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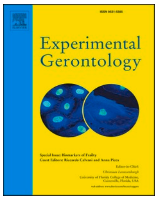

Effects of age, sex, frailty and falls on cognitive and motor performance during dual-task walking in older adults

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ABSTRACT

Background: Dual-task (DT) walking is of great interest in clinical evaluation to evaluate the risk of falling or cognitive declines in older adults. However, it appears necessary to investigate deeply the confounding factors to better understand their impact on dual-task performance.
Objective: To evaluate the effect of age, sex, falls and frailty on cognitive and motor parameters in dual-task walking.
Subjects: 66 older participants (mean age = 75.5 ± 6.3; mean height = 165.8 ± 8.4 cm; mean weight = 68.4 ± 14 kgs) were split into groups based on their age, sex, fall and frailty status.
Methods: Participants performed single-task walking, single-task cognitive (serial subtraction of 3), and dual-task walking (subtraction + walking) for 1 min at their fast pace. Gait speed, step length, step length variability, stance and swing phase time, single and double support, cadence, step time variability and gait speed variability were recorded in single- and dual-task walking and used to calculate the dual-task effect (DTE) as ((DT − ST) / ST) * 100). The cognitive score (*DTEcog*) was calculated as the number of correct responses minus errors. Generalized linear mixed models (GLMM) were used to compare the effects of falls, frailty, age and sex on gait and cognitive variables.
Results: The interaction frailty*sex and frailty*age were the major effect on the DTEs. Specifically, the DTE was higher in women than men and in the frail group compared to non-frail.
Conclusions: The present findings provide a better understanding on the confounding factors explaining the behavior in DT that could be used to develop more effective dual-task clinical programs for community-living older adults.

1. Introduction

Aging is often associated with a decline in mobility, a reduction in activity levels, declines in functional and cognitive capabilities, neurological disorders and early mortality (Plassman et al., 2010; Wingert et al., 2014; Bortone et al., 2021). These age-related declines are commonly assessed in routine testing to avoid hospitalization and reduced dependency (Koch et al., 1994). Dual-task (DT) tests paradigms allow the detection of subtle gait impairments which under the single task traditional gait assessment (Timed Up and Go test (TUG), 10-m walking) may remain undetected in neurotypical aging population (Bridenbaugh and Kressig, 2015). The DT tests consist of adding a motor or cognitive task to the single task (ST) condition (walking) to increase the difficulty of walking that could help to better discriminate the vulnerable patients among the healthy one. It has been demonstrated that the inability to maintain a conversation while walking ("stop walking when talking") is a marker of future falls in older adults (Beauchet et al., 2009). Recently, a growing number of studies investigated the paradigm of dual-tasking (DT) as the first experiments conducted have yielded encouraging results in the DT's ability to be a clinical marker of cognitive impairment (Ehsani et al., 2019; Bahureksa et al., 2016; Martínez-Ramírez et al., 2016), fall risk (Martínez-Ramírez

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et al., 2016; Wollesen et al., 2017; Bayot et al., 2020) and frailty status (Giusti Rossi et al., 2019; Cadore et al., 2015) in older adults.

