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1 **The differential effect of first time single-point cane use between healthy young and older**  
2 **adults**

3 **Running title:** Cane use in younger and older adults

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35 **Patient Consent**

36 All participants provided informed written consent prior to participating. This study was  
37 approved by the Health Sciences Ethics Review Board of The University of Western Ontario,  
38 London, Canada (HSREB#108430).

39 **The differential effect of first time single-point cane use between healthy young and older**  
40 **adults**

41 **ABSTRACT**

42 **Introduction:** Walking aids are often introduced to older adults to enable independent mobility.  
43 Single-point canes are the most common device used. Benefits are tempered by research  
44 suggesting that walking aids increase falls risk. A better understanding of the effect of walking  
45 aid use on gait performance is required.

46 **Objective:** To evaluate differences in the effect of initial single-point cane use on gait between  
47 younger (YA) and older adults (OA).

48 **Design:** Cross-sectional.

49 **Setting:** Community-dwelling.

50 **Participants:** Twenty-six YA (aged:  $23.7 \pm 2.8$  years) and 25 OA (aged:  $70.8 \pm 14.1$  years)  
51 participated. Inclusion criteria were: age 18-35 for YA or  $\geq 50$  for OA, able to ambulate  
52 unassisted, and without any condition affecting mobility.

53 **Interventions:** Not applicable.

54 **Main Outcome Measure(s):** Gait velocity and stride time variability under different walking  
55 path configurations (straight path, Groningen Meander Walking Test, Figure of Eight Test) and  
56 conditions (unassisted walking, walking with a single-point cane, and walking with a single-  
57 point cane while completing a cognitive task) was recorded in a laboratory. The arithmetic task  
58 of subtracting ones from 100 was used as the secondary cognitive task. Data analysis included  
59 separate three-way mixed ANOVAs (path/condition/group).

60

61 **Results:** There was a statistically significant two-way interaction between walking path and  
62 condition for velocity ( $p < 0.001$ ,  $\omega^2 = 0.03$ ) and stride time variability ( $p = 0.032$ ,  $\omega^2 = 0.02$ ).  
63 Additionally, a significant main effect of group was also observed (velocity:  $p = 0.004$ ,  $\omega^2 = 0.07$ ;  
64 stride time variability:  $p = 0.001$ ,  $\omega^2 = 0.09$ ).

65 **Conclusions:** Using a single-point cane decreased velocity and increased stride time variability  
66 in both younger and older adults. However, the cognitive load and effect on gait of initial cane  
67 use was not different between age groups. Standardized guidelines aimed at facilitating a client's  
68 transition towards the safe use of a walking aid are needed. Future research should evaluate if  
69 training can mitigate some of the adverse changes to gait stability observed with initial walking  
70 aid use.

71 **Keywords:** Aging, Gait, Assistive Devices, Cane, Multitasking Behavior.

## 72 INTRODUCTION

73 About 30% of older adults fall at least once annually, which may result in pain and  
74 immobility.<sup>1</sup> Age-related sensory system changes, and balance and walking impairments are  
75 prominent risk factors for falls in older adults.<sup>2</sup> Walking aid provision is a common strategy that  
76 facilitates independence as it allows for physical support and haptic sensory feedback.<sup>3</sup> An  
77 estimated 24% of older adults use mobility aids,<sup>4</sup> yet most obtain their device without consulting  
78 a healthcare professional, which can result in improper sizing and unsafe technique.<sup>5,6</sup> Contrary  
79 to the outlined benefits, walking aid use is independently associated with an increased risk of  
80 falls.<sup>7</sup> Walking aids require coordinated movements, can come in contact with obstacles or a  
81 person's own body, can obstruct visual space, and can be difficult to maneuver under certain  
82 situations (e.g., opening a door).<sup>3</sup> Although these aids may be introduced to anyone, they are  
83 generally reserved for those with health issues affecting balance and walking; thus complicating  
84 inquiries of the relationship between aid use and falls. Nonetheless, the increasing proportion of  
85 older adults, and the associated healthcare costs and consequences of falls warrant a better  
86 understanding of how walking aids affect gait.

87 Walking involves higher-order cognitive processes, specifically executive function,  
88 which allows for the planning, monitoring, and adjustment of movements.<sup>8</sup> Executive function  
89 decreases with age and executive function may limit an individual's capacity to accommodate  
90 for resource-demanding situations.<sup>8,9</sup> If the demands of executing a task exceed cognitive  
91 capacity then performance will decline. In older adults, walking while performing a second task  
92 (i.e., dual-task) results in greater performance deterioration than in younger adults.<sup>10</sup> The use of a  
93 walking aid increases the cognitive demands of ambulation.<sup>11</sup> Therefore, changes in cognition

94 and the decreased motor learning that accompany aging, combined with situational cognitive  
95 demands, may account for the increased falls risk associated with walking aid use.<sup>3</sup>

96 Canes require precise timing and movement coordination with the contralateral leg.<sup>3</sup>  
97 Thus, canes provide arguably more of a cognitive challenge than other devices (e.g., walkers).  
98 This is relevant because canes are also the most common walking aid used.<sup>4</sup> Only three studies  
99 have evaluated gait with initial use of a single-point cane: one in healthy older adults,<sup>12</sup> and two  
100 in healthy younger adults.<sup>13,14</sup> For healthy older adults, the first-time use of a single-point cane  
101 reduced velocity and increased stride time variability,<sup>12</sup> while for healthy younger adults it  
102 resulted in reduced velocity,<sup>14</sup> a lower cadence and an increased swing time and a decreased  
103 stance time on the side of the body holding the cane.<sup>13</sup>

104 Even though most daily activities involve dual-tasking,<sup>15</sup> only one study has assessed the  
105 relative changes in performance when the use of a single-point cane is paired with a secondary  
106 task.<sup>12</sup> In healthy older adults, and upon walking with a single-point cane while completing a  
107 cognitive task, gait was slower and stride time variability higher compared to unassisted  
108 walking.<sup>12</sup> This dual-task effect on stride time variability was found to be larger in older adults  
109 with mild to moderate Alzheimer's disease relative to healthy older adults.<sup>12</sup> Moreover, in older  
110 adults, performance further declines when walking complex paths as this demands increased  
111 cognitive resources.<sup>12,16</sup> No research has sought to investigate if a differential effect of first-time  
112 single-point cane use exists between younger and older adults, and whether this effect is  
113 dependent on cognitive load or the difficulty of the walking path. This information is relevant to  
114 the prescription and training with walking aids and may be a mechanism to explain the increased  
115 risk of falls seen with the use of these devices.

