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

Running title: Cane use in younger and older adults

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Patient Consent

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

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ABSTRACT

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

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

Design: Cross-sectional.

Setting: Community-dwelling.

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

Interventions: Not applicable.

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

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

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

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

INTRODUCTION

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

Walking involves higher-order cognitive processes, specifically executive function, which allows for the planning, monitoring, and adjustment of movements.[8] Executive function decreases with age and executive function may limit an individual's capacity to accommodate for resource-demanding situations.[8,9] If the demands of executing a task exceed cognitive capacity then performance will decline. In older adults, walking while performing a second task (i.e., dual-task) results in greater performance deterioration than in younger adults.[10] The use of a walking aid increases the cognitive demands of ambulation.[11] Therefore, changes in cognition and the decreased motor learning that accompany aging, combined with situational cognitive demands, may account for the increased falls risk associated with walking aid use.[3]

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

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

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

METHODS

Participants

Participants for this study were recruited from March 2017 to May 2018. Younger adults (YA) were aged 18-35 years and were recruited from The University of Western Ontario, London, Canada. Older adults (OA) were aged ≥50 years and were recruited via newsletter from a local health centre in London, Canada. Inclusion criteria for both groups were: being able to understand and follow instructions in English, and do not require a walking aid for ambulation. Participants with conditions hindering movement, such as muscle and/or nerve damage, were excluded. During a phone screening, and prior to any collection, participants were asked if they had any health issues currently affecting their balance and/or gait. A second set of questions regarding comorbidities or any medical or surgical issues affecting mobility were asked at the day of testing to ensure the exclusion of individuals with impairment. All participants provided informed written consent prior to participating. This study was approved by the Health Sciences Ethics Review Board of The University of Western Ontario, London, Canada (HSREB#108430).

Outcome measures

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

Cognitive single-task assessment

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

Walking assessment

Spatio-temporal gait parameters were assessed with the use of two tri-axial accelerometers (LEGSys™, BioSensics, Cambridge, MA). The LEGSys™ system test-retest reliability for velocity is excellent (ICC=0.82-0.85),[23] and the sensors have been shown to be valid compared to other measurement techniques in older adults.[24,25] Accelerometers were affixed to the lower limbs of each participant at the level of the tibial tuberosity and oriented in the frontal plane. Gait velocity and stride time variability were collected to represent the domains of pace and variability, respectively.[26,27] These gait parameters and domains are the most established and have been associated with age and changes in cognitive status in older adults.[28] Furthermore, decreased performance in pace and variability domains is associated with falls in older adults,[27,29] especially in regards to stride time variability.[30] Stride time variability was quantified using the coefficient of variation (CoV) as follows:

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

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

Participants completed single-task walking (ST), cane walking trials (CW), and dual-task with the cane (DT) for each path, which consisted respectively of: 1) walking without use of the cane, 2) walking with a single-point cane, and 2) walking with a single-point cane while completing the cognitive task of counting backwards from 100 by 1s. Total number and accuracy of responses were recorded. No instructions were given to prioritize any one task. The secondary task used for the dual-task conditions was chosen for several reasons. A motor task may have interfered with the use of the cane. Moreover, a cognitive task allowed for the recording of secondary task performance which enabled other examinations (i.e., cognitive task cost, task prioritization). During pilot testing and compared to counting backwards by 3s or reciting the days of the week, subtracting 1s from 100 was deemed most appropriate as it was able to be performed by all participants and would be challenging to perform while using a cane for the first time across different walking paths. The cognitive task used has been validated in various subpopulation of older adults,[20,21] and was standardized as per recommended guidelines.[22]

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

Data analysis

Demographic and clinical characteristics were summarized using medians and interquartile ranges or frequencies and percentages. Normality was assessed for continuous variables using Shapiro-Wilks tests, histograms, and Q-Q plots. Age, BMI, visual contrast sensitivity, binocularity, years of education, MMSE, number of prescription medications, and number of comorbidities, did not meet normality assumptions and were assessed across groups using Kruskal-Wallis H tests. Biological sex (binary: male, female) was compared across groups using the chi-square test of homogeneity and the Fisher's exact test was used to compare 12 months' fall history, and comorbidities. All p-values were adjusted using a Holm-Bonferroni correction for multiple comparisons. Furthermore, Cohen's d (d) were used to represent effect sizes; whereby the values of 0.20, 0.50, and 0.80 represented small, medium, and large effect sizes, respectively.[35,36]

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

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

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

Poorer performance is indicated by negative values, improved performance is indicated by positive values. A negative multiplier was used during the calculation of stride time variability task cost so that this consistency of interpretation was kept. Separate three-way mixed methods ANOVAs were used to analyze gait task cost, whereby the within-subject factor was walking path and condition (CW, DT) while the between-subject factor was age group.

