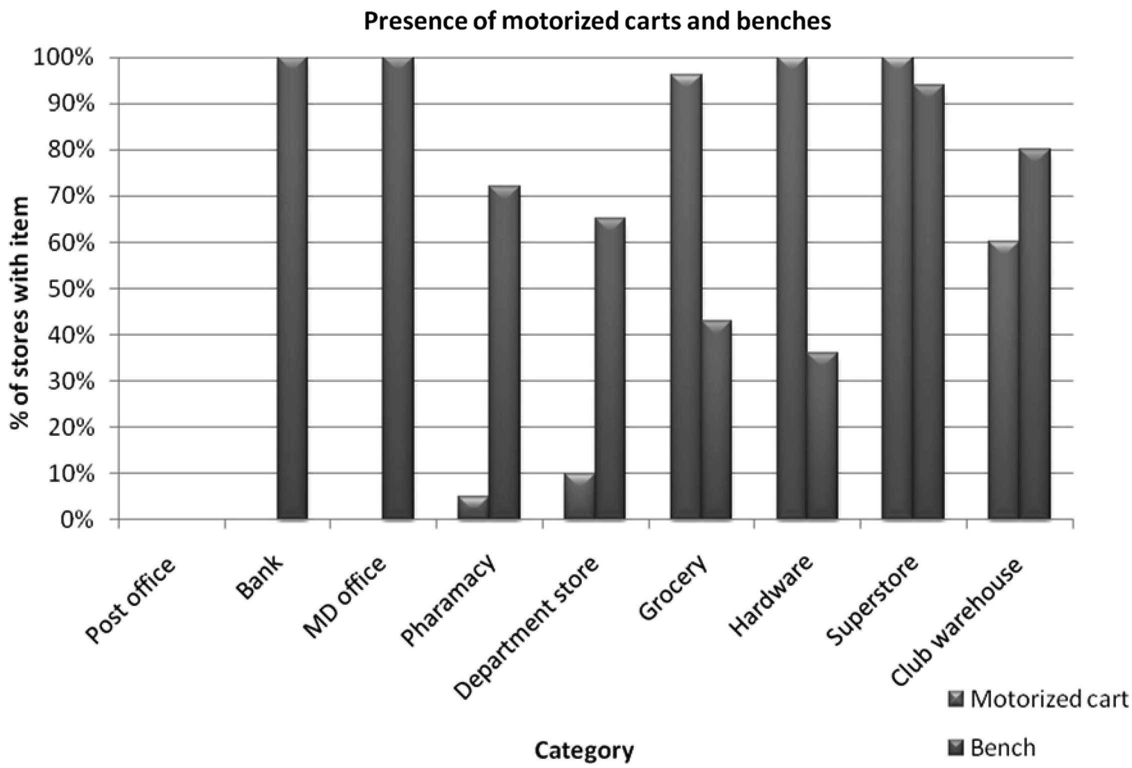

Figure 2. Availability of motorized carts and benches by category.

Table 2. Distance and Temporal Parameters for Allotted and Participants' Gait Speed in Crosswalks (N = 128)

	Mean (SD)
Allotted walk time (s)	30.67 (10.57)
Crosswalk length (m)	13.29 (3.84)
Allotted crosswalk speed (m/s)	0.49 (0.22)
Participants' crossing time (s)	10.29 (2.59)
Participants' speed obtained (m/s)	1.32 (0.31)

decades as these health care providers may have become more aware of the benefit of providing better accessibility to patients, especially those with disabilities.

Big box retail stores were not commonplace when the previous researchers measured community distances. As anticipated, the distances needed to traverse these stores with large footprints are higher than the distances required for the other categories. These measurements may even be conservative estimates of distance requirements in these large retail settings since the methods replicating the Lerner-Frankiel et al[6] study did not require the investigators to measure down most of the aisles. We contend that patrons who wish to ambulate in large hardware stores, superstores, and club warehouses should be able to ambulate at least 600 m without needing to sit down. This contrasts dramatically with scales addressing levels of ambulation that consider distances less than one-tenth of 600 m to be sufficient for independent ambulation.[4,5]

We did note that most of the superstores and club warehouses had powered mobility devices and benches in the stores for customers to use. Based upon previous pilot studies, multiple locations have added benches for their customers within the previous 2 years. The large hardware stores did not typically provide benches for their customers, possibly with the rationale that there are not many places to safely sit given the large items that are often moved throughout the store. All hardware stores measured, however, did provide motorized carts for their customers who are unable or unwilling to ambulate distances approaching 700 m.

