Age-related differences in spatiotemporal markers of gait stability during dual task walking

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Abstract

Increased stride-to-stride variability during walking characterizes gait instability and predicts falling in older adults. Walking while performing cognitive tasks (dual task walking) is also associated with increased risk of falling. The purpose of the study was to examine whether gait velocity and stride-to-stride variability in gait velocity differ in older adults compared with middle-aged and younger adults during normal and dual task walking conditions. Sixty older (n = 20, mean age = 81 years), middle-aged (n = 20, mean age = 48 years), and young adults (n = 20, mean age = 25 years) participated in the study. Gait parameters were quantified with GAITRite® instrumentation. In the dual task condition, participants spelled five-letter words in reverse while walking across the walkway. Across groups, gait velocity was slower (p < 0.001) and stride-to-stride variability in gait velocity was greater (p = 0.001) in dual task walking. Older subjects walked more slowly than did middle-aged and younger subjects and the difference in gait velocity was greatest in the dual task condition (p < 0.05). Variability in stride velocity was increased in older subjects compared with middle-aged and younger subjects (p < 0.05). Additionally, in older subjects, impaired walking performance was associated with impaired cognitive performance in dual task walking. The gait changes observed in dual task walking characterize decreased gait stability and indicate that cognitively demanding tasks during walking have a destabilizing effect on gait and may place older people at a greater risk of falling.

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1. Introduction

According to the Centers for Disease Control and Prevention, falls are the leading cause of unintentional injury deaths in the United States among people age 65 years and older, accounting for over 13,000 deaths in 2003, and non-fatal falls are among the leading causes of hospitalizations for older adults [1]. From a systems perspective, fall-related injuries are not inconsequential. Fall-related injuries in older adults resulted in US$ 19.5 billion in direct medical care costs in 2000 [2]. From an individual perspective, falls are not inconsequential either. Apart from injuries and subsequent morbidity that occur after a fall, psychological consequences occur as well. Many people who fall, whether they sustain injury or not, develop a fear of falling and subsequently limit their activity leading to reduced mobility, weakness and increased risk of future falls.

Risk factors for falls are described as being extrinsic or intrinsic. Extrinsic risk factors include environmental risks such as tripping hazards (e.g., throw rugs on floors), lack of stair railings, and poor lighting conditions, any of which can cause falls. Intrinsic risk factors generally include personal characteristics such as age, physiological impairments and medication use, among others, that can predispose an individual to falls. Modifying these risk factors when possible can reduce fall risk. One of the modifiable risk factors for falls is impaired gait stability. Gait instability is characterized by increased variability from stride to stride and is common in many older adults, even in absence of pathology [3]. Increased variability reflects inconsistent stepping patterns and reduced postural control during walking. In persons with neurological
pathology, deficits in the central nervous system’s ability to coordinate motor outputs are largely responsible for gait instability [4,5]. In elderly persons without apparent neurological pathology, it is not entirely clear why gait instability occurs. The reasons are most likely multifactorial, including deficits in physiological function such as impaired joint range of motion and muscle performance and deficits in neuropsychological or cognitive status that can exacerbate the effects of impaired physiological capacity. Relatively few studies have examined age-related changes in gait stability [3,6–8]. Nevertheless, initial investigations suggest that impaired gait stability may be a more powerful predictor of falling than static measures of balance [6].

Maintaining stability in walking was traditionally considered an automatic or reflex-controlled task requiring motor responses to sensory stimuli, but requiring minimal cognitive resources. Recent evidence, however, suggests that maintaining postural stability requires both cognitive and sensorimotor processes [9]. Dual task paradigms are used to examine the effects of cognitively challenging tasks on primary activities such as walking. In older persons compared to younger adults, postural stability in standing is significantly reduced during cognitively demanding tasks [10]. During walking, many falls in older persons occur not during normal walking, but rather when they are walking and performing secondary tasks such as talking [11]. The influence of cognitive activity on gait stability has been studied in patient populations and results consistently show decreased gait velocity and increased gait variability in dual task conditions [12–16]. To our knowledge, however, only three small studies have examined with cross-sectional designs whether age-related differences in gait variability during dual task walking exist in healthy persons [17–19]. In each, measures of gait variability were greater in older subjects than in younger subjects. Given the limited numbers of subjects in the aforementioned studies [17–19], whether there are age-related differences in gait variability during dual task walking, as compared to pathology-related differences, warrants further study.

