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Gait Speed and Variability for Usual Pace and Pedestrian Crossing Conditions in Older Adults Using the GAITRite Walkway

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Abstract

Objectives: To determine gait characteristics of community-dwelling older adults at different speeds and during a crosswalk simulation. **Methods:** Twenty-two older adults completed walking trials at self-selected slow, usual, and fast paces, and at a crosswalk simulation, using the GAITRite walkway. These objective measures were complemented by self-report health and mobility questionnaires. **Results:** Gait speeds at self-selected slow, usual, and fast paces were 98.7 (18.1) cm/s, 140.9 (20.4) cm/s, and 174.0 (20.6) cm/s, respectively, and at simulated crosswalk conditions was 144.2 (22.3) cm/s. For usual pace, right step length variability was 2.0 (1.4) cm and step time variability was 13.6 (7.2) ms, compared with 2.4 (1.3) cm and 17.3 (9.7) ms, respectively, for crosswalk conditions. **Discussion:** Our sample of healthy older adults walked at a speed exceeding standards for crossing urban streets; however, in response to a crosswalk signal, participants adopted a significantly faster and more variable gait.

Keywords

walking speed, outdoor mobility, pedestrian

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Introduction

The ability to safely cross the street may be taken for granted by some, but for older adults, many of whom experience age-related changes in mobility, full community engagement can become impeded by difficulties crossing the street. Age-related changes can include decreased gait speed (Bendall, Bassey, & Pearson, 1989; Bohannon, 1997; Imms & Edholm, 1981) and increased variability (Callisaya, Blizzard, Schmidt, McGinley, & Srikanth, 2010; Kang & Dingwell, 2008), which can be explained in part by declining body function, such as reduced strength and flexibility (Bendall et al., 1989; Kang & Dingwell, 2008). Verghese et al. (Verghese, Holtzer, Lipton, & Wang, 2009) reported that each decrease of 10 cm/s in gait speed was associated with a 7% increased risk for falls; other studies also found associations between slow gait speed and incident falls (Montero-Odasso et al., 2005; Perracini, Teixeira, Ramos, Pires, & Najas, 2012). Measures of gait variability are also higher in older adults who subsequently fall compared with those who do not (Brach, Berlin, VanSwearingen, Newman, & Studenski, 2005; Hausdorff, Edelberg, Mitchell, Goldberger, & Wei, 1997; Hausdorff, Rios, & Edelberg, 2001; Maki, 1997; Verghese et al., 2009).

Regulations for pedestrian crosswalks in Canada (Transportation Association of Canada, 1998), as well as in the United States (Hoxie & Rubenstein, 1994), United Kingdom (Asher, Aresu, Falaschetti, & Mindell, 2012), and South Africa (Amosun, Burgess, Groeneveldt, & Hodgson, 2007) are based on a walking speed of 1.2 m/s, which is beyond the normal capabilities of many older adults (Asher et al., 2012; Hoxie & Rubenstein, 1994; Langlois et al., 1997; Montufar, Arango, Porter, & Nakagawa, 2007). Older adults report that crossing the

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street can be concerning or even dangerous (Hoxie & Rubenstein, 1994) and that this is a barrier to engaging in their physical environment (Grant, Edwards, Sveistrup, Andrew, & Egan, 2010). Thus, it is important to understand the physical response to pedestrian crosswalks, to support older adults' participation in their communities and prevent further mobility decline.

Many existing studies on older adults' street-crossing behaviors examine gait speed (Asher et al., 2012; Hoxie & Rubenstein, 1994; Langlois et al., 1997; Montufar et al., 2007), but omit other, clinically relevant, gait parameters. Therefore, we conducted a descriptive, cross-sectional study to measure temporal and spatial gait parameters. Our aim was to determine the gait speed and patterns of healthy, community-dwelling older adults as they completed walking trials at different speeds, and during a crosswalk simulation to characterize response to a common outdoor mobility activity. A complete description of older adults' reaction to walking under different conditions is necessary to understand the gait-related risks older adults face when participating in community ambulation.

Method

Participants

We recruited 22 healthy, community-dwelling, older adults, using a convenience sample from a list of previous research participants at our center, and respondents to an electronic advertisement circulated through local hospital distribution lists and posted on our website. We obtained ethics approval from our local and hospital institutional research ethics boards (H11-00238); all participants provided written informed consent prior to taking part in the study.