The DT paradigm consists of the simultaneous execution of two tasks for example walking while talking or counting backward. Under DT conditions, performance of motor and/or cognitive task can deteriorate because of competing demands, when the available central resource capacity is exceeded (Yogev-Seligmann et al., 2012; Abernethy, 1988). The literature has focused on analyzing age, sex, frailty and fall-related difference in DT, but no study has analyzed them together (Ehsani et al., 2019; Bahureksa et al., 2016; Martínez-Ramírez et al., 2016; Bayot et al., 2020; Giusti Rossi et al., 2019; Wollesen and Voelcker-Rehage, 2019). It was found that, during DT, spatio-temporal parameters were more altered in healthy older adults than their younger counterparts (greater decrease in gait speed, increase in stride variability, stride time…) (Al-Yahya et al., 2011; Smith et al., 2016; Gomes and Teixeira-Salmela, 2016; Hollman et al., 2007). Also, Hollman et al. (2011) showed that, whereas gait speed decreased and variability in gait speed increased in men and women, men walked with greater variability during DT walking than did women. Finally, frail older subjects had their gait speed, cadence and stride time more affected by DT than the non-frail group (Martínez-Ramírez et al., 2016; Bayot et al., 2020; Cadore et al., 2015; Guedes et al., 2014). These studies only focused on the DT without comparing it to the ST. However, in dual-tasking, there is a need to manage interference and switching between tasks, which can be done by having a reference with ST. (Fallahtafti et al., 2021) This can be done through the calculation of the dual-task effect (DTE) which is a ratio between the DT and ST parameters (McIsaac et al., 2015). The DTE enables the magnitude and direction of the impact of dual-tasking on a specific parameter to be quantified, by looking on its positive or negative sign and its value, which indicates the difference between DT and ST. A study using the DTE found no difference in gait speed between non-frail and frail groups (Cadore et al., 2015) whereas other studies that just compared these groups during DT found a significant difference in gait speed (Martínez-Ramírez et al., 2016; Bayot et al., 2020; Cadore et al., 2015; Guedes et al., 2014). Moreover, Nordin et al. (2010) found that gait speed, step width, step time and step length DTEs might predict an increased risk of falling or a protective strategy, which highlights the relevance of the DTE.

In this context, the aim of this study was to quantify the effects of age, sex, frailty and incidence of falling on cognitive performance (which is the score in counting backwards by 3) and on the 10 gait variables during DT walking by calculating their DTE. It was hypothesized that frailty, fall, sex and age would have a greater effect on gait variables than on cognitive performance.

2. Material and methods

2.1. Participants

Seventy-three older adults were recruited (mean age = 75.5 ± 6.5 year old, mean height = 165.3 ± 8.3 cm, mean weight = 68.2 ± 13.8 kgs). Inclusion criteria were an ability to walk independently for, at least, 50 m and have corrected-to-normal hearing and vision. Participants were excluded if they had a history of neurological disorders, cognitive dysfunction, any orthopedic conditions affecting gait, an acute hospital stay within the last 3 months, or a lower extremity amputation. Patients with cognitive dysfunction were screened by the Frontal Assessment Battery (FAB) and were excluded if their score ranged between 14.6 and 16.6 based on the level of education (Appollonio et al., 2005). Approval of the study was obtained (*n° 2015-A01188-41)* and all participants signed the informed consent form.

Participants were classified based on their sex, age, incidence of falling and their level of frailty. This information was collected through clinical questionnaires. Concerning the frailty classification, patients were classified into three categories based on five phenotypic components (Fried's criterion (Fried et al., 2001)): non-frail (NF) (no deficit in any of the phenotypic components), pre-frail (PF) (deficit in one or two phenotypic components) and frail (F) (deficit in three or more phenotypic components). The operationalization of the five phenotypic components was: 1. unintentional loss of ≥5 % of body weight in the past year, 2. self-report of feeling "tired all the time" 3. Mean speed to complete a 10 m walk <1 m/s, 4. Low physical activity and 5. clearly abnormal strength on physical examination (Fried et al., 2001). Concerning incidence of falling, the participant was classified as a faller if one or more falls occurred in the past year and as a non-faller if no falls occurred.

2.2. Dual-task protocol

Participants were instructed to walk continuously without assistance for 1 min along a 10 m walkway (turning at the end each time) at their fastest speed. The fastest speed was chosen rather than a self-selected one as it was shown that the most difficult gait task will amplify dual-task interference (Plummer-D'Amato et al., 2012). The 2 first and 2 last steps, considered as acceleration and deceleration phases, were not included in the calculation (Fig. 1). 10 spatio-temporal parameters were measured over 1 min of walking without an additional task (*ST*) and walking while doing the specific cognitive task (*DT*). They were gait speed (m/s), step length (m), step length variability, stance and swing phase time (s) and single and double support (the first and second double support were grouped) as a percentage of the gait cycle (%), cadence (steps/min), step time variability (cadence variability) and speed variability. The coefficient of variation was used to assess variability. The cognitive task was a serial subtraction of 3 from a random number between 200 and 300 (Srygley et al., 2009; Hausdorff et al., 2008). This secondary task was found to be more pertinent and challenging than verbal fluency or a motor task (Ehsani et al., 2019; Smith et al., 2016; Piche et al., 2022). The cognitive task was performed in a seated position (*score_ST*) and while walking (*score_DT*), each for 1 min. The cognitive performance was quantified in ST and DT conditions as the total number of subtractions (TNS) minus all mistakes. No instructions were given regarding which task to prioritize during the dual-task condition, walking or counting backward, in order to establish an ecological situation similar to real life. To reduce possible fatigue effects, a rest period was given after each single- and dual-task condition (Behrens et al., 2018). At the end of each condition, the participant was asked to rate the perceived difficulty of the task with a visual analog scale.