Objective #2b: Task cost was also calculated for cognitive performance. The correct response rate (CRR) was first calculated for the seated single-task cognitive test to account for the speed and accuracy of responses.[37] CRR was calculated as:

Correct response rate (CRR) = responses per second x percentage of correct responses

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

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

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

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

Objective #3: Performance-resource operating characteristic plots were used to compare trade-offs in performance for gait and cognitive task costs during dual-task.[39] Overall gait task cost was calculated as the average between velocity and stride time variability task cost. A diagonal reference line splits the graph and indicates task prioritization. Performance that falls on the left of the reference line are indicative of gait prioritization and those that fall on the right are indicative of cognitive task prioritization. Points directly on the reference line indicate no change between single-task and dual-task testing.

A priori, and based on our previous work,[40] a sample size of 25 participants per group was deemed necessary assuming α=0.05, β=0.20, and a dual-task effect size of 15%.

RESULTS

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

Spatio-temporal gait parameters

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

For both velocity (p<0.001, ω^2=0.03) and stride time variability (p=0.032, ω^2=0.02) there was a statistically significant two-way interaction between walking path and condition, indicating the effect of condition on performance was dependent on the walking path configuration (Figure 1 and Figure 2). A reduced gait velocity and higher stride time variability was observed with increased difficulty of the walking condition and walking path configuration. Additionally, there was a significant main effect of group for both gait parameters (velocity: $p=0.004$, $\omega^2=0.07$; stride time variability: $p=0.001$, $\omega^2=0.09$). Older adults walked slower and had higher stride time variability than younger adults irrespective of walking path configuration or condition.

Gait task cost

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

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

Cognitive task cost

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

Performance-Resource Operating Characteristic (POC)

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

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

DISCUSSION

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

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

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

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

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

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

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

CONCLUSIONS

Single-point cane use resulted in reduced velocity and increased stride time variability in healthy YA and OA. An age-related differential effect of cane use on gait was not observed. In a healthy sample, the cognitive load of using a cane was appreciable; however, further research is needed to understand the effect of initial use of a walking aid across subpopulations of older adults more likely to need these devices. Moreover, future work should evaluate if training may help diminish some of the adverse changes in gait (i.e., increased stride time variability) 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.

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

Hypertension	0 (0.0%)	8 (32.0%)	**0.012**
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%)	**<0.001**

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	**Main effects:** Path: p=0.26 Condition: p=0.66 Group: p=0.46
GMWT	17.31 ± 44.18	-22.22 ± 71.51	-21.20 ± 74.32	-20.85 ± 58.68	**Interaction term:**
Figure of 8 Test	-5.69 ± 44.91	-12.97 ± 43.91	-51.44 ± 106.57	-23.89 ± 117.47	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

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.

Walking Path Configuration	Younger Adults (n=26)	Older Adults (n=25)	Two-way Mixed ANOVA
Straight Path	-39.78 ± 18.96	-32.84 ± 23.97	**Main effects:** Path: p=0.28 Group: p=0.16 **Interaction term:** 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.