116           The study objective was to determine if there were age-related differences: (1) on spatio-  
117 temporal gait parameters with single-point cane use while performing a secondary cognitive task,  
118 (2) on the relative change in gait and cognitive performance and task prioritization between  
119 unassisted walking, walking using a single-point cane and walking using a single-point cane with  
120 a cognitive task. It was hypothesized that single-point cane use would result in greater velocity  
121 decreases and increased stride time variability in older adults compared to younger adults. This  
122 differential effect would be most pronounced in dual-task and in more complex walking paths.  
123 Upon dual-task testing, a higher percentage of older adults would prioritize gait over the  
124 secondary cognitive task, resulting in more cognitive errors being recorded compared to younger  
125 adults.

## 126 **METHODS**

### 127 **Participants**

128           Participants for this study were recruited from March 2017 to May 2018. Younger adults  
129 (YA) were aged 18-35 years and were recruited from The University of Western Ontario,  
130 London, Canada. Older adults (OA) were aged  $\geq 50$  years and were recruited via newsletter from  
131 a local health centre in London, Canada. Inclusion criteria for both groups were: being able to  
132 understand and follow instructions in English, and do not require a walking aid for ambulation.  
133 Participants with conditions hindering movement, such as muscle and/or nerve damage, were  
134 excluded. During a phone screening, and prior to any collection, participants were asked if they  
135 had any health issues currently affecting their balance and/or gait. A second set of questions  
136 regarding comorbidities or any medical or surgical issues affecting mobility were asked at the  
137 day of testing to ensure the exclusion of individuals with impairment. All participants provided

138 informed written consent prior to participating. This study was approved by the Health Sciences  
139 Ethics Review Board of The University of Western Ontario, London, Canada (HSREB#108430).

#### 140 **Outcome measures**

141 The following participant demographic and clinical characteristics were collected: age,  
142 biological sex, height and weight to calculate body mass index (BMI), the Mars Contrast  
143 Sensitivity Test (Perceptrix®)<sup>17</sup> and the Stereo Fly Test (Stereo Optical Company®) to assess  
144 vision, years of education, comorbidities, prescription medications, cognitive status as per the  
145 Mini-Mental State Examination (MMSE),<sup>18</sup> and 12 months' falls history. A fall was defined as:  
146 "an unexpected event in which the participant comes to rest on the ground, floor, or lower  
147 level".<sup>19</sup> The study was approximately 60 minutes in length and took place in a laboratory  
148 setting. All outcome measures were collected by two trained research assistants using a  
149 standardized protocol. The research assistant lead was kept consistent throughout the totality of  
150 participant recruitment.

#### 151 **Cognitive single-task assessment**

152 To evaluate the effect of dual-tasking on cognitive performance, a single-task cognitive  
153 assessment was first completed while seated. This assessment consisted of participants  
154 completing 10 consecutive serial subtractions by ones from 100. The time to complete the  
155 assessment, total responses, and total correct responses were recorded. Time was recorded to the  
156 nearest hundredth of second with a stopwatch.

#### 157 **Walking assessment**

158 Spatio-temporal gait parameters were assessed with the use of two tri-axial  
159 accelerometers (LEGSys™, BioSensics, Cambridge, MA). The LEGSys™ system test-retest  
160 reliability for velocity is excellent (ICC=0.82-0.85),<sup>23</sup> and the sensors have been shown to be

161 valid compared to other measurement techniques in older adults.<sup>24,25</sup> Accelerometers were  
162 affixed to the lower limbs of each participant at the level of the tibial tuberosity and oriented in  
163 the frontal plane. Gait velocity and stride time variability were collected to represent the domains  
164 of pace and variability, respectively.<sup>26,27</sup> These gait parameters and domains are the most  
165 established and have been associated with age and changes in cognitive status in older adults.<sup>28</sup>  
166 Furthermore, decreased performance in pace and variability domains is associated with falls in  
167 older adults,<sup>27,29</sup> especially in regards to stride time variability.<sup>30</sup> Stride time variability was  
168 quantified using the coefficient of variation (CoV) as follows:

$$169 \quad CoV (\%) = \left( \frac{Standard\ deviation}{Mean} \right) \times (100)$$

170

171 Three separate walking path configurations were included: a 6-meter straight path (SP),  
172 the Groningen Meander Walking Test (GMWT),<sup>31</sup> and the Figure of Eight Test (F8).<sup>32</sup>  
173 Increasing cognitive challenge was embedded in the walking path configurations, whereby SP is  
174 low and GMWT and F8 walking are more challenging. Complex paths approximate real-life  
175 walking challenges, including adaptation to negotiate obstacles and change directions.<sup>33</sup> A floor  
176 template was used for the GMWT and F8 walks.

177 Participants completed single-task walking (ST), cane walking trials (CW), and dual-task  
178 with the cane (DT) for each path, which consisted respectively of: 1) walking without use of the  
179 cane, 2) walking with a single-point cane, and 2) walking with a single-point cane while  
180 completing the cognitive task of counting backwards from 100 by 1s. Total number and accuracy  
181 of responses were recorded. No instructions were given to prioritize any one task. The secondary  
182 task used for the dual-task conditions was chosen for several reasons. A motor task may have  
183 interfered with the use of the cane. Moreover, a cognitive task allowed for the recording of

184 secondary task performance which enabled other examinations (i.e., cognitive task cost, task  
185 prioritization). During pilot testing and compared to counting backwards by 3s or reciting the  
186 days of the week, subtracting 1s from 100 was deemed most appropriate as it was able to be  
187 performed by all participants and would be challenging to perform while using a cane for the  
188 first time across different walking paths. The cognitive task used has been validated in various  
189 subpopulation of older adults,<sup>20,21</sup> and was standardized as per recommended guidelines.<sup>22</sup>

190 A single-point cane was provided and assigned to be used in the dominant hand. Each  
191 participant stood with their arms resting by their side and the cane was adjusted by a trained  
192 research assistant so that the handle leveled with their wrist crease.<sup>34</sup> Participants were taught  
193 how to use the cane appropriately during walking. The order of tasks was not randomized to  
194 minimize confusion as the present dataset was part of a larger study examining the use of  
195 walking aids in older adults with Alzheimer’s disease. Instead, participants first completed the  
196 walks without the walking aid and then using the cane for each walking path configuration in  
197 order of difficulty (SP, GMWT, F8). A 5-minute walking practice period prior to recordings was  
198 provided. A practice trial and two recorded trials, which were averaged for analysis, were  
199 completed at a self-selected walking speed for each condition and each walking path. When  
200 requested by the participant, seated rest in between tests was provided.