2.3. Data analysis

Spatio-temporal gait parameters were obtained with the validated Optogait system (Optogait, Microgate, Bolzano, Italy) (Lienhard et al., 2013). For this study, a 10-m instrumented walkway was used, consisting of 10 transmission bars and 10 reception bars, with a separation of 120 cm. Each bar (100 cm × 8 cm) contains 96 light emitters 3 mm from the ground. Optical sensors operate at a frequency of 1000 Hz, with accuracy of 1 cm, to detect spatiotemporal parameters (Fig. 1). Finally, the dual-task effect (DTE), which represents a ratio of performance between ST and DT, was calculated for the 10 gait parameters and for cognitive performance (*DTEcog*) as proposed by Plummer et al (Plummer-D'Amato et al., 2012):

$$\mathrm{DTE} = \frac{(DT - ST)}{ST} * 100.$$

For gait speed (*DTEmotor*), step length, stance and swing phase time, single support and cadence, negative values indicate that performance deteriorated under DT conditions (i.e., dual-task cost), and positive values represent an improvement in the DT condition relative to ST performance (i.e., dual-task benefit). However, for step length variability, double support, step time variability and speed variability, the dual-task cost is represented by a positive value. Then, the higher the

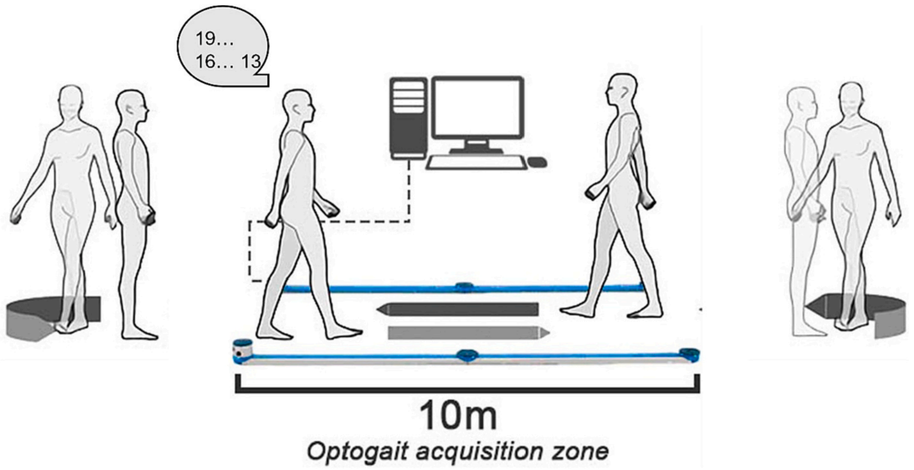

Fig. 1. Dual-task walking protocol consisting in 1 min of walking inside the 10 m of the Optogait acquisition zone. Each turnaround were made outside the zone.

positive value is (or the absolute value for the negative DTE), the higher is the dual-task cost.

