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Short Communication

Gait Speed and Spatiotemporal Strategies in Young-Old and Middle-Old Adults

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Keywords

- Aging; Gait; Stride-length; Spatiotemporal Gait Patterns; Healthy Older Adults

Abstract

Background: The timed up and go (TUG) is a commonly used field-test for clinicians to evaluate physical function and risk of falling in older adults. Alterations in gait are well reported both with age and falls risk, however reported normative spatiotemporal gait metrics vary across studies in healthy older adults.

Purpose: This study aimed to quantify spatiotemporal gait strategies in young-old and middle-old adults during a 6-meter Timed Up and Go (TUG) assessment.

Methods: Participants were recruited from a tri-weekly exercise group on campus and asked to complete three TUG trials across a pressure-sensor walkway. Time to complete the TUG (tTUG), gait speed (SPD), cadence (CAD), and stride length (avSL) were measured. The first step upon standing and TUG turn-around occurred off the walkway and were not included in gait analysis. Pearson correlations were completed across the sample size and within young- old (YO) and middle-old (MO) groups. Un-paired t-tests were used to compare YO and MO.

Results: 20 participants (n=11 females) between the ages of 65 and 89 participated in the study. Between group comparisons revealed significant differences between YO and MO in tTUG (10.563 ± 0.273 and 12.177 ± 0.383 seconds, YO and MO respectively, p=0.027), SPD (1.388 ± 0.039 and 1.232 ± 0.036 m/s YO and MO respectively, p=0.046), and avSL (1.344 ± 0.022 and 1.214 ± 0.025 YO and MO respectively, p=0.013). There was no difference between groups in CAD (124.613 ± 2.213 and 122.662 ± 1.686 spm, YO and MO respectively, p=0.626). Across the sample, significant correlations were found between tTUG and SPD (r=-0.917, p<0.0001), SPD and CAD (r=0.764, p<0.001), and SPD and avSL (r=0.882, p<0.0001). There were no significant differences between group correlations.

Conclusion: This study indicates that in healthy older adults, young-old and middle- old adults modulate speed using stride length while maintaining cadence.

BACKGROUND

The use of spatiotemporal gait parameters to understand patterns of aging [1-4], and falling [4-7], is well supported. For example, younger adults [2-11], or older adults who have not fallen [4-13], are likely to have faster walking speeds than their counterparts. These patterns are reflected in descriptive [2,3], retrospective [14], and prospective [5-17], studies.

Normative values for gait parameters are also well established. Hollman et al (2011) published normative spatiotemporal gait data for adults over the age of 70, identifying a "pace" domain that included gait speed, step length, and stride length, as well as a "rhythm" domain that considered cadence [2]. Rössler et al., expanded on these norms in an analysis of the COmPLETE cohort study, reporting gait metrics for adults (n=629) over 20 years of age [3]. While there appear to be sex-differences, gait speed (m/s; GS) declines linearly with age starting in roughly the 4th or 5th decade, stride length (SL) appears to decline after the 4th decade, and cadence (CAD) is generally maintained, if not slightly increasing with age after the 5th decade [3]. This pattern of decreased SL and increased CAD is a commonly reported strategy [11] as confidence and/or balance decreases with age.

As risk and rate of falling increases with age, it makes sense that gait patterns are similar in older individuals and individuals who have fallen. Results of the KORA-Age study, as published by Thaler-Kall et al., found that there were significant differences in stride length between fallers and non-fallers, but not in velocity, cadence, time, stride-duration, or step width [4]. Interestingly, in a study that considered gait strategies, adults demonstrated the strongest relationship between CAD and SL when walking at a self-selected pace, a relationship that held true

regardless of age. This relationship disintegrated when CAD or SL was restricted [18].

The Timed Up and Go (TUG) assessment is common in clinical practice, and while moderately valid in discriminating between fallers and fallers [19,20], its high inter- and intra-rater reliability [21], as well as accessibility for both clinicians and participants makes it a useful tool to evaluate physical function in older adults [22]. The TUG is a timed task that requires participants to stand from a chair without the use of their arms, walk 3 meters out, turn around, and return the 3 meters to their original seated position. As an assessment, it inherently considers lower-extremity strength required to stand from a seated position, as well as balance and coordination required to not only ambulate but also turn around [21,23]. Additionally, it inherently considers walking speed, now commonly being discussed as a vital sign in older adults [24,25].

While spatiotemporal gait patterns are defined, normative values vary dramatically, likely due to variations in age, falls, health history, and sex profiles. This study specifically aimed to quantify spatiotemporal gait strategies in healthy and active young-old and middle-old adults during a 6-meter Timed Up and Go (TUG) assessment.