We included participants who were 65 years plus; living in the community; and able to walk a distance of 10 m without stopping, with or without a mobility aid. Individuals were excluded if they had: uncontrolled medical problems; sustained a fall-related fracture in the previous 12 months; experienced three or more falls in the previous 12 months; severe visual impairment or color blindness; unstable angina or experienced a heart attack in the previous month; uncontrolled hypertension or resting tachycardia; and/or a history of stroke with existing neurological impairments.

Instruments

We used the GAITRite Electronic Walkway (CIR Systems Inc., Peekskill, NY), an electronic gait analysis system, to collect quantitative gait information. The GAITRite walkway is 6 m long and 0.6 m wide, and uses pressure-activated sensors to measure temporal and spatial gait parameters (CIR Systems Inc, June 13, 2012); it is a reliable and valid system for measuring gait parameters in older adults (Menz, Latt, Tiedemann, Mun San Kwan, & Lord, 2004; Webster, Wittwer, & Feller, 2005). We measured gait velocity (speed), step length, step time, step length variability, and step time variability. We defined all variables according to the GAITRite manual (CIR Systems Inc, June 13, 2012). In addition, for trials using the crosswalk scenario, we used a demonstration unit of a pedestrian crossing signal compliant with regulations for city streets. The LED light signal had an orange symbol, indicating "Don't Walk," and a white symbol, indicating "Walk."

Test Procedure

Anthropometry. We measured height to the nearest millimeter with a stadiometer (Seca 242, Seca GmbH & Co. Kg., Hanover, MD), and weight to the nearest 0.1 kg with a scale (Seca 840, Seca GmbH & Co. Kg., Hanover, MD). We measured left and right leg length once from the greater trochanter to the floor using a standard tape measure, with participants wearing shoes.

Questionnaires. Participants completed a questionnaire consisting of demographic and general health information, home and community mobility, and perceptions of community walkability, and safety while walking. Questions were multiple choice, Likert-type scale, or allowed for open responses, and were developed to address the aims of the current study.

GAITRite Walking Trials. We measured three walking conditions: usual, fast, and slow paces. These were self-selected by each participant; they were instructed to "walk at [their] usual pace," "walk at a fast pace," and "walk at a slow pace," respectively. Within each of these conditions, participants completed three trials (nine trials). Usual pace was performed first, and fast and slow paces were randomized to prevent order effects. All tasks were repeated with two separate raters (18 trials total). Each walk was approximately 10 m in length: 6 m along the GAITRite mat with acceleration and deceleration periods of 2 m.

In the crosswalk scenario, participants completed three trials using a simulated pedestrian crossing signal. Beginning at the start of the GAITRite mat, participants were instructed to walk "at [their] usual pace when the crossing signal change[s] from the 'Don't Walk' to the 'Walk' symbol." The walk signal was used for the duration of the trials, that is, in our simulation, there was no indication of how much longer participants had to cross the street and the signal did not change back to the "Don't Walk" symbol.

To reduce possible fatigue, walks were broken up by condition and rater, and participants were given the opportunity to take rest breaks as desired. A research team member was close by during all walking trials in case assistance was needed. The entire testing procedure took approximately 1 hr.

Table 1. Participant Characteristics (N = 22).

Characteristic	M (SD) unless indicated	Range
Age, years	72.4 (4.8)	67-81
Sex, no. (%) women	19 (86.4%)	
Height, cm	165.6 (8.0)	149-180
Weight, kg	67.6 (9.3)	55.7-95.4
Body mass index, kg/m^2	24.7 (3.8)	19.4-30.5
Left leg length, cm	89.4 (6.5)	77.5-102
Right leg length, cm	89.0 (6.5)	77.3-101.5
Gait speed[a], cm/s	140.9 (20.4)	92.9-186.5
Gait speed variability (step-to-step)[a], cm/s	7.3 (3.1)	0.1-14.0
Step length[a,b], cm	70.5 (8.2)	50.4-87.4
Step time[a,b], ms	504.0 (41.7)	416.7-608.3
Step length variability[a,b], cm	1.9 (0.97)	0.4-6.2
Step time variability[a,b], ms	13.8 (5.6)	4.4-37.0
Fell in last 12 months, count (%)	8 (36.4%)	
Number of chronic conditions, median (25th, 75th percentile [IQR[c]])	1.5 (1, 2 [1])	0-3
Number of prescriptions, median (25th, 75th percentile [IQR[c]])	1.0 (0, 3 [3])	0-10

[a]Gait parameters at self-selected usual walking pace.
[b]Represents an average of values from left and right legs.
[c]IQR = interquartile range.