## 201 **Data analysis**

202 Demographic and clinical characteristics were summarized using medians and  
203 interquartile ranges or frequencies and percentages. Normality was assessed for continuous  
204 variables using Shapiro-Wilks tests, histograms, and Q-Q plots. Age, BMI, visual contrast  
205 sensitivity, binocularity, years of education, MMSE, number of prescription medications, and  
206 number of comorbidities, did not meet normality assumptions and were assessed across groups

207 using Kruskal-Wallis H tests. Biological sex (binary: male, female) was compared across groups  
208 using the chi-square test of homogeneity and the Fisher's exact test was used to compare 12  
209 months' fall history, and comorbidities. All p-values were adjusted using a Holm-Bonferroni  
210 correction for multiple comparisons. Furthermore, Cohen's d (d) were used to represent effect  
211 sizes; whereby the values of 0.20, 0.50, and 0.80 represented small, medium, and large effect  
212 sizes, respectively.<sup>35,36</sup>

213 *Objective #1:* Gait velocity met assumptions of normality while stride time variability did  
214 not. Statistical analysis for stride time variability was carried out using log<sub>10</sub> transformed data.  
215 Means and standard deviations were calculated for velocity and medians and interquartile ranges  
216 were reported for the untransformed stride time variability. Separate three-way mixed methods  
217 ANOVAs were used to examine the effect of cane use and dual-task testing on gait parameters  
218 (velocity and stride time variability). The within-subject factors were walking path (SP, GMWT,  
219 F8) and condition (ST, CW, DT) while the between-subject factor was age group (YA, OA).

220 *Objective #2a:* Gait task cost was calculated as the percentage change between ST  
221 (walking without a cane) and walking with a cane, and between ST and DT (use of a cane with a  
222 secondary task) for each walking path. Velocity and stride time variability task cost met  
223 normality. Task cost was calculated as:

$$224 \quad \text{Gait Task Cost} = \left[ \frac{CW \text{ (or DT)} - ST}{ST} \right] \times (100)$$

225 Poorer performance is indicated by negative values, improved performance is indicated  
226 by positive values. A negative multiplier was used during the calculation of stride time  
227 variability task cost so that this consistency of interpretation was kept. Separate three-way mixed

228 methods ANOVAs were used to analyze gait task cost, whereby the within-subject factor was  
229 walking path and condition (CW, DT) while the between-subject factor was age group.

230 *Objective #2b:* Task cost was also calculated for cognitive performance. The correct  
231 response rate (CRR) was first calculated for the seated single-task cognitive test to account for  
232 the speed and accuracy of responses.<sup>37</sup> CRR was calculated as:

233 
$$\text{Correct response rate (CRR)} = \text{responses per second} \times \text{percentage of correct responses}$$

234

235 Following the calculation of CRR, cognitive task cost was calculated as follows:

236

237 
$$\text{Cognitive Task Cost} = \left[ \frac{\text{CRR walking in DT} - \text{CRR seated}}{\text{CRR seated}} \right] \times (100)$$

238

239 Negative values indicate a deterioration in cognitive task performance while positive  
240 values indicate an improvement. A two-way mixed methods ANOVA was used to assess  
241 cognitive task cost across walking paths between age groups.

242 The assumptions of homogeneity, sphericity, and normality of the residuals was met for  
243 all ANOVAs. Holm-Bonferroni post-hoc pairwise comparisons were completed where  
244 appropriate. Main effects were interpreted in the absence of statistically significant interactions.  
245 Omega squared ( $\omega^2$ ) effect sizes were calculated to assist with the interpretation of results,  
246 whereby the values of 0.01, 0.06, and 0.14 represented small, medium, and large effect sizes,  
247 respectively.<sup>36</sup> All statistical analyses were completed using SPSS version 25.0 (SPSS, Inc.,  
248 Chicago, IL) and R version 4.0.2,<sup>38</sup> with experiment-wise alpha specified to be 0.05.

249 *Objective #3:* Performance-resource operating characteristic plots were used to compare  
250 trade-offs in performance for gait and cognitive task costs during dual-task.<sup>39</sup> Overall gait task

251 cost was calculated as the average between velocity and stride time variability task cost. A  
252 diagonal reference line splits the graph and indicates task prioritization. Performance that falls on  
253 the left of the reference line are indicative of gait prioritization and those that fall on the right are  
254 indicative of cognitive task prioritization. Points directly on the reference line indicate no change  
255 between single-task and dual-task testing.

256 *A priori*, and based on our previous work,<sup>40</sup> a sample size of 25 participants per group  
257 was deemed necessary assuming  $\alpha=0.05$ ,  $\beta=0.20$ , and a dual-task effect size of 15%.

## 258 **RESULTS**

259 A total of 26 YA (aged:  $23.7 \pm 2.8$  years, 73.1% female) and 25 OA (aged:  $70.8 \pm 14.1$   
260 years, 76.0% female) were recruited (Table 1). Forty-four percent (n=11) of people within the  
261 OA group were younger than 65 years of age. Statistically significant differences in age  
262 (adjusted  $p<0.001$ ,  $d=3.33$ ), BMI (adjusted  $p=0.001$ ,  $d=1.28$ ), high visual contrast sensitivity  
263 (adjusted  $p<0.001$ ,  $d=1.84$ ), low visual contrast sensitivity (adjusted  $p<0.001$ ,  $d=1.97$ ), MMSE  
264 scores (adjusted  $p=0.036$ ,  $d=0.54$ ), number of prescription medications (adjusted  $p=0.01$ ,  $d=$   
265  $0.93$ ), and number of comorbidities (adjusted  $p<0.001$ ,  $d=1.57$ ) were observed between groups.  
266 As expected, YA were less impaired than OA. All participants were able to perform the study  
267 protocol in its entirety without any falls.

### 268 **Spatio-temporal gait parameters**

269 No three-way interaction term was statistically significant for velocity (Figure 1) or stride  
270 time variability (Figure 2) in the three-way mixed ANOVAs.

271 For both velocity ( $p<0.001$ ,  $\omega^2=0.03$ ) and stride time variability ( $p=0.032$ ,  $\omega^2=0.02$ ) there  
272 was a statistically significant two-way interaction between walking path and condition,  
273 indicating the effect of condition on performance was dependent on the walking path

274 configuration (Figure 1 and Figure 2). A reduced gait velocity and higher stride time variability  
275 was observed with increased difficulty of the walking condition and walking path configuration.  
276 Additionally, there was a significant main effect of group for both gait parameters (velocity:  
277  $p=0.004$ ,  $\omega^2=0.07$ ; stride time variability:  $p=0.001$ ,  $\omega^2=0.09$ ). Older adults walked slower and  
278 had higher stride time variability than younger adults irrespective of walking path configuration  
279 or condition.