The primary purpose of this cross-sectional study was to examine whether markers of gait instability, particularly reductions in gait velocity and increases in stride-to-stride variability in gait velocity, occur in older adults compared with younger and middle-aged adults during dual task walking. The secondary purpose of the study was to compare errors in the cognitive task during dual task walking between groups and to quantify the relationships between cognitive performance and walking performance.

2. Methods

2.1. Subjects

In a pilot study [18], stride-to-stride variability in gait velocity in older subjects increased from a coefficient of variation of 4.9% in a normal walking condition to a coefficient of variation of 16.4% in a dual task walking condition. To detect a comparable change in stride-to-stride variability among older subjects at \( \alpha = 0.05 \) and to achieve a statistical power of 0.90, minimally 10 subjects per group were required to participate. We recruited 20 subjects per group, a conservative number of subjects estimated to achieve a statistical power exceeding 0.90.

Sixty subjects participated in the study: 20 older subjects over the age of 70 years (7 men, 13 women, mean age = 81 ± 5 years), 20 middle-aged subjects between the ages of 40 and 55 years (9 men, 11 women, mean age = 48 ± 5 years), and 20 younger subjects between the ages of 20 and 35 years (9 men, 11 women, mean age = 25 ± 3 years). All subjects were independent, community-dwelling individuals classified as “non-fallers” who were capable of ambulating independently without an assistive device. Subjects were excluded from participating in the study if they had a medically diagnosed pathology that impaired their ability to ambulate independently or if they were taking psychoactive medications that contribute to increased risk of falls. To further minimize the likelihood that any of the subjects were at increased risk of falls, subjects were excluded from participating in the study if they (1) reported a fall within 6 months prior to testing, (2) required greater than 13 seconds to complete a Timed Up-and-Go (TUG) test [20,21], or (3) achieved a score under 30 on the Short Test of Mental Status (STMS) [22]. To assess falls history, a “fall” was operationally defined as any event leading to an unexpected contact with a supporting surface, excluding unavoidable hazards such as a chair collapsing [21]. A history of falling is highly specific as a risk factor for future falls [23]. The TUG test has high intra-rater reliability [20] and requiring greater than 13 s to complete the TUG test is highly sensitive and specific for identifying fallers [21]. We believed the falls history question and the TUG test provided a valid and reliable method to exclude potential subjects from participating whom may have been at elevated risk of falls. The STMS is a screening tool for mild cognitive impairment [22]. To minimize the potential that impaired cognitive ability might influence a person’s ability to walk in a dual task condition, only subjects who achieved a score of 30 or higher on the STMS were eligible to participate. The study was approved by the Mayo Foundation Institutional Review Board. All subjects provided informed consent prior to participating in the study.

Subject characteristics are presented in Table 1. While TUG and STMS scores differed between groups, the differences between older, middle-aged, and younger subjects were not clinically meaningful since all subjects performed at levels on the TUG test and STMS that did not reach thresholds for being excluded from the study.

2.2. Instrumentation

Gait data were quantified with GAITRite® Gold Version 3.4 software and GAITRite® instrumentation (CIR Systems Inc., Clifton, NJ) consisting of an electronic walkway 8.3 m
in length and 0.9 m in width. Data were sampled at 80 Hz and subsequently processed and stored with an IBM compatible computer. Data obtained with GAITRite® has high concurrent validity with video-based and computer-assisted motion analysis systems for spatial and temporal parameters of gait, with correlation coefficients that exceed 0.93 for most of the parameters the GAITRite® system is capable of measuring [24,25]. Similarly, its test–retest reliability is high, with reliability coefficients that exceed 0.85 for measures including velocity, cadence, stride length, single limb support time, and double limb support time [24,25].