Statistical Analysis

We used means (M) and standard deviations (SDs) to describe participants' characteristics. To estimate all gait parameters, we used GAITRite Clinical Software Version 4.0 (CIR Systems Inc., Havertown, PA). Data were combined among trials and raters for all conditions (i.e., six trials each for usual, fast, and slow paces, and three trials for crosswalk conditions). We investigated four outcomes (gait speed, gait speed variability, step time variability, and step length variability), and we report different ways of mathematically expressing these characteristics based on the literature. Gait speed and gait speed variability were direct outputs from the GAITRite software. We calculated step length variability and step time variability in three ways, separately for each foot: first, as the SD output for step length and step time, respectively, across trials for each condition. Second, we calculated step-to-step variability; to do this, we first calculated differences by subtracting the previous value in a measurement series from the current value, and then obtained the SDs of these first differences. Third, we calculated the coefficient of variation for step length variability and step time variability ($CoV = 100 \times SD / M$, where SD is the output standard deviation for step length or time and M is the output step length or time). To measure the differences in gait speed and variability (left and right step length SD, and left and right step time SD) between crosswalk and usual conditions, we performed multilevel mixed regression analyses to account for the effects of clustering (at the individual, trial, and rater levels), and unbalanced data. Similarly, we used multilevel mixed-effects regression models to investigate the effects of fatigue using measurements from the first and last runs of the crosswalk condition. Last, we compared gait speed and variability between fallers and non-fallers using multilevel mixed-effects regression. We set statistical significance at $p \leq .05$. We used Stata Software Version 12 (StatCorp LP, College Station, TX) for all analyses.

Results

Participant Characteristics

In total, 22 participants took part in this study. The average age of the participants was 72 years (range 67-81 years); 19 (86%) were women and three were men. No participants used assistive walking devices. Participants reported a median 1.5 chronic conditions (range 0-3), the most common of which included arthritis (45%), visual impairment (32%), upper gastrointestinal disease (27%), osteoporosis (23%), and asthma (14%). In total, 17 (77%) participants were taking prescription medication; the number of prescriptions ranged from zero to 10, with a median of one. Eight participants reported falling at least once in the previous 12 months, of whom three reported no injury, four reported mild injury (bruising/swelling lasting one or two days), and one reported moderate injury (extensive bruising/swelling lasting several days). Table 1 shows the anthropometric characteristics and gait measurements of their usual walking pace.

Home and community mobility. Nineteen (86%) participants indicated that they left their home on a daily basis, and all participants left their home at least three times per week. Participants reported leaving their home for the following reasons: activities of daily living (91%), visiting friends (86%), recreational programs (86%),

Table 2. Observed Temporospatial Gait Parameters at Self-Selected Usual, Slow, and Fast Paces and in Response to Crosswalk Signal.

	Self-selected walking pace, values represent *M* (*SD*)			
Gait parameter	Usual pace	Slow pace	Fast pace	Crosswalk
Gait speed, cm/s	140.9 (20.4)	98.7 (18.1)	174.0 (20.6)	144.2 (22.3)
Gait speed variability (step-to-step), cm/s	7.3 (3.1)	6.6 (2.4)	9.3 (4.8)	9.2 (3.4)
Step length, cm				
Left	70.5 (8.4)	60.7 (8.3)	77.1 (9.5)	70.8 (8.5)
Right	70.5 (8.2)	60.4 (7.6)	76.8 (9.5)	70.9 (8.8)
Step time, ms				
Left	505.0 (42.6)	625.1 (70.3)	443.7 (37.8)	495.8 (46.2)
Right	502.9 (42.2)	620.5 (68.3)	442.9 (36.8)	495.5 (46.1)
Step length variability, cm				
Left	1.9 (1.0)	2.1 (1.0)	2.1 (1.3)	2.5 (1.6)
Right	2.0 (1.4)	2.3 (1.2)	2.1 (1.3)	2.4 (1.3)
Step time variability, ms				
Left	13.9 (7.0)	23.7 (15.0)	12.4 (6.5)	17.7 (12.7)
Right	13.6 (7.2)	22.8 (16.2)	12.0 (6.2)	17.3 (9.7)