Clinical measures that are used to determine independence in ambulation require patients to be able to ambulate only 62 m or less. These measures thus provide a ceiling effect for those patients who wish to return to full, independent community ambulation, given the findings of this study. Certainly, some patients' goals will be to return to that of a limited community ambulator. If a patient is content with limiting his community ambulation to locales such as the bank, post office, and physician's office, then the typical clinical measures are appropriate. However, if full

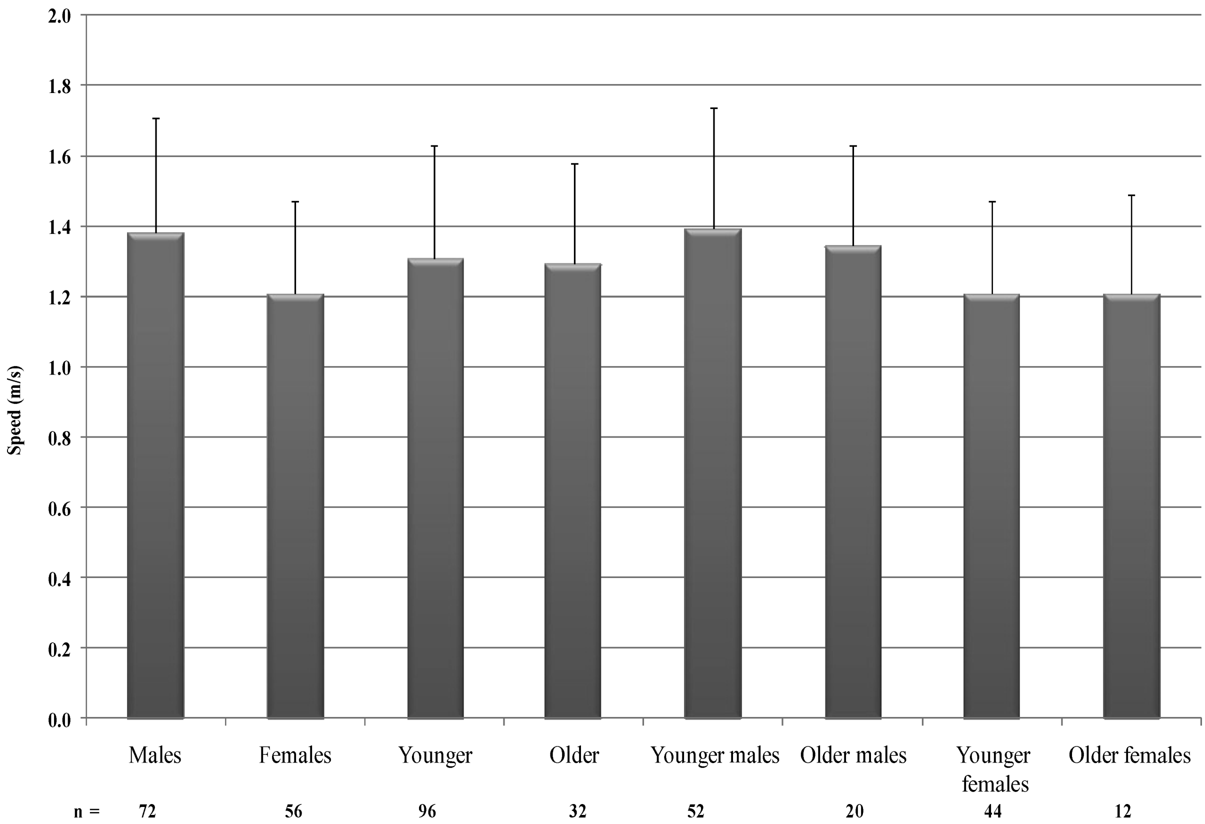

Figure 3. Crosswalk speed stratified by age and gender. The means for each group are given below the chart with error bars representing standard deviations.

community ambulation is the patient's goal, he will need to be able to ambulate much further than 62 m.