2.3. Procedures

After inclusion and exclusion criteria were assessed, subjects eligible to participate in the study walked across the walkway under each of two conditions. For normal walking trials, subjects walked at self-selected speeds, initiating and terminating each sequence a minimum of 1 m fore and aft of the walkway to allow sufficient distance to accelerate to and decelerate from a steady state of ambulation across the walkway. For dual task walking trials, subjects walked across the walkway in a similar manner. Additionally, they verbally spelled a five-letter word backward (for example, “spell ‘earth’ backward”) while walking. A different word was chosen for each trial in the dual task condition. Three trials were completed in both conditions. Subjects wore a gait belt and one investigator walked alongside during dual task walking to provide assistance if a loss of balance occurred during testing. Another investigator counted and recorded the number of spelling errors in the dual task condition.

2.4. Data analysis

While the GAITRite® is capable of measuring numerous temporal and spatial parameters of gait, we specifically analyzed gait velocity and stride-to-stride variability in gait velocity, the parameter having been identified as the best predictor of falls among elderly individuals [6]. Mean gait velocity and the coefficient of variation (%CV) in stride velocity across three walking trials in both walking conditions were analyzed for each subject.

Two 3 × 2 mixed model analyses of variance (ANOVA) with one between-subjects factor (group: younger, middle-aged, and older adults) and one within-subjects factor (condition: normal and dual task walking) were conducted to examine differences in mean gait velocity and stride-to-stride variability in gait velocity ($\alpha = 0.05$). Post hoc $t$-tests with the Bonferroni-adjusted $\alpha$ were conducted to identify the comparisons that were statistically significant. Errors in the cognitive task (number of backward spelling errors) during dual task walking between the groups were also compared. The distributions of errors were not normally distributed, so spelling errors were analyzed with the non-parametric Kruskal-Wallis analysis of variance by ranks ($\alpha = 0.05$). Last, to quantify relationships between cognitive performance and walking performance, correlations between variables with normally distributed data (gait velocity, stride-to-stride variability in velocity and STMS scores) were analyzed with Pearson product–moment ($r$) correlation coefficients. Correlations involving the non-normally distributed number of spelling errors were analyzed with Spearman rank ($r_s$) correlation coefficients ($\alpha = 0.05$). Data were analyzed with SPSS 10.0 statistical software (SPSS Inc., Chicago, IL).

3. Results

3.1. Gait velocity

Gait velocity was slower in dual task walking than in normal walking (Fig. 1 has representative data; $F_{1,57} = 55.061$, $p < 0.001$). The difference in gait velocity was statistically significant within each group (Table 2). Additionally, gait velocity differed significantly between groups ($F_{2,57} = 20.649$, $p < 0.001$). Older adults walked more slowly than did younger and middle-aged adults in both walking conditions (Table 2). Gait velocity did not differ significantly between the younger and middle-aged groups.

The group × condition interaction was also statistically significant ($F_{2,57} = 3.822$, $p = 0.028$). The relative difference in gait velocity between normal and dual task walking was greater in the older-adult group (20% difference) than in the middle (7% difference) and younger (8% difference) age groups.

3.2. Stride-to-stride variability in gait velocity

Stride-to-stride variability in gait velocity was greater in dual task walking than in normal walking (Fig. 1 has representative data; $F_{1,57} = 12.376$, $p = 0.001$). The difference in stride-to-stride variability was statistically significant in middle-aged and older adults, but not in younger

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### Table 1

Subject characteristics (mean ± S.D.)