### 280 **Gait task cost**

281 No three-way interaction term was statistically significant for velocity (Figure 3) or stride  
282 time variability (Table 2) task cost in the three-way mixed ANOVAs.

283 For velocity task cost, a statistically significant two-way interaction between walking  
284 path and condition ( $p<0.001$ ,  $\omega^2=0.05$ ) was observed, indicating the effect of condition on task  
285 cost was dependent on the walking path configuration (Figure 3). Gait velocity task cost was  
286 lower in the more complex walking conditions and higher during walking with a cane. No  
287 statistically significant three-way interactions or main effects ( $p>0.05$ ) were observed for stride  
288 time variability task cost (Table 2).

### 289 **Cognitive task cost**

290 No statistically significant two-way interaction or main effects were observed for  
291 cognitive task cost (Table 3).

### 292 **Performance-Resource Operating Characteristic (POC)**

293 Visual analysis of POC graphs revealed that increased walking path complexity resulted  
294 in greater prioritization towards the gait task (Figure 4). For the OA group, 64.0% ( $n=16$ )  
295 prioritized gait in the SP path and this increased to 72.0% ( $n=18$ ) in the GMWT and 76.0%

296 (n=19) in the F8. Yet, for the YA group gait prioritization was highest with 84.6% (n=22) in the  
297 SP path, followed by 76.9% (n=20) in the F8 and 52.6% (n=19) in the GMWT.

## 298 **DISCUSSION**

299         The present study demonstrated that the magnitude and direction of the effect of first-  
300 time single-point cane use on gait or secondary task performance did not differ by age group.  
301 Instead, the effect of different walking conditions was dependent on the difficulty of the walking  
302 path configuration. Across groups, a posture-first strategy was consistently used at the expense  
303 of cognitive task performance during dual-task, hypothetically minimizing instability which  
304 became most pronounced in the more difficult paths. This is the first study to directly assess the  
305 differential effects on gait parameters of initial cane use between healthy YA and OA.

306         The walking aid-related changes to gait observed are consistent with previous research in  
307 samples of only YA<sup>14</sup> or OA.<sup>12</sup> Gait velocity in our YA group was higher (1.13-1.37 m/s) than  
308 that reported by Suzuki et al. (1.04-1.12 m/s).<sup>14</sup> The differences are likely explained by the fact  
309 that Suzuki et al. used a motor reaction time task that was arguably more challenging (wrist  
310 extensions in response to a phone vibration) and had to be incorporated into the gait pattern  
311 while using a cane with the other hand.<sup>14</sup> Moreover, Suzuki et al. instructed participants to walk  
312 longer distances (60 m) which may have resulted in fatigue and lower velocity averages.<sup>14</sup> As  
313 Jayakaran et al. only assessed cadence and different phases of the gait cycle,<sup>13</sup> comparisons to  
314 the present study cannot be made. Also consistent with the existing literature, complex walking  
315 path configurations resulted in deteriorated gait in both groups.<sup>33,41,42</sup> Our study contributes to  
316 the literature by demonstrating that the cognitive demands associated with initial use of a cane  
317 were appreciable, yet comparable between younger and older adults. This finding supports the

318 role for healthcare professionals to be involved in the prescription and training of walking aids  
319 while monitoring progression of motor learning over time.

320         With experience the cognitive burden of performing a novel task may decrease due to  
321 motor learning. Evidence of task automaticity in experienced walking aid users has been  
322 observed in OA.<sup>43</sup> Research has yet to understand what a typical timeframe for learning to use a  
323 walking aid is, what factors contribute the most to the motor learning associated with walking aid  
324 use, or if training would minimize some of the negative effects of initial walking aid use on gait  
325 stability. A clear indication of the mechanisms (e.g., intrinsic, behavioural, situational) behind  
326 the relationship between walking aid use and falls risk does not currently exist. Moreover, falls  
327 prevention guidelines offer no specifics to clinicians regarding the introduction of a walking aid  
328 or the assessment of falls risk in older adults who use walking aids.<sup>44</sup> Thus, future research on  
329 walking aid use and motor learning is considered critical and an initial step for the development  
330 of a standardized, evidence-based clinical protocol for healthcare professionals aiding clients'  
331 transition towards the full-time use of a walking aid.

332         A differential effect of first-time single-point cane use was expected, especially as OA  
333 performed lower on global cognition, had worse visual sensitivity, were taking more prescription  
334 medications and reported a higher number of comorbidities. It has been demonstrated that gait is  
335 adversely affected in people with dementia learning to use a cane compared to healthy older  
336 adults.<sup>12,16</sup> The lack of age group differences observed in the presence of cognitive test  
337 divergence may be due to an insufficient cognitive challenge which did not exceed the capacity  
338 of OA. Moreover, age-related differences in dual-task performance are more consistently  
339 observed when the secondary task of choice involves executive or visuo-spatial function.<sup>10</sup>

340 Future research should examine how different ecologically valid protocols and secondary tasks  
341 may affect gait in people using walking aids for the first time.

342         Importantly, the results of the present study are clinically relevant. Regardless of age,  
343 participants experienced some negative gait effects with initial cane use, which became more  
344 pronounced in environments resembling real-life. Although a practice period and trials were  
345 provided to participants before gait recordings, an evaluation of performance stability over a  
346 series of trials was not performed. A practice effect may confound the impact of cane use on  
347 walking performance, which future research should aim to examine. The present study supports  
348 the need for research on training regimes to facilitate walking aid motor learning. This is  
349 important as the majority of cane users are not prescribed their device by a healthcare  
350 professional; 67% indicated to have learned how to use their device on their own. Regarding the  
351 use of a device, 54% have the height set inappropriately, 28% hold their cane on the wrong side,  
352 and close to a third have difficulty adjusting their gait pattern to integrate their cane.<sup>5</sup> Healthcare  
353 professionals aiding the provision of a walking aid should consider that clients may see benefit  
354 from a follow-up. During this follow-up, gait parameters indicative of instability can be  
355 monitored, while also assessing if the client is adhering to the prescribed use of the walking aid  
356 or if any barriers are currently inhibiting proper motor learning. A modified gait protocol from  
357 this study could be used by clinicians to evaluate and monitor gait velocity (using a stopwatch to  
358 measure time to walk a fixed distance) with the provision and training of a cane. Clinicians and  
359 researchers are encouraged to follow a standardized gait assessment protocol, such as the  
360 Canadian Consortium on Neurodegeneration in Aging guidelines.<sup>22</sup>