2.4. Statistical analysis

Data were screened for extreme values using Mahalanobis distances and Grubb's test and 7 outliers were thus removed from the analysis. Some of their values were incoherent and humanly impossible to reach. Then, each dependent variable was tested for normality using Shapiro-Wilk. When normality was assessed, linear mixed models (LMMs) were used (*DTEstep_length*) and when data were positively skewed, a gamma regression was applied (*DTEcog, DTEstance, DTEswing, DTEdouble_support, DTEstep_time_var*). If none of the above conditions (normality or positively skewed) were verified, a log transformation was applied to reach normality (*DTEmotor, DTEstep_length_var, DTEsingle_support, DTEcadence, DTEspeed_var*). A random intercept effect structured by participants was included to control for the non-independence of the data and inter-subject variability. The LMM for the analysis of each variable included the level of frailty (non-frail (NF) vs. pre-frail (PF) vs. frail (F) participants), sex (female vs. male), incidence of falling (faller vs. non-faller) and age (65–69 vs. 70–74 vs. 75–79 vs. >80 years old) as fixed factors. Also, a Fisher's LSD correction for multiple comparison was applied and a Tukey's HSD test was used for post-hoc analysis. LMMs were chosen as they can attain higher statistical power than ANOVA and can reduce type I-error because of the consideration of the sampling variability of both participants and experimental conditions (Boisgontier and Cheval, 2016; Ma et al., 2012). Statistical analysis was performed using SPSS (IBM Corp.(2015) IBM SPSS Statistics for Windows (V23) Armonk, NY).

3. Results

Sixty-six participants were kept in the analysis (mean age = 75,5 ± 6,3; mean height = 165,8 ± 8,4 cm; mean weight = 68,4 ± 14 kgs) (Table 1).

For counting performance (*DTEcog*), the LMM showed a significant main effect of age (F(3,33) = 4.222, p = .013) and sex*incidence of falling (F(1,33) = 5.832, p = .022). Indeed, *DTEcog* decreased with age (Table 1 in supplementary materials) and was significantly different between fallers and non-fallers only in the male group (F(1,33) = 9.743, p = .004).

Concerning walking speed (*DTEmotor)*, a significant main interaction of frailty*sex was found (F(2,33) = 5.633, p = .008) and sex*-age*incidence of falling (F(3,33) = 4.55, p = .01). Specifically, frail women had higher DTEs than pre-frail women (F(2,33) = 5.671, p < .001) regarding their absolute value and, in men, the DTE was higher in the pre-frail group compared to the non-frail group (F(1,33) = 4.987, p = .036)(Fig. 2) (Table 1 in supplementary materials).

Concerning stance phase, (*DTEstance*), a significant main interaction of frailty*sex was found (F(2,33) = 7.559, p = .002), and frailty*age (F (5,33) = 5.811, p = .001) and frailty*incidence of falling (F(2,33) = 4.389, p = .021) also reached significance. In the frail group, significantly higher DTEs (F(1,33) = 9.172, p = .014) were found in women (M = 40.39, SD = 25.86) compared to men (M = 14.3, SD = 9.11) while no significant difference was found in pre-frail or non-frail groups (Table 1 in supplementary materials). Also, no significant differences between groups were found in men, whereas among women the frail and pre-frail groups showed significantly different DTEs (F(2,33) = 7.421, p = .024). Also in the non-frail group, DTEs significantly increased with age while in the PF and NF the increase is not significant.

For swing phase (%) (*DTEswing*), the LMM showed a significant main effect of sex (F(1,33) = 4.716, p = .039), frailty*sex (F(2,33) = 4.934, p = .015), frailty*age (F(5,33) = 3.897, p = .009), frailty*incidence of falling (F(2,33) = 4.409, p = .022) and age*incidence of falling (F(3,33) = 4.23, p = .014). Specifically, women had significantly higher DTEs than men, especially in frail participants (M(women) = 24.2, SD (women) = 23; M(men) = 5.7, SD(men) = 12.1, p = .005) (Table 1 in supplementary materials). Significant differences between the frail, pre-

Table 1
: Characteristics of all participants and their distribution in groups of interest (mean ± SD).

	Frail			Incidence of falling		Age				Sex	
	NF	PF	F	No	Yes	65–69	70–74	75–79	>80	M	W
Number, n (%)	19 (28.9)	31 (46.9)	16 (24.2)	38 (57.6)	28 (42.4)	16 (24.24)	16 (24.24)	18 (27.28)	16 (24.24)	24 (36.36)	42 (63.64)
Age, years (Stdev)	75 (11.8)	74.9 (15)	77.2 (14.9)	75.3 (5.8)	75.8 (6.9)	68 (1.2)	72.1 (1.3)	77 (1.3)	84 (2.7)	75.8 (5.6)	75.4 (6.6)
Height, cm (Stdev)	165.63 (7)	165.52 (8.9)	166.56 (9.3)	165.1 (8.1)	166.8 (8.7)	165.2 (10.3)	164.9 (9.2)	167.1 (6.6)	165.9 (7.8)	173.5 (6.4)	161.4 (5.8)
Weight, kgs (Stdev)	66.3 (5.6)	68.2 (7.3)	71.1 (4.7)	65.6 (12.9)	72.1 (14.9)	65.7 (13.2)	70.8 (13.1)	71.2 (14.5)	65.3 (15.4)	80.3 (13.1)	61.5 (9.2)