<table>
<thead>
<tr>
<th></th>
<th>Younger adults ($n = 20$)</th>
<th>Middle-aged adults ($n = 20$)</th>
<th>Older adults ($n = 20$)</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>173.1 ± 9.1</td>
<td>172.0 ± 9.5</td>
<td>167.9 ± 11.1</td>
<td>1.517</td>
<td>0.228</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>88.2 ± 17.2</td>
<td>93.3 ± 19.2</td>
<td>84.8 ± 13.3</td>
<td>1.317</td>
<td>0.276</td>
</tr>
<tr>
<td>TUG score (s)</td>
<td>5.5 ± 0.9</td>
<td>6.4 ± 1.5</td>
<td>8.9 ± 2.0</td>
<td>25.508</td>
<td>0.001</td>
</tr>
<tr>
<td>STMS score</td>
<td>35.4 ± 1.3</td>
<td>34.9 ± 1.8</td>
<td>33.2 ± 2.2</td>
<td>7.746</td>
<td>0.001</td>
</tr>
</tbody>
</table>

TUG: Timed Up-and-Go test; STMS: Short Test of Mental Status.
adults (Table 3). Additionally, stride-to-stride variability in gait velocity differed significantly between groups ($F_{2,59} = 7.433$, $p = 0.001$). Older adults walked with significantly greater stride-to-stride variability than did younger and middle-aged adults in both walking conditions (Table 3). Stride-to-stride variability in gait velocity did not differ significantly between the younger and middle-aged groups. The group $\times$ condition interaction for stride-to-stride variability was not statistically significant ($F_{2,57} = 0.973$, $p = 0.384$).

### 3.3. Cognitive performance during dual task walking

The median number of backward spelling errors in younger adults was 0.5 errors (range = 0–10 errors, mode [10 subjects] = 0 errors). The median number of backward spelling errors in middle-aged adults was 2.5 errors (range = 0–8 errors, mode [six subjects] = 0 errors). The median number of backward spelling errors in older adults was 2.0 errors (range = 0–10 errors, mode [eight subjects] = 0 errors). Cognitive performance in dual task

### Table 2

<table>
<thead>
<tr>
<th>Gait velocity (mean $\pm$ S.D.)</th>
<th>Normal walking$^a$</th>
<th>Dual task walking$^a$</th>
<th>$t$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adults ($n = 20$)</td>
<td>146.0 ± 18.3</td>
<td>134.7 ± 22.4</td>
<td>3.206</td>
<td>0.005</td>
</tr>
<tr>
<td>Middle-aged adults ($n = 20$)</td>
<td>148.0 ± 15.1</td>
<td>135.5 ± 16.3</td>
<td>5.256</td>
<td>0.001</td>
</tr>
<tr>
<td>Older adults ($n = 20$)</td>
<td>121.9 ± 22.6$^b$</td>
<td>97.4 ± 22.5$^c$</td>
<td>4.973</td>
<td>0.001</td>
</tr>
</tbody>
</table>

$^a$ Unit of measure is cm/s.

$^b$ Older adults walked more slowly than did younger adults ($t_{38} = 3.708$, $p = 0.001$) and middle-aged adults ($t_{38} = 4.291$, $p < 0.001$) in the normal walking condition.

$^c$ Older adults walked more slowly than did younger adults ($t_{38} = 5.281$, $p < 0.001$) and middle-aged adults ($t_{38} = 6.175$, $p < 0.001$) in the dual task walking condition.

### Table 3

<table>
<thead>
<tr>
<th>Stride-to-stride variability in gait velocity (mean $\pm$ S.D.)</th>
<th>Normal walking$^a$</th>
<th>Dual task walking$^a$</th>
<th>$t$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adults ($n = 20$)</td>
<td>3.9 ± 2.3</td>
<td>5.2 ± 3.0</td>
<td>1.501</td>
<td>0.150</td>
</tr>
<tr>
<td>Middle-aged adults ($n = 20$)</td>
<td>3.6 ± 1.5</td>
<td>5.1 ± 1.6</td>
<td>3.635</td>
<td>0.002</td>
</tr>
<tr>
<td>Older adults ($n = 20$)</td>
<td>6.1 ± 2.0$^b$</td>
<td>9.0 ± 6.5$^c$</td>
<td>2.256</td>
<td>0.036</td>
</tr>
</tbody>
</table>

$^a$ Unit of measure is the coefficient of variation (%CV).