METHODOLOGY

This study was approved by the Colorado College Institutional Review Board.

Participants were recruited from a tri-weekly exercise group on campus targeted at retirees of the campus and their spouses. We specifically recruited older adults over the age of 65, regardless of their falls history. Participants were split into two groups for data analysis: young-old (YO; 65-74 years of age) and middle-old (MO; 75-85 years of age).

Instrumentation

Walkway. A custom Tekscan Strideway (Tekscan, Boston, MA.) gait system was utilized to measure gait parameters. The walkway consisted of three force plates measuring 2.48m in total length. Each platform was made up of 2,288 individual sensors, providing the ability to determine spatiotemporal parameters of gait, including, gait speed (SPD; meters/second; m/s), cadence (CAD; steps per minute; spm), and the average between left and right stride length as measured between posterior heel points of two consecutive footprints parallel to the line of progression (avSL; meters; m). Metrics were averaged across all three trials. The walkway was calibrated consistent with the Tekscan-defined calibration methods for the most accurate measurements [26.27] before testing began. Collection occurred at 75 Hz [27,30] a sampling rate consistent for gait analysis among geriatric populations [29,33].

Procedures

Intake. Upon entry into the lab, participants completed an informed consent and a small health-history survey which included 1-year and 3-year self-reported falls history. Falls risk score was determined by use of the CDC STEADI-3 [22,34] framework, specifically using their three primary questions regarding falls: “Have you fallen in the last 1 year,” “are you afraid of falling,” and “do you feel unsteady when standing or walking?” An affirmative answer earned 1 point, with possible scores ranging from 0-3 and a higher score indicating increased risk of falling. A positive response to any of the prior questions would signal further physical testing by the CDC STEADI [22,34].

After at least 5 minutes of seated rest, intake-blood pressure was taken with a SunTech Tango M2 auscultatory Blood Pressure Monitor (SunTech Medical, Morrisville, NC, USA). Clinical [35] and manufacturer procedures were followed.

TUG. The TUG is a standardized assessment where participants are instructed to stand from a chair on “go,” walk 3 meters to a piece of tape on the floor, turn around after the tape, and return to a seated position on the original chair (36). Time to complete the TUG (tTUG) was measured from “go”, until the participant returned to a seated position. Participants completed three TUG trials and were instructed to walk “as quickly and as safely as possible.” All gait trials were completed across the StrideWay pressure sensor walkway, such that the first step began off the walkway and that the turnaround occurred off the walkway. Therefore, the first step upon standing and the turn was not included in the analysis but was included in the time to complete the TUG [29].

Data analysis. Data analysis was completed using Microsoft Excel (Microsoft, Everett, Washington, USA). T-tests were used for YO and MO group and experimental comparisons. Pearson correlations were used to evaluate the following relationships across all participants and within YO compared to MO: age versus tTUG, tTUG vs SPD, SPD vs CAD, SPD vs avSL, CAD v avSL. Bonferroni corrections were not used when comparing gait metrics between YO and MO groups due to the small sample size and non- imperative avoidance of a type 1 error [37]. Bonferroni corrections were used to adjust significance thresholds when determining significance of correlations

across the sample and between groups.

RESULTS

20 participants (n=11 females) between the ages of 65 and 89 participated in this study. Two participants exceeded the MO age threshold (87 and 89 years old respectively) and were included in the MO group for analysis. The average age of study participant was 75.9 ± 7.25 years, n=11 females, n=5 1-year history fallers, and n=5 3-year history fallers. There were no significant differences between YO and MO groups in sex, 1-year fall history, 3-year fall history, resting mean arterial pressure (MAP), height, or weight (Table 1). Falls risk score was significantly different between groups (0.5 ± 0.118 and 1.6 ± 0.115 points, YO and MO respectively, p= 0.035).

Sample gait metric correlations. Across all participants (n=20; Table 2), there was a near-significant correlation between age and tTUG (r=0.478, R2 = 0.229, p=0.063). tTUG and SPD were highly correlated across all participants (r=-0.917, R2 = 0.842, p<0.0001). SPD and CAD were moderately correlated across all participants (r=0.764, R2 = 0.584, p<0.0001). SPD and avSL were highly correlated across all participants (r=0.882, R2 = 0.778, p<0.0001). CAD and avSL were not significantly correlated with each other (r=0.377, R2 = 0.142, p=0.101).

Between group gait comparisons. Significant differences were observed between YO and MO groups in tTUG, SPD, lSL, rSL, and avSL (Table 3 and Figure 1). No significant differences were observed between groups in CAD. tTUG was significantly longer in MO compared to YO (12.177 ± 0.383 and 10.563 ± 0.273 seconds respectively, p=0.027).

Table 1: Between group descriptives.