frail and non-frail groups were found among men. A significant increase in DTEs with age was also measured in the frail group (M(65–69) = 9.13, SD(65–69) = 9.8; M(>80) = 17.2, SD(>80) = 8.9) (Table 1 in supplementary materials).

In single support (%) (*DTEsingle_support*), no significant main effect or interaction was shown (p > .05) while in double support (%) (*DTEdouble_support*) the analysis highlighted a significant main effect of age (F(3,33) = 4.689, *p* = .009) and sex*age*incidence of falling (F(3,33) = 3.057, *p* = .044). Specifically, DTEs decreased with age (Fig. 3) (Table 1 in supplementary materials). No other interaction was found to be significant.

Regarding the variability in step time (*DTEstep_time_var*), the LMM showed significant main interaction of frailty*sex (F(2,33) = 11.267, p < .001), frailty*age (F(5,33) = 3.463, p = .014), frailty*incidence of falling (F(2,33) = 7.803, p = .002), frailty*sex*age (F(4,33) = 4.502, p = .006), frailty*sex*incidence of falling (F(2,33) = 6.483, p = .005) and sex*age*incidence of falling (F(3,33) = 8.585, p < .001). Specifically, the pre-frail and frail DTEs in men and women were significantly different (respectively F(2,33) = 5.584, p = .008 and F(2,33) = 18.582, p < .0001), the DTE also increased with the level of frailty but only in the non-falling group (F(2,33) = 11.128, p < .0001) (Table 1 in supplementary materials) (Fig. 4).

Finally, for the variability in walking speed (*DTEspeed_var*), the LMM showed a significant frailty*sex interaction ((F(2,33) = 4.849) = p = .015). Specifically, no significant main difference was noticed in men whereas a significantly higher DTE in frail women (M = 114.31; SD = 134.1) than pre-frail women (M = 6.8; SD = 60.3) was shown (Table 1 in supplementary materials).

No significant results were found in step length (*DTEstep_length*), step length variability (*DTEstep_length_var*) nor in cadence (*DTEcadence*).

4. Discussion

The aim of the present study was to determine the influence of frailty status, fall history, age and sex on cognitive (*DTEcog*) and motor performance (*DTEmotor*) and on the 10 spatiotemporal gait parameters during dual-tasking. We hypothesized that frailty, sex, fall history and age will have a great effect on the gait DTE but less on the cognitive DTE and that frailty will have the greatest effect on the DTE. The results of the present study confirm partly this hypothesis, showing that frailty status, fall history, age and sex had an effect on the DTE for most of the gait parameters and less on *DTEcog*. The DTEs were mainly impacted the interaction frailty*age and frailty*sex.

First, the present study found an effect of age and sex*incidence of falling on *DTEcog*. Specifically, the DTE increased with age and was significantly different between fallers and non-fallers for the men group only. This means that there is a higher cost in counting performance with age and with the risk of falling. While the age-related effect in this study was found through older adults, a recent study (Goh et al., 2021) also found an age-related effect on *DTEcog* between young and old adults. Using arithmetic tasks, Goh et al. (2021) found an increase in DTE with age (*DTE_young* = 11.79 ± 11.55 %; *DTE_old* = 26.85 ± 20.21 %) (Goh et al., 2021). Thus, our study is one of the first to reveal the effect of age within a restricted population of older adults. While an age-related effect on *DTEcog* using arithmetic tasks has been found (Goh et al., 2021), Yogev-Seligmann et al. (2012) did not observe it on *DTEcog* when using a verbal fluency task, showing the importance of the type of cognitive task. While arithmetic tasks are thought to engage numerical processing skills and are associated with activation in the bilateral prefrontal cortices, left posterior inferior parietal lobule, and left supplementary motor area (Kazui et al., 2000), verbal fluency tasks have been shown to evoke activation in the frontal network and temporal lobe (Kawakubo et al., 2018). These differences might explain that, in DT compared to ST, participants calculated fewer numbers in arithmetic tasks (p = .03) leading to a negative DTE, while no change was noticed in enumerating animals (p > .1) (Theill et al., 2011). A recent study supports that the impact of aging on dual-task gait might be domain specific and that it should be taken into consideration for the assessment of dual-task walking in older adults (Goh et al., 2021).