$^b$ Older adults walked with greater stride-to-stride variability in velocity than did younger adults ($t_{38} = 3.113$, $p = 0.004$) and middle-aged adults ($t_{38} = 4.308$, $p < 0.001$) in the normal walking condition.

$^c$ Older adults walked with greater stride-to-stride variability in velocity than did younger adults ($t_{38} = 2.227$, $p = 0.032$) and middle-aged adults ($t_{38} = 2.471$, $p = 0.018$) in the dual task walking condition.

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Fig. 1. Representative examples of gait velocity and stride-to-stride variability in gait velocity from one young, one middle-aged, and one older adult during the normal and dual task walking conditions. In dual task walking, gait velocity is slower and stride-to-stride variability is greater than in normal walking conditions, particularly in the older adult.
walking did not differ significantly between groups ($\chi^2 = 1.273, p = 0.529$).

3.4. Relationships between cognitive performance and walking performance

Neither gait velocity nor stride-to-stride variability in gait velocity was significantly correlated with STMS scores or with errors in the cognitive task in younger or middle-aged adults. In older adults (Table 4), however, errors in the cognitive task during dual task walking were negatively correlated with gait velocity ($r_s = -0.487, p = 0.030$) and positively correlated with stride-to-stride variability ($r_s = 0.534, p = 0.015$).

4. Discussion

4.1. Effect of dual tasking on gait

Results of the study support our hypotheses that gait velocity would be reduced and stride-to-stride variability would be increased in dual task walking. Results also support our hypothesis that the gait changes would be most pronounced in older subjects. Gait velocity was lower in dual task walking than in normal walking in all three groups, but the difference in gait velocity between normal and dual task walking was greater in older adults (20% reduction) than in younger (8% reduction) and middle-aged adults (7% reduction). Stride-to-stride variability in gait velocity increased by 1.3% in younger adults, by 1.5% in middle-aged adults, and by 2.9% in older adults in the dual task condition as compared to normal walking. The stride-to-stride variability increase in dual task walking was statistically significant only in the middle-aged and older adults. The gait changes in dual task walking are consistent with other studies [12,15,17–19], demonstrating that attention-demanding tasks have a destabilizing effect on gait and that attentional processes are involved in walking.

In contrast to results presented by Yogev et al. [13] and Springer et al. [26], results of the present study indicate that both gait velocity and gait variability are affected in dual task walking, particularly in older persons. Yogev et al. [13] studied gait in older persons with Parkinson’s Disease and in age-matched control subjects during dual task walking. They reported that gait velocity decreased in the dual task condition in both groups of subjects but that gait variability increased only in subjects with Parkinson’s Disease. They concluded that regulation of gait variability does not require attentional capacities in healthy adults. Springer et al. [26] studied gait in healthy older persons who were fallers, in healthy older persons who were non-fallers, and in healthy younger adults. They reported that gait velocity decreased during multiple dual task conditions in all three groups but that gait variability increased only in older fallers and not in young adults or older non-fallers. They concluded that elderly non-fallers as well as healthy young adults maintain a stable gait in dual task walking and that there is no evidence of detrimental effects of dual task activities on gait variability associated with aging. The Yogev et al. and

Table 4

Relationships (Pearson product–moment and Spearman rank correlation coefficients) between walking performance and cognitive performance in young, middle-aged, and older-adult subjects