and medical appointments (77%). Twenty (91%) participants somewhat or strongly agreed that stores and many other places to go were within easy walking distance of their home. All agreed that it was easy to walk to a transit stop from their home. Participants also identified enablers and barriers for walking around their neighborhood. The most common enablers included good infrastructure (such as sidewalks and pedestrian crossings; $n = 4$), proximity to parks ($n = 4$) or other destinations ($n = 3$), and nice weather ($n = 3$). Barriers included inclement weather ($n = 5$), uneven walking surfaces ($n = 3$), and poor lighting or diminished safety at night ($n = 3$).

Perceptions of community walkability and safety while walking. All participants agreed that there were sidewalks on most streets of their neighborhoods, and 15 out of 21 agreed that these sidewalks were well maintained. All but two participants agreed that crosswalks and pedestrian signals were present to help people cross busy streets as well as to make them feel safe while crossing streets. All participants indicated that they had to cross the street at least three times a week. Only one participant believed that traffic lights at pedestrian crossings do not provide enough time to cross the road safely (however, two additional participants were unsure about this statement). Six participants (27%) did not feel confident about their safety when crossing the road. Of these, three reported feeling apprehensive about crossing the road; two reported feeling anxious; and one reported feeling endangered. However, none of the six participants responded that this discouraged them from walking on the road.

Gait Measurements

Usual, slow, and fast conditions. At usual, self-selected walking pace, the mean gait speed of our participants was 140.9 (20.4) cm/s. At a slow pace, the mean velocity was 98.7 (18.1) cm/s, while at a fast pace the mean velocity was 174.0 (20.6) cm/s. There were no statistically significant differences at the $p \leq .05$ level between any parameters measured from the left and right legs. Step length variability increased at both slow and fast paces compared with usual pace, and step time variability increased at slow pace compared with usual pace; neither of these trends were tested for statistical significance (Table 2). We found no statistically significant differences between fallers ($n = 8$) and non-fallers ($n = 14$) in gait speed ($p = .44$), or variability (step length $p = .38$; step time $p = .93$).

Crosswalk scenario. The mean gait speed under simulated crosswalk conditions was 144.2 (22.3) cm/s. Under crosswalk conditions, step lengths were longer, step time was shorter compared with usual pace; however, this was not tested for statistical significance (Table 2). Table 3 compares gait parameters between usual and crosswalk conditions; step length and time variability were higher during crosswalk conditions than at usual pace (left step length variability $p < .001$, right step length variability $p = .009$, left step time variability $p = .003$, right step time variability $p = .004$). We found no statistically significant differences over time between variability measures; however, there was a statistically significant increase of 6.5 cm/s for gait speed between Trials 1 and 3 ($p = .023$; Table 4).

Discussion

Our aim was to determine the gait speed and patterns of older adults as they completed walking trials under four different conditions, including a pedestrian crosswalk simulation. We found statistically significant differences in gait speed and variability (step length, step time, and

Table 3. Model Estimated Gait Speed and Variability of Usual and Crosswalk Conditions.

Gait parameter	Usual pace	Crosswalk	Estimated difference	95% confidence interval	*p* value
Gait speed, cm/s	140.8	145.9	5.1	[2.4, 7.9]	.000
Gait speed variability (step-to-step) cm/s	7.3	9.4	2.1	[1.4, 2.7]	.000
Step length variability					
Left, cm	1.9	2.5	0.6	[0.3, 0.9]	.000
Right, cm	2.0	2.4	0.4	[0.1, 0.8]	.009
Step time variability					
Left, ms	13.9	17.7	3.8	[1.3, 6.4]	.003
Right, ms	13.6	17.0	3.4	[1.1, 5.7]	.004
Step length variability (step-to-step)					
Left, cm	2.3	3.5	1.2	[0.7, 1.7]	.000
Right, cm	2.4	3.2	0.8	[0.4, 1.4]	.001
Step time variability (step-to-step)					
Left, ms	16.3	22.3	6.0	[2.8, 0.9]	.000
Right, ms	15.9	20.2	4.3	[0.8, 7.6]	.015
Step length variability (CoV)					
Left, %	2.7	3.5	0.8	[0.4, 1.2]	.000
Right, %	2.8	3.5	0.7	[0.2, 1.1]	.004
Step time variability (CoV)					
Left, %	2.7	3.5	0.8	[0.2, 1.2]	.004
Right, %	2.7	3.3	0.6	[0.2, 1.1]	.006