	Young-old n=10	Middle-Old N=10	P-value
Age (years)	69.8 ± 0.639	82 ± 1.005	*p<0.000 **
Sex	N=5 females	N=6 females	*p= 0.673*
1-year fall history	N=2	N=2	*p>0.50*
3-year fall history	N=3	N=3	*p>0.50*
Falls Risk Score	0.5 ± 0.118	1.6 ± 0.115	*p= 0.035 **
Resting MAP (mmHg)	102.9 ± 2.5	95.3 ± 2.1	*p= 0.123*
Height (cm)	173 ± 2.530	167.15 ± 1.611	*p=0.188*
Weight (kg)	78.094 ± 2.066	72.525 ± 2.656	*p=0.258*

**Indicates a between-group difference where p<0.05*

Table 2: Gait metrics; Pearson correlation results of average TUG trials across all participants

n=20	r	R_2	p-value
Age v. tTUG	0.478	0.229	*0.063*
tTUG v SPD	-0.917	0.842	*<0.0001**
SPD v CAD	0.764	0.584	*<0.0001**
SPD v avSL	0.882	0.778	*<0.0001**
CAD v avSL	0.377	0.142	*0.101*

A Bonferroni correction was used to determine the significance level of p<0.01.

Table 3: Gait metrics; average performance across 3 TUG trials

	Young-Old	Middle-Old	p-value
tTUG (seconds)	10.563 ± 0.273	12.177 ± 0.383	*0.027**
SPD (m/s)	1.388 ± 0.039	1.232 ± 0.036	*0.046**
CAD (spm)	124.613 ± 2.213	122.662 ± 1.686	*0.626*
lSL (m)	1.336 ± 0.023	1.213 ± 0.026	*0.023**
rSL (m)	1.353 ± 0.022	1.216 ±0.024	*0.008**
avSL (m)	1.344 ± 0.022	1.214 ± 0.025	*0.013**

*tTUG reflects the average time in seconds it took for groups to complete the TUG assessment; SPD reflects the gait speed in m/s during the TUG, sans first step and turn-around; CAD reflects cadence in steps per minute while on the walkway. lSL and rSL are the left and right stride lengths respectively; avSL is the average between lSL and rSL. All data were averaged across three TUG trials. *Indicates p-value <0.05.*

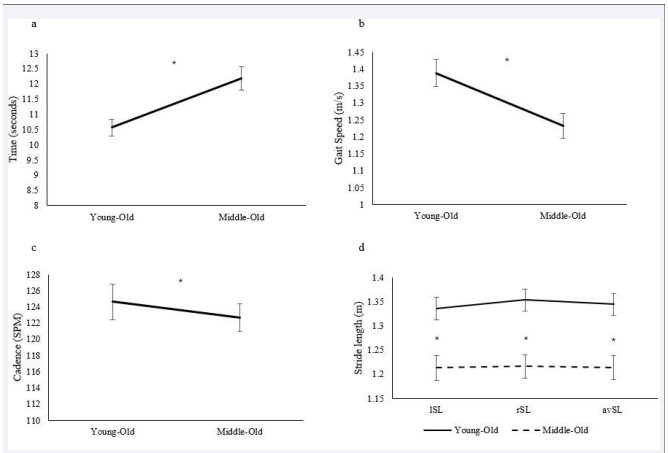

Figure 1 a-d. Between group comparisons of TUG and gait metrics. *Indicates a significant p-value <0.0125. a. Between group comparison of time to complete TUG (tTug; seconds). B. Between gropu comparison of gait speed (SPD; M/S). c. Between group of comparison of cadence (CAD; spm). D. Between gropu comparison of left, and average stride length (ISL, rSL, and avSL respectively; m).

YO had a significantly faster SPD than MO (1.388 ± 0.039 and 1.232 ± 0.036 m/s respectively, p=0.046). avSL was significantly longer in YO compared to MO (1.344 ± 0.022 and 1.214 ± 0.025 respectively, p=0.013). There was no difference between groups in CAD (124.613 ± 2.213 and 122.662 ± 1.686 spm, YO and MO respectively, p=0.626).

Gait metric correlations within groups. Significant correlations were found within groups (Table 4) between tTUG and SPD (r=-0.85, p=0.002 and r=-0.954, p<0.0001, YO and MO respectively), SPD and CAD (r=0.798, p=0.003 and r=0.821, p<0.003, YO and MO respectively), and SPD and avSL (r=0.802, p=0.003 and r=0.898, p<0.001, YO and MO respectively). CAD and avSL were not correlated within groups. There were no significant differences between group correlations (Table 4).