361         Several limitations should be highlighted. A convenience sample was used and therefore our  
362 sample is not representative of all community-dwelling YA and OA. Older adults were high

363 functioning and recruited from a community health centre; therefore, our results may  
364 underestimate the effect of initial walking aid use for those most likely to need one (e.g., OA  
365 with an increased risk for falls). None of the participants needed a walking aid in order to solely  
366 evaluate the cognitive demands of first use of the aid without the effects of any underlying  
367 pathology or pain. Moreover, the OA group was between the ages of 50 to 91 years. An  
368 examination of first-time cane use in middle-aged (50-64 years) and older adults (>65 years) is  
369 important as the introduction of a walking aid can occur at any age for various reasons (e.g.,  
370 sprained ankle). Across both groups, there were more females than males, although a statistically  
371 significant difference in sex proportion between the age groups was not observed. Sex-  
372 differences exist in balance, gait and dual-task gait performance,<sup>45,46</sup> thus future research should  
373 aim to assess the effect of first-time walking aid use on gait based on this factor. Future research  
374 should also explore if other walking aid types (e.g., wheeled walkers), environmental factors  
375 (e.g., lighting, surfaces) or behavioural factors (e.g., handedness) influence gait performance to  
376 refine relevant factors for assessment and intervention through rehabilitation. A strength of the  
377 present study was the sample size of 51 participants. Additionally, different walking paths and a  
378 dual-task condition were used to increase both cognitive challenge and ecological validity, and  
379 walking performance was evaluated using instrument-recorded gait parameters in both healthy  
380 YA and OA.

## 381 **CONCLUSIONS**

382         Single-point cane use resulted in reduced velocity and increased stride time variability in  
383 healthy YA and OA. An age-related differential effect of cane use on gait was not observed. In a  
384 healthy sample, the cognitive load of using a cane was appreciable; however, further research is  
385 needed to understand the effect of initial use of a walking aid across subpopulations of older

386 adults more likely to need these devices. Moreover, future work should evaluate if training may  
387 help diminish some of the adverse changes in gait (i.e., increased stride time variability)  
388 observed with the provision of a walking aid.

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**Table 1:** Demographic and clinical characteristics of the sample of healthy younger and older adults.

Variable	medians [IQR] or n (%)		Adjusted
	Younger Adults (n=26)	Older Adults (n=25)	p-value
Age (years) <sup>†</sup>	24.0 [22.0-25.0]	75.0 [56.0-82.0]	<b>&lt;0.001</b>
Biological Sex (% female) <sup>‡</sup>	19 (73.1%)	19 (76.0%)	0.81
Body Mass Index (kg/m <sup>2</sup> ) <sup>†</sup>	21.7 [20.1-24.6]	26.7 [24.1-28.7]	<b>0.001</b>
High Visual Contrast Sensitivity <sup>†</sup> (log minimum angle of resolution)	-0.01 (-0.01-0.00)	0.10 (0.01-0.20)	<b>&lt;0.001</b>
Low Visual Contrast Sensitivity <sup>†</sup> (log minimum angle of resolution)	0.10 (0.00-0.10)	0.40 (0.20-0.45)	<b>&lt;0.001</b>
Circles Stereo Fly Test (seconds) <sup>†</sup>	40.0 (40.0-40.0)	40.0 (40.0-80.0)	0.153
Animals Stereo Fly Test (seconds) <sup>†</sup>	100.0 (100.0-100.0)	100.0 (100.0-100.0)	0.374
Education (years) <sup>†</sup>	17.0 [16.0-18.0]	16.0 [13.8-18.5]	0.374
History of falls in the past 12 months <sup>§</sup>	4 (15.4%)	6 (24.0%)	0.50
Mini-Mental State Examination (MMSE) <sup>†</sup>	30.0 [30.0-30.0]	30.0 [28.0-30.0]	<b>0.036</b>
Number of Prescription Medications <sup>†</sup>	0.0 [0.0-1.0]	2.0 [1.0-3.0]	<b>0.01</b>
Number of Comorbidities <sup>†</sup>	0.0 [0.0-0.0]	2.0 [0.0-3.0]	<b>&lt;0.001</b>
Summary of Comorbidities <sup>§</sup>			

Hypertension	0 (0.0%)	8 (32.0%)	<b>0.012</b>
Diabetes	0 (0.0%)	1 (4.0%)	0.49
Osteoarthritis	0 (0.0%)	6 (24.0%)	0.05
Cancer	0 (0.0%)	5 (20.0%)	0.08
Cataract	0 (0.0%)	5 (20.0%)	0.08
Macular Degeneration	0 (0.0%)	5 (20.0%)	0.08
Other	0 (0.0%)	13 (52.0%)	<b>&lt;0.001</b>

Note: Statistical significance was  $p < 0.05$  for the results of: † Mann-Whitney U test, ‡ chi-square test of homogeneity, § Fisher's exact test. All presented p-values were adjusted using a Holm-Bonferroni correction.

**Table 2:** Results of three-way mixed methods ANOVA assessing stride time variability task cost (%) in walking with a single-point cane and walking with single-point cane while completing a secondary cognitive task across different walking paths in healthy younger and older adults.

Walking Path Configuration	Younger Adults (n=26)		Older Adults (n=25)		Three-way Mixed ANOVA
	CW	DT	CW	DT	
Straight Path	-89.22 ± 419.69	-6.59 ± 85.24	-31.60 ± 85.15	-55.56 ± 172.44	<b>Main effects:</b> Path: p=0.26 Condition: p=0.66 Group: p=0.46 <b>Interaction term:</b> Path x Condition: p=0.46 Path x Group: p=0.62 Condition x Group: p=0.73 Path x Condition x Group: p=0.15
GMWT	17.31 ± 44.18	-22.22 ± 71.51	-21.20 ± 74.32	-20.85 ± 58.68	
Figure of 8 Test	-5.69 ± 44.91	-12.97 ± 43.91	-51.44 ± 106.57	-23.89 ± 117.47	

Note: CW = single-point cane walking, GMWT = Groningen Meander Walking Test, DT = dual-task (walking with single-point cane while completing a secondary cognitive task). Statistical significance was  $p < 0.05$  for the results of the three-way ANOVA.