<table>
<thead>
<tr>
<th></th>
<th>Velocity-normal</th>
<th>Velocity-dual</th>
<th>%CV-normal</th>
<th>%CV-dual</th>
<th>STMS score</th>
<th>Cognitive errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity-normal</td>
<td>–</td>
<td>0.719*</td>
<td>–0.019</td>
<td>0.058</td>
<td>0.412</td>
<td>0.290</td>
</tr>
<tr>
<td>Velocity-dual</td>
<td>–</td>
<td>–0.210</td>
<td>–0.206</td>
<td>0.219</td>
<td>0.095</td>
<td></td>
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<tr>
<td>%CV-normal</td>
<td>–</td>
<td>–</td>
<td>–0.059</td>
<td>0.079</td>
<td>0.166</td>
<td></td>
</tr>
<tr>
<td>%CV-dual</td>
<td>–</td>
<td>–</td>
<td>0.242</td>
<td>0.059</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STMS score</td>
<td></td>
<td></td>
<td>–</td>
<td>0.136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle-aged adults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity-normal</td>
<td>–</td>
<td>0.774*</td>
<td>–0.231</td>
<td>0.012</td>
<td>0.132</td>
<td>–0.028</td>
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<tr>
<td>Velocity-dual</td>
<td>–</td>
<td>–0.345</td>
<td>–0.257</td>
<td>–0.011</td>
<td>–0.070</td>
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<tr>
<td>%CV-normal</td>
<td>–</td>
<td>0.365</td>
<td>–0.244</td>
<td>0.076</td>
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<tr>
<td>%CV-dual</td>
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<td>–</td>
<td>0.250</td>
<td>0.158</td>
<td></td>
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<tr>
<td>STMS score</td>
<td></td>
<td></td>
<td>–</td>
<td>0.268</td>
<td></td>
<td></td>
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<tr>
<td>Cognitive errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Older adults</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Velocity-normal</td>
<td>–</td>
<td>0.516*</td>
<td>–0.203</td>
<td>0.147</td>
<td>0.135</td>
<td>0.036</td>
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<tr>
<td>Velocity-dual</td>
<td>–</td>
<td>–0.185</td>
<td>–0.569*</td>
<td>0.293</td>
<td>–0.487*</td>
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</tr>
<tr>
<td>%CV-normal</td>
<td>–</td>
<td>0.461*</td>
<td>–0.143</td>
<td>0.294</td>
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<tr>
<td>%CV-dual</td>
<td>–</td>
<td>–</td>
<td>0.113</td>
<td>0.534*</td>
<td></td>
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</tr>
<tr>
<td>STMS score</td>
<td></td>
<td></td>
<td>–</td>
<td>–0.280</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive errors</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

%CV: stride-to-stride variability in gait velocity (%coefficient of variation); STMS: Short Test of Mental Status score.

* $p < 0.05$. 

Springer et al. studies employed different cognitive tasks, including phoneme monitoring and arithmetic tasks, than did the present study. Additionally, the studies quantified stride time and swing time variability as measures of gait variability as compared to variability in gait velocity. Methodological differences may account for different findings among the studies. Nevertheless, results of the present study refute the conclusions of Yogev et al. [13] and Springer et al. [26]. Particularly in older adults, stride-to-stride variability in velocity increased during dual task walking. All of the subjects were healthy, cognitively non-impaired non-fallers. The effects of dual tasking on gait variability are present in older persons who do not have evidence of cognitive impairment.

The reduction in gait velocity among all three groups of subjects in the present study represents a coping mechanism to handle the cognitive and attention-demanding challenge of the dual task activity. The finding that gait velocity decreases in response to attention-demanding dual task activities is consistent with most of the studies that have employed similar methodologies [12,13,15,18,26]. Reducing one’s gait velocity is thought to be a compensation that people take on during walking when stability is challenged.