Gait Speed

The results of this study pertaining to gait speed at intersections differ from those of Hoxie and Rubenstein.[14] These previous investigators found that 27% of the individuals observed were not able to cross the intersection in the time allotted by the signals whereas all of our participants were able to cross the street in the allotted time. The speed required to cross the intersection examined in the prior study was 0.81 m/s, whereas the mean velocity required to cross the intersections examined in this study was only 0.48 m/s. Both of these velocities are slower than the recommended range of between 0.9 and 1.2 m/s (3.0 and 4.0 ft/s).[17,18] Other previous investigators also found gait speed requirements for crossing intersections to be higher than 0.48 m/s. Over the last 2 decades, transportation engineers and city planners may have increased the time allowed to cross intersections so as to minimize the increased risk of being hit crossing the street that aging adult pedestrians face.[15] The effect of regional variations in these different studies on allotted crosswalk times also cannot be ruled out; this is the first study to examine allotted crosswalk velocities in the southeastern United States. Crosswalk velocity requirements may vary based on geographic region.

The mean gait speed for the older participants through the crosswalks in this study (1.29 m/s) was greater than the mean gait speed for older participants in a prior study (0.86 m/s).[14] Faster gait speeds through the intersections by the aging adult participants in this study were more in line with previously published normative values for gait speed measured in clinical and laboratory settings.[20,21]

The speeds measured for the older participants did not appear to differ from the speeds measured for the younger participants (see Figure 3). This contrasts with normative gait speeds, which shows that younger adults have faster gait speeds than do older adults.[20,21] The similar gait speeds in this study irrespective of age group may reflect the setting in which the measures were taken. Participants in this study were measured walking through intersections with timed crosswalk signals. They were provided feedback from the crosswalk signals about the finite period of time they had to cross the intersection before cars would be allowed to traverse the crosswalk. This understanding may have forced those who typically walk slower to increase their gait speed and may have allowed those who typically walk faster to slowdown, especially as they reached the end of the crosswalk prior to stepping onto the curb. The setting for this study contrasts with the typical setting used in determining gait speed normative values. When determining normative values for gait speed, researchers typically test their participants in the clinical or laboratory setting. Participants are asked to walk at their comfortable walking speed and they are not provided feedback cueing them to walk faster or allowing them to slow down.[20,21]

Limitations/Future Research

As with prior studies that investigated community ambulation distance and gait speed requirements, this study was limited in scope to one geographical region. Distance and gait speed requirements may vary from one region to the next though many of the big box stores are national in their scope.

Measurements in this study were taken in a mixture of rural, suburban, and urban settings.[19] The data set was not large enough, however, to allow for stratification of the data by size of the town or city. A larger sample of gait speed and distance measurements in rural, suburban, and urban communities will allow future investigators to differentiate community ambulation requirements between these different settings.

The methods used in collecting gait speeds did not ensure that all participants were accurately placed in the correct age group. Greater accuracy of age group placement may have occurred if the investigators had questioned each participant as to his or her birth year.

The results of this study do not allow one to generalize the gait speeds obtained to the general population of community ambulators. Gait speeds were determined from participants only in crosswalks. Gait speeds may have been different if measurements were taken with participants on sidewalks or in stores. Furthermore, not all those who ambulate in the community are confident enough in their ability to cross the street; thus, our sample may have been biased toward those who were confident in their ability to cross the street safely and in a timely manner.

Other possible limitations or considerations for future data collection include increasing difficulty collecting distance data within banks due to security measures, increase in the number of automated teller machines and drive-up windows, changes in configuration of the superstores, realistic utility of motorized carts, especially for older adults, changes in timing for crosswalks based upon pedestrian versus vehicular activation of crosswalk signals, and changes in crosswalk light notifications to pedestrians from flashing signals to countdown timers.

CONCLUSIONS

Distance requirements for full community ambulation may need to be increased to 600 m or more given the plethora of retail establishments that now have larger footprints. Gait speeds requirements at crosswalks, at least in this study, are set to accommodate the gait speed capabilities of aging adult pedestrians.

ACKNOWLEDGMENTS

This project was supported by a grant from the Graduate Student Research Fund at Elon University. We are grateful to the following individuals who conducted the pilot project for this study: William Jordan, Brad Kessler, Timothy McHugh, Elizabeth Storholt, and Stephanie Thompson.

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