Note. CoV = coefficient of variation (100 × *SD* / *M*). These results were estimated using multilevel mixed-effects linear regression and may differ from the actual or observed values reported in Table 2.

Table 4. Model Estimated Gait Speed and Variability of First and Third Crosswalk Runs.

Gait parameter	Run 1	Run 3	Estimated change	95% confidence interval	*p* value
Gait speed, cm/s	141.2	147.7	6.5	[0.9, 12.0]	.023
Gait speed variability (step-to-step), cm/s	9.2	8.8	−0.4	[−1.7, 1.00]	.579
Step length variability–Left, cm	2.7	1.9	−0.8	[−1.6, 0.1]	.082
Step length variability–Right, cm	2.4	2.4	0.0	[−0.7, 0.6]	.889
Step time variability–Left, ms	18.4	18.4	0.0	[−7.3, 7.2]	.988
Step time variability–Right, ms	19.8	17.0	−2.7	[−8.7, 3.2]	.368

gait speed variability) at crosswalk conditions compared with usual pace. Thus, even healthy older adults are inclined to change their gait at crosswalk conditions, and might be at increased risk for falls and related injuries due to the higher variability at crosswalk conditions than when walking at a usual pace (Hausdorff et al., 2001).

When walking at their own self-selected "usual" pace, our participants walked at a faster pace than observed in other studies (Bohannon, 2008; Bohannon & Andrews, 2008; Brach, Studenski, Perera, VanSwearingen, & Newman, 2007; Callisaya et al., 2010; Langlois et al., 1997; Montufar et al., 2007; Oh-Park, Holtzer, Xue, & Verghese, 2010). Callisaya et al. (2010) reported a mean gait speed of 116.0 (21.1) cm/s in a healthy sample with a similar mean age to our participants; however, their participants had a higher body mass index (BMI) and higher prevalence of hypertension, diabetes, and stroke. Two studies (Langlois et al., 1997; Oh-Park et al., 2010) had older participants, and one study (Montufar et al., 2007) had a different study design (observing participants walking within the community). Bohannon and Andrews's (Bohannon & Andrews, 2008) meta-analysis provides values of 138.1 and 133.7 cm/s for men and 123.9 and 117.1 cm/s for women in their 60s and 70s, respectively; however, the 44 studies analyzed likely include participants who have more health or mobility problems than our sample. The different mean gait speed obtained from analysis of National Health and Nutrition Examination Survey (NHANES) data (Bohannon, 2008) may also be accounted for by heterogeneity of participants. Nevertheless, similarly high values to our own have been found by some studies of community-dwelling older adults (Gérin-Lajoie, Richards, & McFadyen, 2006; Rantakokko et al., 2009). In addition, comparable findings to our crosswalk scenario were found by Montufar et al. (2007), who observed a statistically significant increase in gait speed (from 114 m/s to 136 m/s) for older adults crossing the street compared with usual walking.

Our variability measurements were lower than those reported in similar studies (Brach et al., 2010; Brach et al., 2007; Callisaya et al., 2010); however, these studies also reported lower gait speed, which is associated with increased variability (Kang & Dingwell, 2008). Furthermore, we must acknowledge that gait variability is limited by the nature of measuring variability. Faude et al. (Faude, Donath, Roth, Fricker, & Zahner, 2012) recommend caution when drawing conclusions from variability parameters due to the low reliability of these measures. Brach et al., (Brach, Perera, Studenski, & Newman, 2008) and Beauchet et al. (2011) also reported lower intraclass correlation coefficients (ICCs) for variability measures than for other gait measures. In particular, some studies have shown variability to be less reliable than gait speed, using different instruments—treadmills (Faude et al., 2012), gait mats (Beauchet et al., 2011; Brach et al., 2008), and footswitches (Beauchet et al., 2011)—and different methods for calculating variability—coefficient of variation (Beauchet et al., 2011; Faude et al., 2012) and *SD* (Brach et al., 2008). Recent literature suggests that when measuring gait reliability, measurement protocols may not include enough strides (Riva, Bisi, & Stagni, 2014). However, we believe it remains worthwhile to report these variability measures, as there is considerable evidence linking gait variability with falls risk, a topic of concern for many older adults; more research is required to elucidate the exact nature of this relationship as it is beyond the scope of the current study.