Concerning motor performance (*DTEmotor*), a frailty*sex and sex*age*incidence of falling interaction was observed. Specifically, frail women had higher absolute DTEs than pre-frail women and pre-frail men had higher absolute DTEs than non-frail men (p = .02). First, the negative DTE means that walking speed is lower in DT than in ST, which is reflected in each group. Then, the higher absolute value is, the more the difference (ie the cost) between DT and ST is which means that the cost in motor performance is higher in frail women compared to pre-frail women and in pre-frail men compared to non-frail men. This may reflects a strong power of dual-task walking in detecting frailty status. Also, it has already been reported that decreases in gait speed due to arithmetic tasks (i.e., *DTEmotor*) during the TUG test is strongly associated with the risk of falls in frail individuals (r = 0.78, p < .01) (Casas-Herrero et al., 2013). From this perspective, we might have been expected to find a frailty*incidence of falling interaction or a frailty or incidence of falling effects but this was not observed. But, previous studies also revealed no significant incidence of falling or frail effect on *DTEmotor* (Cadore et al., *2015*; Nordin et al., *2010*; Freire Júnior et al., *2017*; Zukowski et al., *2021*) even if a decline in gait speed was observed (0.23 m/s dual-task decline in gait speed in fallers compared to 0.19 m/s for non-fallers) (Zukowski et al., 2021).

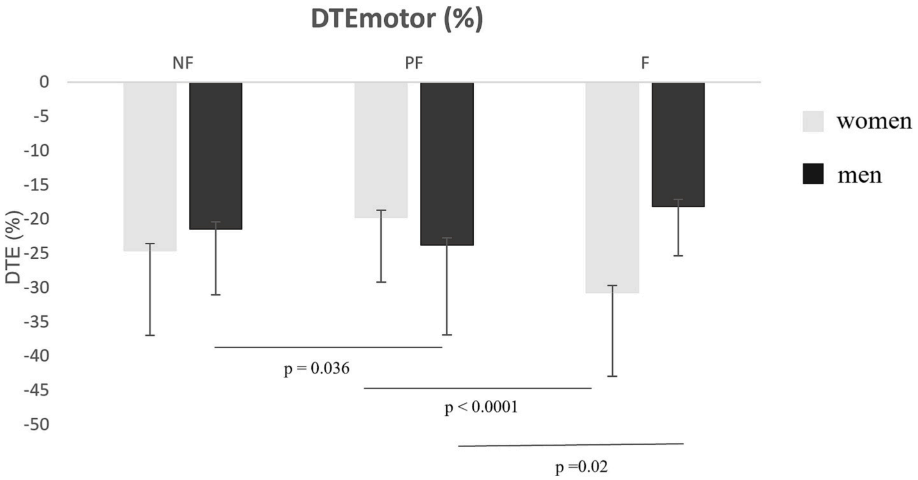

Fig. 2. The effect of frailty (non-frail (NF), pre-frail (PF) and frail (F))*sex (women in gray and men in black) on the DTE in motor performance (DTEmotor). Only significant *p*-values are presented (p < .05).