**Table 3:** Results of two-way mixed methods ANOVA assessing cognitive task cost (%) in walking with a single point cane while performing a cognitive secondary task across different walking paths in healthy younger and older adults.

<b>Walking Path Configuration</b>	<b>Younger Adults (n=26)</b>	<b>Older Adults (n=25)</b>	<b>Two-way Mixed ANOVA</b>
Straight Path	-39.78 ± 18.96	-32.84 ± 23.97	<b>Main effects:</b> Path: p=0.28 Group: p=0.16 <b>Interaction term:</b> Path x Group: p=0.89
GMWT	-43.62 ± 20.40	-34.82 ± 18.59	
Figure of 8 Test	-40.69 ± 20.96	-32.90 ± 23.53	

Note: GMWT = Groningen Meander Walking Test. Negative values indicate deterioration in performance and positive values indicate improved performance. Statistical significance was  $p < 0.05$  for the results of the two-way mixed methods ANOVA.

454 **FIGURE LEGENDS**

455 **Figure 1:** Results of three-way mixed ANOVA assessing gait velocity (m/s) in unassisted  
456 walking, walking with a single-point cane, and walking with single-point cane while completing  
457 a secondary cognitive task across different walking paths in healthy younger and older adults  
458 using a single-point cane.

459 **Figure 2:** Results of three-way mixed ANOVA assessing stride time variability (CoV%) in  
460 unassisted walking, walking with a single-point cane, and walking with single-point cane while  
461 completing a secondary cognitive task across different walking paths in healthy younger and  
462 older adults using a single-point cane.

463 **Figure 3:** Results of three-way mixed methods ANOVA assessing gait velocity task cost (%) in  
464 walking with a single-point cane and walking with single-point cane while completing a  
465 secondary cognitive task across different walking paths in healthy younger and older adults.

466 **Figure 4:** Performance-resource operating characteristic graphs comparing gait and cognitive  
467 performance in dual-task across A) Straight Path (SP), B) Groningen Meander Walk Test  
468 (GMWT) and C) Figure of Eight (F8) configurations in younger and older adults.

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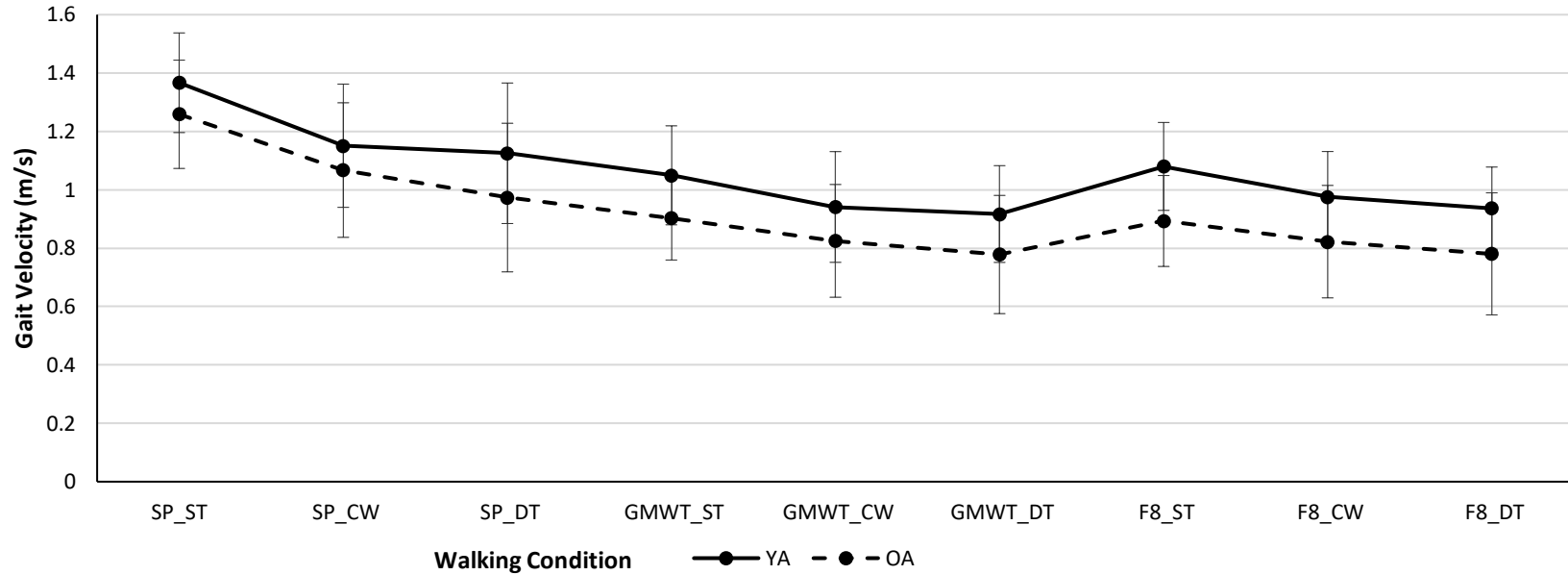
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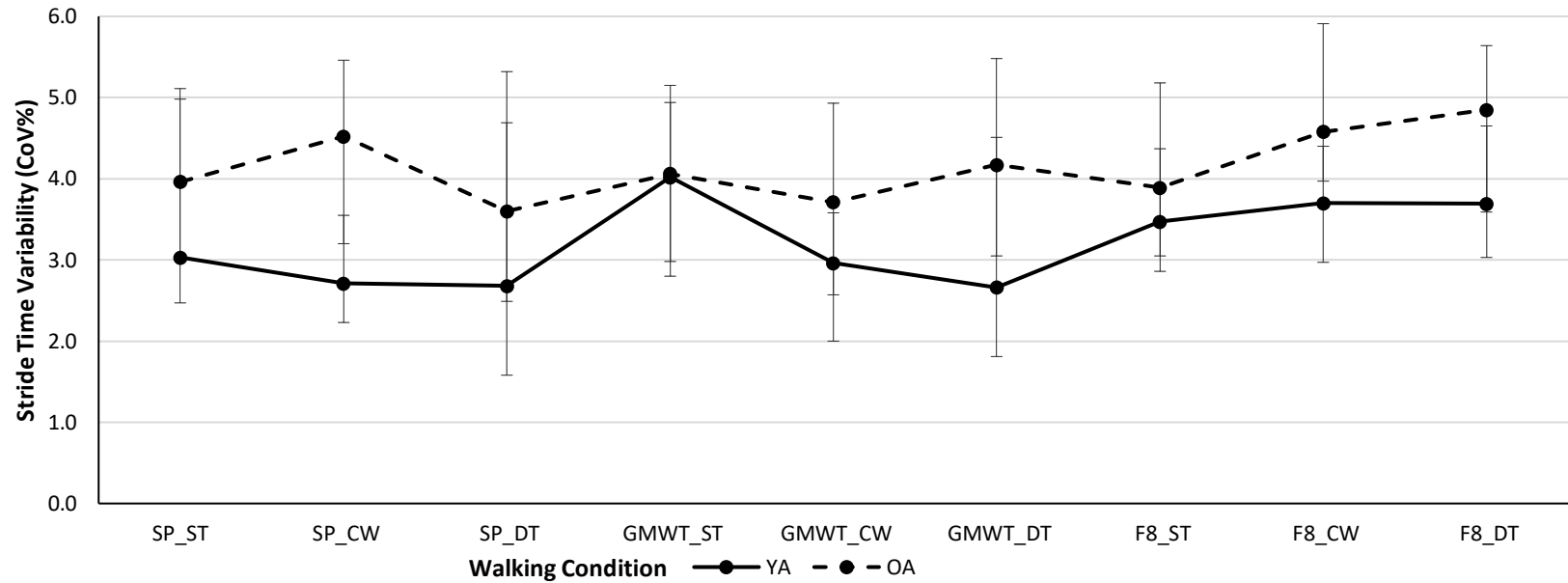
Figure 1.