FINDINGS

Observed rate of falling within our sample was consistent with that of older adults in America [38], and predictably, falls risk score was greater in the MO group

Table 4: Gait metrics; Pearson correlation results of average TUG trials within groups.

	Young-Old n=10			Middle-Old n=10		
	r	R^2	p-value	r	R^2	p-value
tTUG v SPD	-0.851	0.724	*0.002**	-0.954	0.91	*<0.0001**
SPD v CAD	0.798	0.637	*0.003**	0.821	0.674	*0.003**
SPD v avSL	0.802	0.644	*0.003**	0.898	0.807	*0.001**
CAD v avSL	0.288	0.083	*0.249*	0.496	0.246	*0.054*

*A Bonferroni correction was used to determine the significance level of p<0.0125, indicated with *. # indicates a significant between-group difference.*

compared to YO, and lower than reported in similar studies [29]. Mean arterial pressure (MAP) was similar between YO and MO, with a slight trend toward a lower MAP in the MO group, similar to previous studies [29], and likely reflective of increased rate of pharmaceutical intervention for hypertension in older adults (39), although this was not explicitly recorded in this study. Across all participants, the average tTUG was 11.37 ± 1.67 seconds, under the proposed 12-second threshold marking independence for community dwelling women [40], but slightly slower than the proposed range of 8.2-10.2 seconds for healthy adults between 70 and 79 years in which our sample size falls (75.9 ± 7.25 years). Thus, our sample of young-old and middle-old adults are representative of a generally healthy and active group.

Interestingly, when considered across all participants (n=20), only 22.9% of the variation in tTUG was accounted for by age (p=0.063), a result we argue is consistent with a highly active group and even the oldest of the MO group performing on par with younger counterparts. Notably, however, this result challenges other literature claiming that TUG performance and gait speed slow with age [4-41].

Unsurprisingly, tTUG and SPD were highly correlated, indicating that use of gait metrics in the context of TUG performance was appropriate. Moderate and high correlations between SPD and CAD as well as SPD and avSL respectively, were consistent with SPD being the product of CAD and step length (please note the comparison between step length and reported stride length), and CAD having little correlation with avSL is consistent with them being largely (although not completely) independent variables from each other.

A perfect comparison of tTUG performance between groups is challenging, as stratification of age groups across literature varies dramatically, however, to the best of our abilities, tTUG results appear to fall within normal ranges for health healthy older-adults [29,41]. Similarly, gait speed falls above the 1m/s threshold identified as a risk of falling indicator [5], suggesting generally healthy participants.

Although not statistically different from each other, cadence in both groups was faster than in comparative studies with reported values near 100 spm [5] and 113 spm [2]. De Campos et al. report an increase in cadence when comparing young adults to older adults, (59.68 and 61.18 strides per minute respectively). While our converted values (steps versus strides per minute) are similar, the increasing cadence in the older population counters the trends that we observed. Aboutorabi et al., completed a literature review reporting stride lengths between 135 and 153 cm: similar to the YO group and longer than the MO group. In this same report, cadence ranged from 103 to 112 spm; a slower cadence than observed in either YO or MO group. These results were contextualized as a compensatory strategy to increase stability: older adults slowed and shortened their steps while widening their step width and time in double-support [11]. Given this pattern, it appears that our particular sample maintained their cadence, and modulated speed more so in stride length, although step width was not evaluated.

Interestingly, correlations between gait metrics did not differ between YO and MO groups, although the correlation tTUG and SPD was strengthened in comparison to the correlation across the sample. While SPD was significantly faster and avSL was significantly longer in the YO group, similar CAD metrics indicate that across healthy and active adults, modulation of walking speed between groups may primarily occur through changes in stride length. This varies dramatically compared to a previous study out of this lab [29], that explored gait metrics after seated versus supine rest, where modulations in walking speed occurred primarily through changes in cadence. Notably, cadence in the current study was similar to that of cadence reported after seated rest, although overall speed was quite a bit faster (approximately 1.3 m/s compared to 1.05 m/s respectively).

CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

Extrapolation of this data is limited to a generally healthy and active older-adult population, especially the results of the middle-old group. Due to similarities between groups, we cannot make claims about high or low falls risk based on this data, although this does strengthen our conclusions based on age. If we assume that we lack the sample size to identify differences in correlations between gait metrics between groups, further studies should consider this question as it works to describe and understand differences between age groups in older adults, between fallers and non-fallers, as well as a marker for falls risk.

In conclusion, this study indicates that in healthy older adults, young-old and middle- old adults modulate speed using stride length while maintaining cadence. As such, clinicians aiming to prevent falls may target their interventions toward increasing stride length. As an increase in stride length would result in more time in single-stance, a focus on balance is paramount, as well as increased lower-extremity functional ranges of motion to promote longer strides.

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