FIGURE LEGENDS

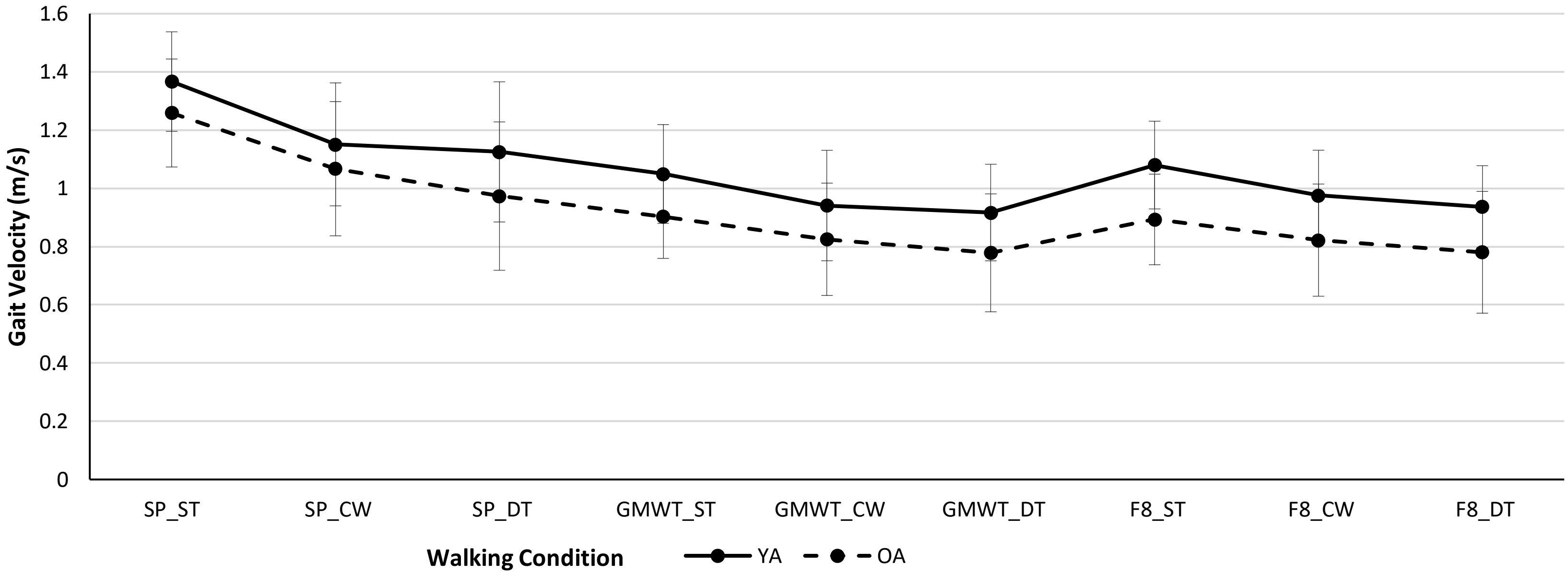
Figure 1: Results of three-way mixed ANOVA assessing gait velocity (m/s) in unassisted walking, walking with a single-point cane, and walking with single-point cane while completing a secondary cognitive task across different walking paths in healthy younger and older adults using a single-point cane.

Figure 2: Results of three-way mixed ANOVA assessing stride time variability (CoV%) in unassisted walking, 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 using a single-point cane.

Figure 3: Results of three-way mixed methods ANOVA assessing gait velocity 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.

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

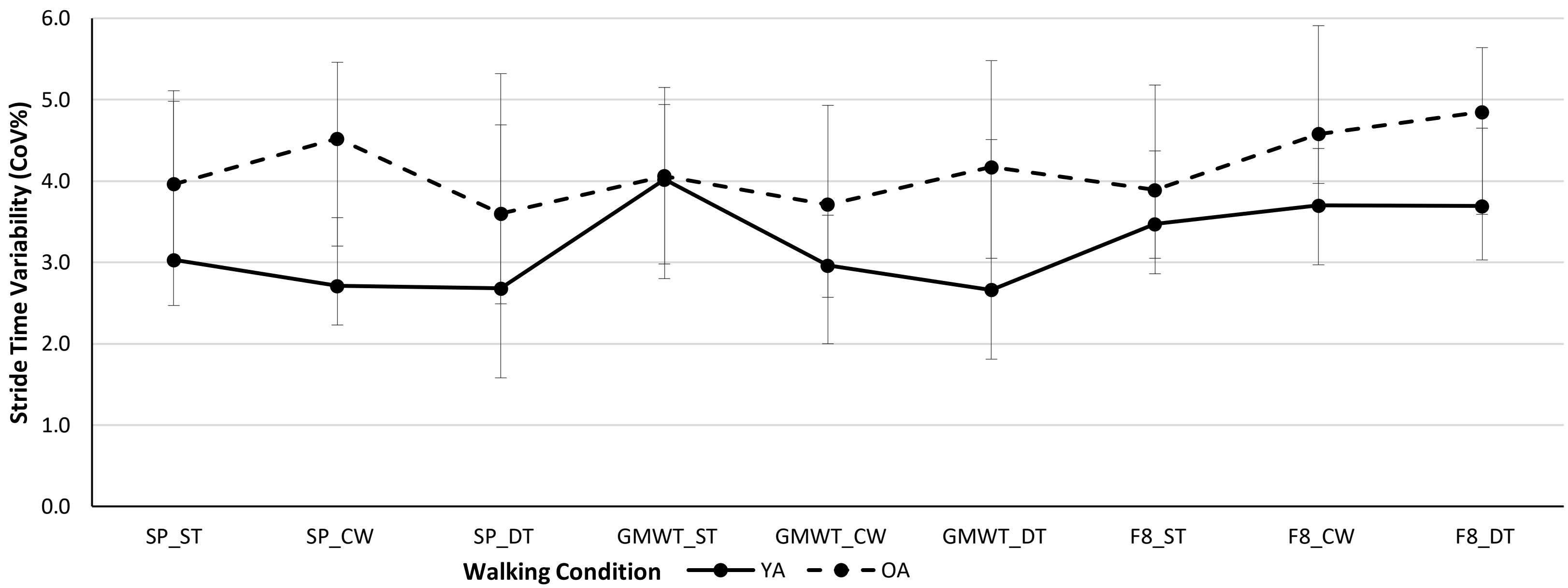
Figure 1.