Walking Path Configuration	Younger Adults (n=26)			Older Adults (n=25)			Three-way Mixed ANOVA
	ST	CW	DT	ST	CW	DT	
Straight Path	1.37 ± 0.17	1.15 ± 0.21	1.13 ± 0.24	1.26 ± 0.19	1.07 ± 0.23	0.97 ± 0.25	<b>Main effects:</b> Path: <b>p&lt;0.001</b> Condition: <b>p&lt;0.001</b> Group: <b>p=0.004</b>
GMWT	1.05 ± 0.17	0.94 ± 0.19	0.92 ± 0.17	0.90 ± 0.14	0.83 ± 0.19	0.78 ± 0.20	
Figure of 8 Test	1.08 ± 0.15	0.98 ± 0.16	0.94 ± 0.14	0.89 ± 0.16	0.82 ± 0.19	0.78 ± 0.21	<b>Interaction terms:</b> Path x Condition: <b>p&lt;0.001</b> Path x Group: p=0.49 Condition x Group: p=0.13 Path x Condition x Group: p=0.24

Note: CW = single-point cane walking, F8 = Figure of 8 Test, GMWT = Groningen Meander Walking Test, DT = dual-task (walking with single-point cane while completing a secondary cognitive task), SP = straight path, ST = single-task (unassisted walking), YA = younger adults, OA = older adults. Statistical significance was  $p < 0.05$  for the results of the three-way ANOVA.

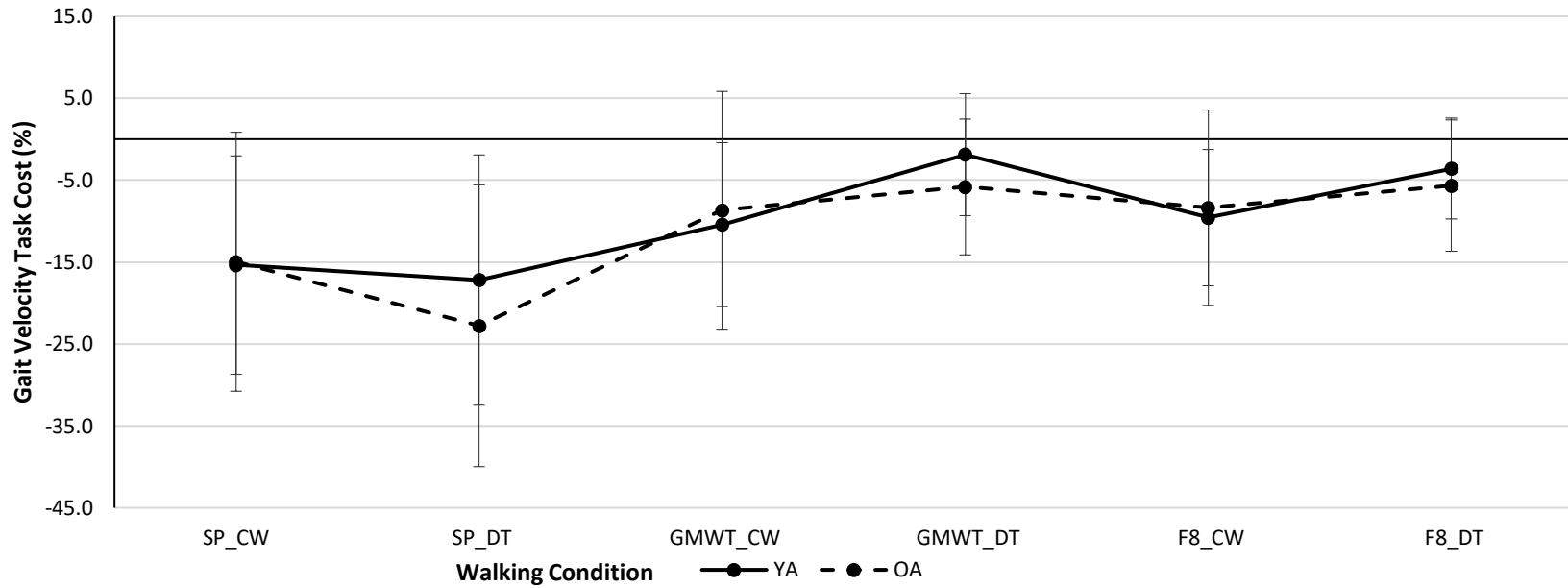
Figure 2.



Walking Path Configuration	Younger Adults (n=26)			Older Adults (n=25)			Three-way Mixed ANOVA
	ST	CW	DT	ST	CW	DT	
Straight Path	3.03 (2.47-4.98)	2.71 (2.23-3.55)	2.68 (1.58-4.69)	3.96 (3.00-5.11)	4.52 (3.20-5.46)	3.60 (2.49-5.32)	<b>Main effects:</b> Path: <b>p&lt;0.001</b> Condition: <b>p=0.002</b> Group: <b>p=0.001</b> <b>Interaction terms:</b> Path x Condition: <b>p=0.032</b> Path x Group: p=0.06 Condition x Group: p=0.57 Path x Condition x Group: p=0.86
GMWT	4.02 (2.98-4.94)	2.96 (2.00-3.58)	2.66 (1.81-4.51)	4.06 (2.80-5.15)	3.71 (2.57-4.93)	4.17 (3.05-5.48)	
Figure of 8 Test	3.47 (3.05-4.37)	3.70 (2.97-4.40)	3.69 (3.03-4.65)	3.89 (2.86-5.18)	4.58 (3.97-5.91)	4.85 (3.59-5.64)	

Note: CW = single-point cane walking, F8 = Figure of 8 Test, GMWT = Groningen Meander Walking Test, DT = dual-task (walking with single-point cane while completing a secondary cognitive task), SP = straight path, ST = single-task (unassisted walking), YA = younger adults, OA = older adults. Statistical significance was  $p < 0.05$  for the results of the three-way ANOVA. Figure displays medians and interquartile ranges.