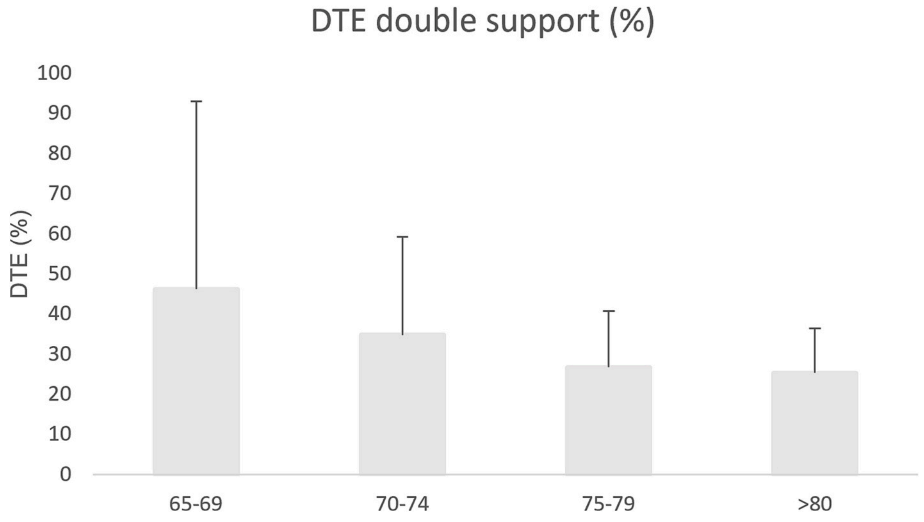

Fig. 3. The effect of age on the DTE in double support (DTE_double_support).

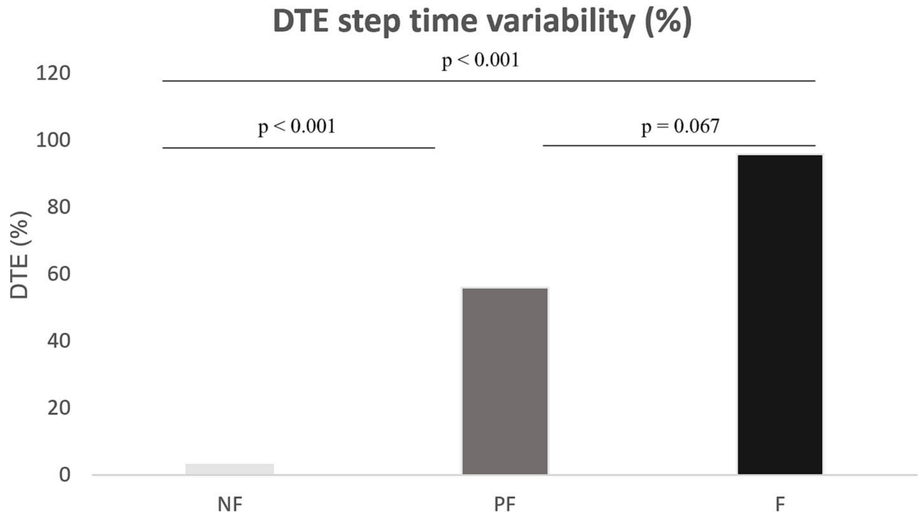

Fig. 4. The effect of frailty (non-frail (NF), pre-frail (PF) and frail (F)) on the DTE in step time variability (DTE_step_time_variability). Post-hoc results are also presented.

Concerning the other spatio-temporal DTEs, a dominant effect of age was noticed on *DTEdouble_support*. Specifically, DTE value was found to decrease with age which supports the idea of an age-related effect on the influence of DT on walking performance. Notice that double support is known to increase with age and also in DT compared to ST (Licence et al., 2015) in contrast with walking speed and that is why DTE is positive. However, it did not fit the hypothesis where the DTE was supposed to increase with age to show that the dual-task is harder to manage while getting older. However, La Roche et al. (LaRoche et al., 2014) found that double support time increased with age from 13 % in the 50s and 15 % in the 70s but that there were no difference between the 60s and other age groups. So maybe the age group in the study is not sufficiently extended to fit the initial hypothesis. Also, an explanation of the *DTEdouble_support* found is that, while getting older, the participant may change his strategy to respond to the dual-task. Indeed, maybe he did not change as much double support in DT compared to ST but to the benefice of another value. Age also have an effect on other variables as *DTEstance* or *DTE_step_time_variability* which is in line with established cognitive theories arguing that dual-task situations overstrain cognitive capabilities resulting in motor and/or cognitive performance decrements. Several authors have reported age-related decrements in performance in DT, such as a decrease in walking speed or shorter steps length (Yogev-Seligmann et al., 2012; Al-Yahya et al., 2011; Lama et al., 2018). These decrements can be attributed to age-related changes in the brain. Older adults are affected by a general loss of brain mass and a distinctive atrophy of the frontal gray matter (Beurskens and Bock, 2012). Additionally, a loss of central neurons and associated synaptic connections accrues, which leads to reduced processing speed and a deficit in the ability to handle several processes simultaneously (Grady and Craik, 2000). Also, some models have highlighted a different brain activation strategy with age that may be associated with the results found here. Indeed, the HAROLD (hemispheric asymmetry reduction in older adults) proposed by Cabeza (2002) has suggested that prefrontal activity during cognitive performances tends to be less lateralized in older adults than in younger adults. Another model (CRUNCH: compensation-related utilization of neural circuits hypothesis) has emphasized that the level or extent of brain activity can change in response to the level of task demand and that older adults rely on additional strategies to solve cognitive problems (Carp et al., 2010). These age-related brain adaptations may explain in some parts the results of the study.