Walking Path Configuration	**Younger Adults (n=26)**			**Older Adults (n=25)**			**Three-way Mixed ANOVA**
	ST	**CW**	**DT**	**ST**	**CW**	**DT**	
							Main effects:
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	Path: **p<0.001** Condition: **p<0.001** Group: **p=0.004**
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	**Interaction terms:**
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	Path x Condition: **p<0.001** 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.

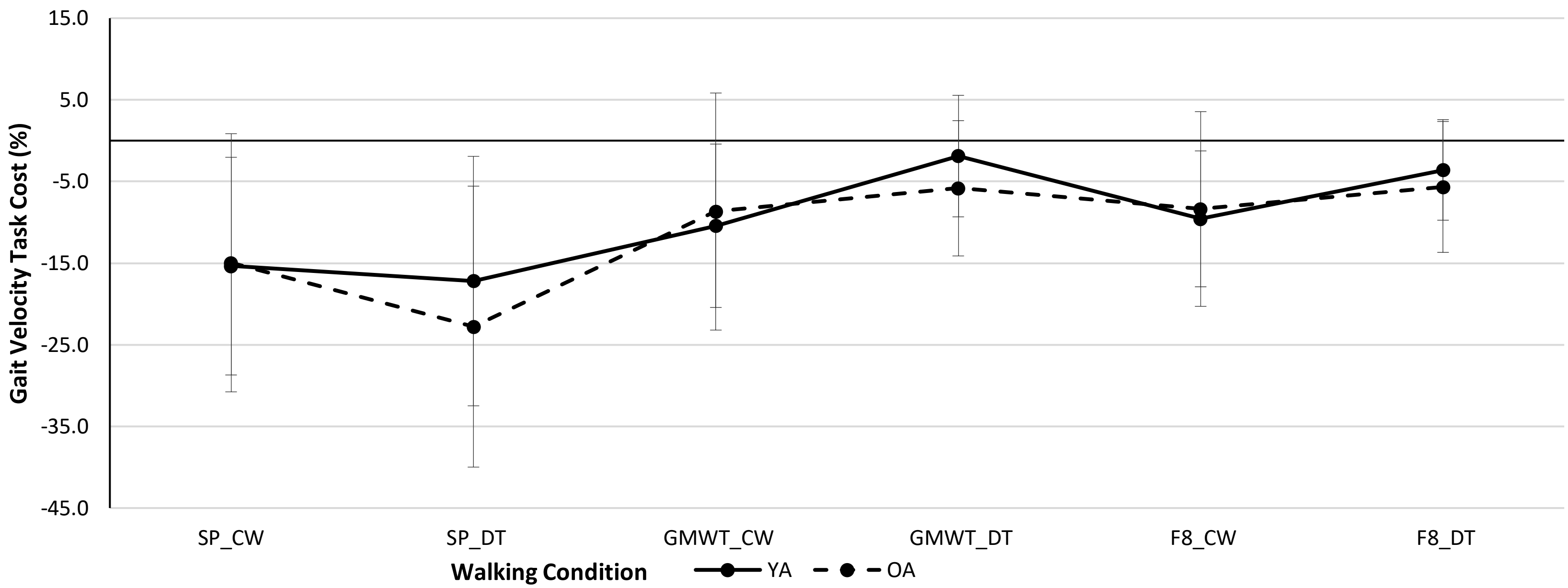
Figure 2.



Walking Path Configuration	**Younger Adults (n=26)**			**Older Adults (n=25)**			**Three-way Mixed ANOVA**
	ST	**CW**	**DT**	**ST**	**CW**	**DT**	
							Main effects:
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)	Path: **p<0.001** Condition: **p=0.002** Group: **p=0.001**
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)	**Interaction terms:**
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)	Path x Condition: **p=0.032** Path x Group: p=0.06 Condition x Group: p=0.57 Path x Condition x Group: p=0.86

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.