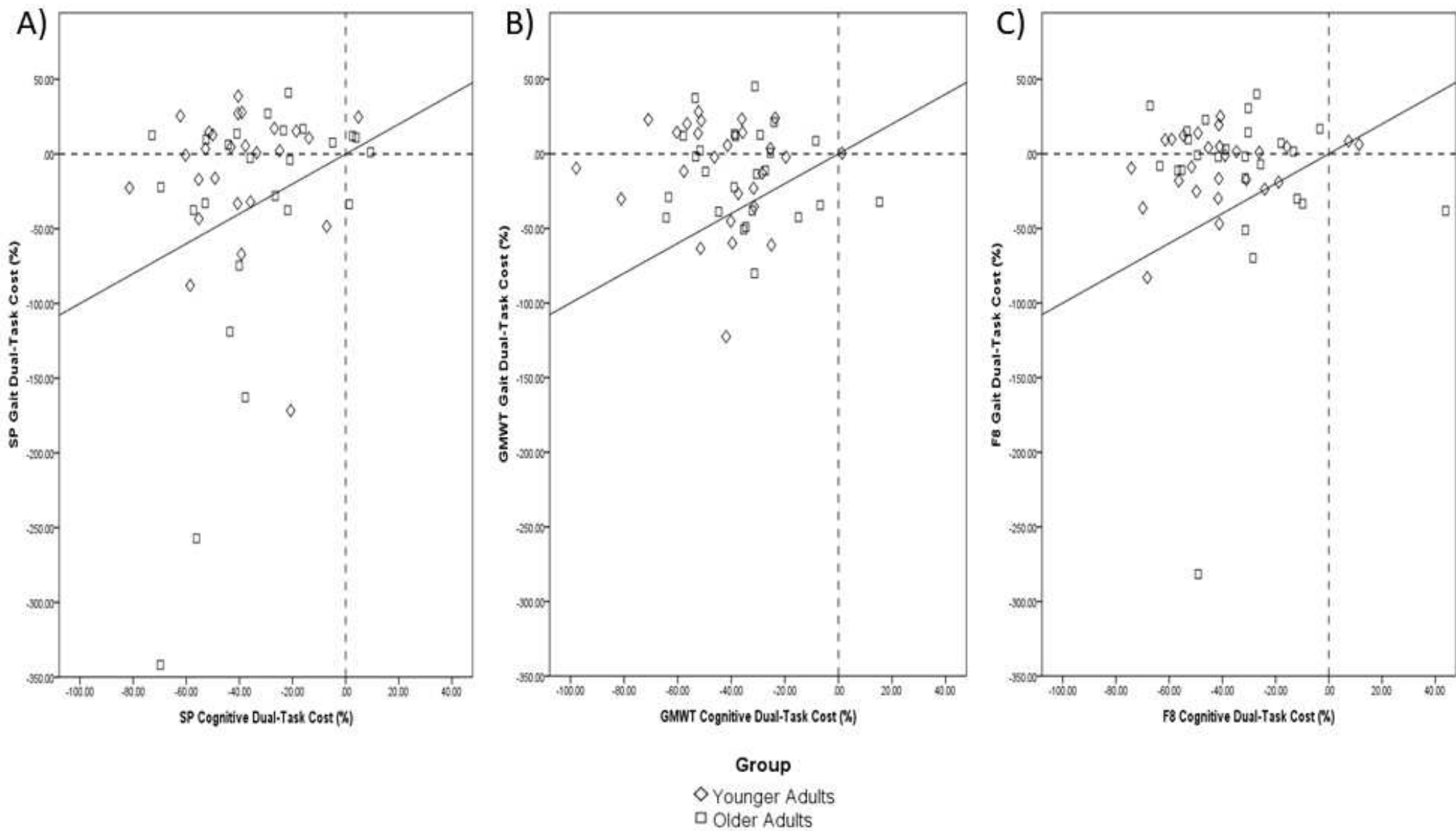
Figure 3.



Walking Path Configuration	Younger Adults (n=26)		Older Adults (n=25)		Three-way Mixed ANOVA
	CW	DT	CW	DT	
Straight Path	-15.37 ± 13.33	-17.20 ± 15.28	-14.96 ± 15.81	-22.78 ± 17.21	<b>Main effects:</b> Path: <b>p&lt;0.001</b> Condition: p=0.20 Group: p=0.57
GMWT	-10.43 ± 10.01	-1.89 ± 7.44	-8.69 ± 14.52	-5.84 ± 8.28	
Figure of 8 Test	-9.58 ± 8.32	-3.59 ± 6.16	-8.37 ± 11.92	-5.67 ± 8.01	<b>Interaction terms:</b> Path x Condition: <b>p&lt;0.001</b> Path x Group: p=0.58 Condition x Group: p=0.07 Path x Condition x Group: p=0.73

Note: CW = single-point cane walking, F8 = Figure of 8 Test, GMWT = Groningen Meander Walking Test, DT = dual-task (walking with single-point cane while completing a secondary cognitive task), YA = younger adults, OA = older adults. Statistical significance was  $p < 0.05$  for the results of the three-way ANOVA.

Figure 4.



454 Note: Graphs are divided into four quadrants: 1) upper left- improved gait but decreased cognitive performance, 2) upper right-  
455 improved gait and cognitive performance, 3) lower left- declined gait and cognitive performance, 4) lower right- declined gait but  
456 improved cognitive performance. A reference line (- - -) cuts through the second and third quadrants. Those that fall on the left side of  
457 the reference line are indicative of gait prioritization and those that fall on the right side of the reference are indicative of cognitive  
458 task prioritization. Points directly on the reference line indicate no change between single-task and dual-task testing. F8 = Figure of 8  
459 Test, GMWT = Groningen Meander Walking Test, SP = straight path.