The sex effect was observed on *DTEswing* and the interaction of frailty*sex and frailty*age on *DTEswing*, *DTEstance*, *DTEstep_time_variability* and *DTEspeed_var*. More precisely, the DTE is higher in women compared to men and is worse in old age in the Frail group and with women. A similar finding was shared by Hancock et al. (2003), who compared the driving performance of men and women while responding to an in-vehicle phone. Women had significantly longer brake response times when distracted by the phone in comparison with men, and their stopping accuracy was dramatically reduced when distracted (Yogev-Seligmann et al., 2010). This suggests that women had a different strategy to manage dual-tasking and may prefer to prioritize cognitive performance rather than motor performance. No significant effect of sex, age, frailty and fall were found in DTEstep_length, DTEstep_length_var and in DTEcadence. In this study, no prioritization of cognitive or motor task was given but Yogev and Seligman et al. (Yogev-Seligmann et al., 2010) were the first study to show evidence of a sex-effect on dual-task walking and on prioritization of tasks. Indeed, with different instructions (no prioritization, cognitive or motor prioritization), they found that young men demonstrated less dramatic prioritization effects, especially in the gait prioritization condition, compared with young women. Thus, the instructions given to the participants are of great importance as they can influence the sex-effect and maybe other effects on the DTE.

This study had a number of limitations that should be mentioned. First, the findings of the study should be taken with caution based on the small sample size in each groups that could have affected the results and their significance. However, this study offers a first insight of the effect of age, sex, frailty, incidence of falling and their interactions on cognitive and motor performance during a dual-task. Even if the participants were cognitively screened, future studies should investigate changes associated with sex, frailty, age and incidence of falling perhaps supplemented with more detailed cognitive testing as the relationship between cognitive decline and physical impairment is strong (Bortone et al., 2021). Also, participants were not instructed to prioritize the cognitive or motor performance during dual-tasking and this could also have influenced the results. Indeed, Yogev-Seligman et al. (Yogev-Seligmann et al., 2010) have shown that, among young adults, the effects of the secondary cognitive tasks on gait speed are strongly influenced by prioritization. This finding was less significant in older adults, suggesting that there is an age-associated decline in the ability to flexibly allocate attention to gait. Finally, the type of tasks could have also influenced the effects shown here. As mentioned above, depending on the motor function type (walking, TUG) and cognition task difficulty, the participants will not have the same results in DT (Ehsani et al., 2019). Another study also found that the motor task itself (Simoni et al., 2013) influences the DTE. Thus, comparisons between studies using different motor and/or cognitive tasks should be made carefully and results should be interpreted with care.

5. Conclusion

The results of this study demonstrated that the mixed interaction between frailty, age, sex and falls mainly impact dual-task cost on motor and cognitive performance. Mixed effects such as frailty*age or frailty*sex also impact the DTE. Specifically, understanding how the DTE differs between older adult fallers and non-fallers, frail and non-frail, men and women and with age may provide new information about potential hospitalization risk factors that could be used to develop more effective dual-task clinical prevention programs for community-ambulating older adults.

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