In general, our participants were relatively young and healthy, reporting high levels of mobility and low mobility anxiety as captured by our questionnaire items. The majority of our participants left their home on a daily basis, agreed that many destinations were within an easy distance to their homes, and responded positively about their community infrastructure. Fewer than 30% did not feel confident about their safety while crossing the road, but this did not discourage them from crossing the road, and only one felt that pedestrian crossings did not actually provide enough time to cross the road safely. Of note, more than 36% of participants reported falling in the previous year, and 23% reported injurious falls. Our questionnaire provides a general picture of the community mobility of our participants, however, the conclusions we could draw from it were limited as it is not a validated questionnaire and as such, we did not use it for any further statistical analysis.

Falls are significant events: Each year, approximately one third of older adults fall (Tinetti, Speechley, & Ginter, 1988). Fall location is an important factor, yet most of the existing literature is focused on indoor falls, and less is known about falls that occur outside (Li et al., 2006). Some studies report that up to half of all falls in older adults occur outside (Kelsey, Procter-Gray, Hannan, & Li, 2012); although older adults who fall outside are younger, with faster gait speed (Kelsey et al., 2012). Two qualitative studies (Clemson, Manor, & Fitzgerald, 2003; Nyman, Ballinger, Phillips, & Newton, 2013) provide greater insight into factors associated with falling outdoors. In Nyman et al. (2013), 45 older adults attended focus groups to discuss their experience falling outdoors. Many participants reported that the fall occurred while getting up/down from a curb or while crossing the street, and some attributed the cause of the fall to personal factors such as rushing or not paying attention (Nyman et al., 2013). Clemson et al. (2003; $N = 15$) noted similar reports of fast walking pace and rushing to cross the street as contributing to the fall. As our study had younger participants, with a faster walking speed, these findings of increased gait variability within a crosswalk scenario suggest further investigation into community-based walking and response to anxiety and/or other related perceptions of the built environment.

A possible limitation to our study was the use of a crossing simulation rather than real-world observation. On real streets, pedestrians encounter distracting sights and sounds, turning vehicles, and other pedestrians in crosswalk situations, which increase the complexity of the basic task of crossing the street. This can cause older pedestrians to walk slower in outdoor gait trials than in indoor trials (Carmeli, Coleman, Omar, & Brown-Cross, 2000). Also, the GAITRite mat by design has a different surface and texture than that of real sidewalks and streets, and timing demands were absent from our simulation; it is possible that these features affected results found in our testing environment. In addition, as the gait speed (but not variability) increased at the third trial for the crosswalk scenario, it is possible that our study participants changed their walking in anticipation of the task. Thus, we acknowledge that this topic requires further study, and present this data as a preliminary investigation into older adults' response to pedestrian crosswalks. Moreover, we have presented data on slow and fast walking conditions for descriptive purposes, but there were no obvious deviations from the expected trends for these measures (e.g., increasing step length and decreasing step time as pace increases from slow to usual to fast) and thus we focused our statistical analysis on usual pace and crosswalk conditions alone. The strength of this study comes from our method: We measured three trials per condition, repeated trials using two different raters, and randomized the order of slow and fast conditions.

Future investigations can build on our study by investigating how older adults respond to more complex crosswalk simulations, such as with distracting sights and sounds, with timing demands involved if a crossing signal is counting down, or with other pedestrians whose own gait characteristics may influence those of participants. More research is also needed to more completely describe gait variability, including comparisons of variability between legs, as this could be affected by anything from leg dominance to lower extremity injury. In sum, further research is needed to understand the motivation to alter gait in response to pedestrian crosswalks, as this increased gait variability is concerning due to the elevated risk for falls in an already susceptible population.

Authors' Note

Ethics approval was obtained from the University of British Columbia (UBC) Clinical Research Ethics Board (H11-00238).

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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