4.2. Relationships between cognitive performance and walking performance

In older adults, there was a statistically significant association between cognitive performance and walking performance (Table 4). While STMS scores were correlated neither with gait velocity nor with stride-to-stride variability in gait velocity, errors in the cognitive task during dual task walking were negatively associated with gait velocity and positively associated with stride-to-stride variability. Variance in older subjects’ performances on the cognitive task during dual task walking accounted for 24\% (r^2 = 0.24) of the variance in gait velocity and 29\% (r^2 = 0.29) of the variance in stride-to-stride variability. Older subjects who struggled with the cognitive task walked more slowly and with more stride-to-stride variability than did their counterparts who performed better on the cognitive task. This finding represents the nature of dual tasking activities. O’Shea et al. [27] suggest that detrimental performance of a physical task in the presence of a competing cognitive task supports a ‘capacity-sharing’ model of dual tasking. According to the capacity-sharing model, performing two attention-demanding tasks reduces the performance of one or both tasks when capacity limits are exceeded. While gait was influenced in younger, middle-aged, and older adults during dual task walking in our study, the relationship between cognitive performance and walking performance was only present in the older subject group. The results provide evidence that capacity limits for multitasking are lower—and perhaps more readily exceeded—in older adults than in middle-aged or younger adults.

4.3. Clinical implications

Results of the present study bring forth several issues that potentially have clinical implications. Foremost, it is important to recognize that attention-demanding tasks have a destabilizing effect on gait and that attentional processes are involved in walking. Recognizing the potential role of attention-demanding tasks on fall risk, one might instruct older individuals who are at risk of falls to avoid performing cognitive tasks while they are walking. In contrast, one may also recognize the utility of dual tasking and choose to engage the individual in cognitive activities while walking in an effort to improve the person’s ability to perform dual tasks in a safe and functional manner. No large-scale studies, to our knowledge, have addressed these issues from a clinical perspective. Silsupadol et al [28], however, provide some evidence through case reports that two patients who received balance training under dual task conditions showed benefits maintained for 3 months that were not evident in a patient who trained under a single task balance training program. Whether training under dual task conditions can improve gait or fall risk during dual task walking needs further investigation.

4.4. Limitations

Two design features may limit interpretations of the results of the present study. First, given the length of the walkway (8.3 m) over which stride-to-stride variability in gait velocity was examined, only 11–20 strides per subject were analyzed depending on stride length and cadence. Older subjects who walked more slowly and with shorter strides generally had more strides on the walkway than did younger subjects. Therefore, variability measures of gait velocity may have been better represented for older subjects than for younger and middle-aged subjects. Owings and Grabner [29] report that, during treadmill locomotion, 200 strides are required to accurately measure stride variability. Hausdorff et al. [30], on the other hand, report that gait variability takes on a fractal organization in healthy persons, meaning that variability over a small number of strides is statistically similar to variations that occur over thousands of strides. Despite the relatively small number of strides analyzed in the present study, we therefore believe our stride variability data are valid. A second limitation is reflected by the cross-sectional design of the study. We cannot answer the question, “Is the effect of dual tasking on gait influenced by aging?” The cross-sectional design merely allows us to conclude that the effect of dual tasking on gait differs between subjects who comprise different age groups. Answering the more direct question, whether aging influences the effect of dual tasking on gait, would require a longitudinal study design in which confounding variables associated with aging were controlled. Despite the limitations presented, results of the study provide strong evidence that, overall, gait velocity and stride-to-stride variability in
gait velocity are influenced by performing a cognitive task. Furthermore, the effect of dual tasking on gait is more pronounced in older subjects than in middle-aged and younger adults.

5. Conclusion

Gait velocity decreased and stride-to-stride variability in gait velocity increased when people walked while performing a cognitively challenging task. The differences were most prominent among older adults. Gait variability observed in the dual task condition characterizes decreased gait stability and indicates that cognitively demanding tasks performed while walking have a destabilizing effect and may place older people at greater risk of falling. These findings may be relevant to the examination of, and interventions for, gait deficits in older persons.

References