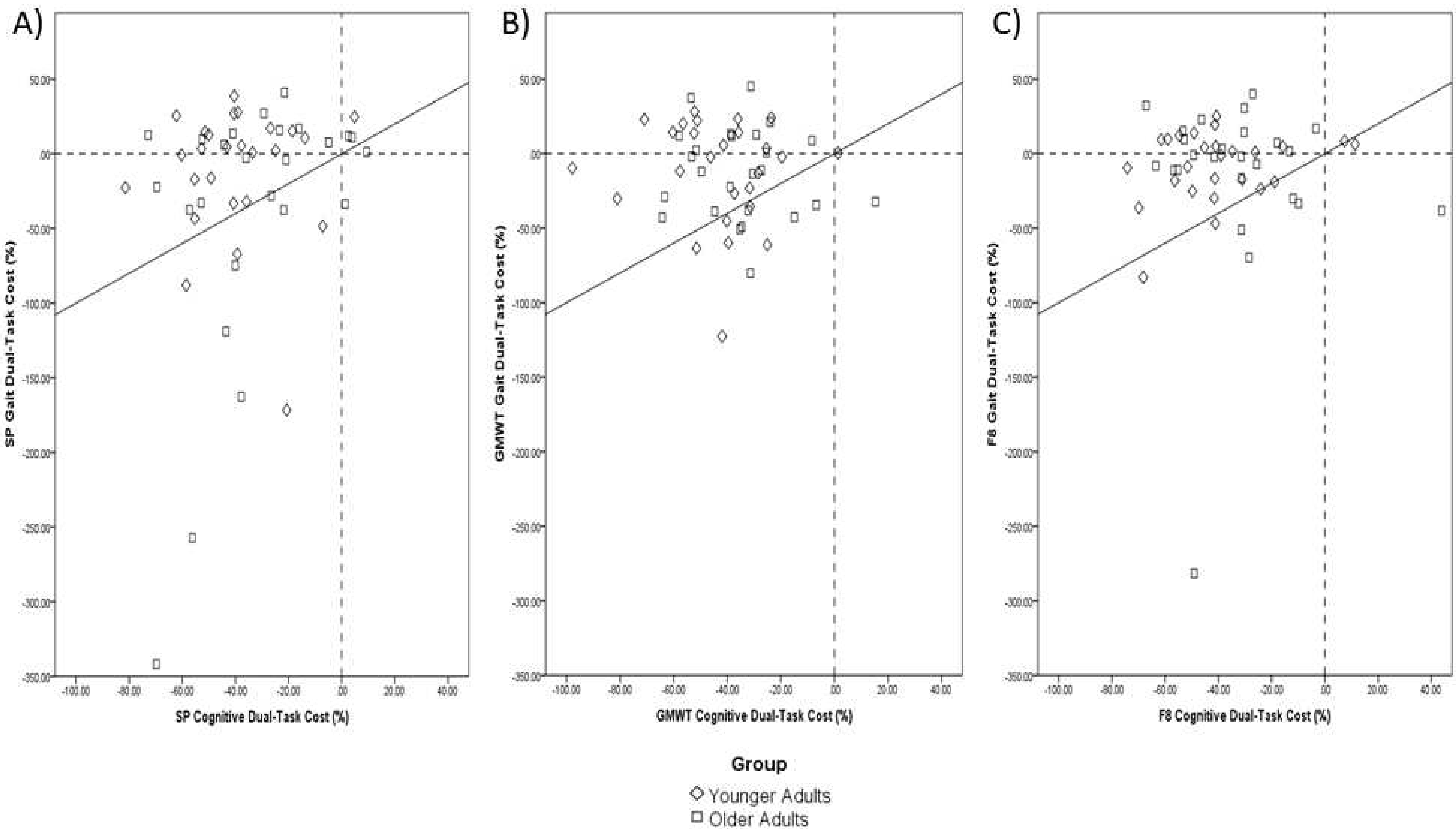
Figure 3.



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	**Main effects:** Path: **p<0.001**
GMWT	-10.43 ± 10.01	-1.89 ± 7.44	-8.69 ± 14.52	-5.84 ± 8.28	Condition: p=0.20 Group: p=0.57 **Interaction terms:**
Figure of 8 Test	-9.58 ± 8.32	-3.59 ± 6.16	-8.37 ± 11.92	-5.67 ± 8.01	Path x Condition: **p<0.001** 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.


A)
B)
C)
SP Gait Dual-Task Cost (%)
SP Cognitive Dual-Task Cost (%)
GMWT Gait Dual-Task Cost (%)
GMWT Cognitive Dual-Task Cost (%)
F8 Gait Dual-Task Cost (%)
F8 Cognitive Dual-Task Cost (%)
Group
Younger Adults
Older Adults

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