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Abstract

Objective: The aim of the study was to explore the association between fear of falling (FOF), dual-task ability during a mobility task and the activities of daily living (ADL) in a sample of older adults.

Methods: Seventy-six older adults (mean age, M =70.87 ± 5.16 years) participated in the study. Data on FOF, walking ability during both single- and dual-task performances and ADL were collected.

Results: Mediation analysis demonstrated the mediation effect of dual-task ability ($\beta = 0.241$, $p = 0.011$) between FOF and ADL level ($\beta = 0.554$, $p < 0.001$). Moreover, significantly lower performances were observed during dual-task condition [F (2, 73) = 7.386, $p < 0.001$], and lower ADL levels were also found in older adults with FOF [F (2, 73) = 13.734, $p < 0.001$].

Conclusion: The study underlines the relationship between FOF, dual-task ability and ADL level. These results could be used to develop specific intervention programmes for successful ageing.

Keywords: Dual Task, Fear of Falling, ADL, ageing

Introduction

Changes in physical (Chodzko-Zajko et al., 2009; Blind for review) and cognitive (Park, O'Connell, & Thomson, 2003) domains that are observed in advancing ageing are among the major factors that cause experiences of falls in older adults (Montero-Odasso, Muir, & Speechley, 2012; Rubenstein, 2006). Approximately, one-third of the individuals (aged 65 years and older) experience falls at least once a year (Montero-Odasso et al., 2012) with adverse consequences in both the physical and psychological domains, leading to a decrease in independence of the activities of daily living (ADL), which often require multitasking and in the quality of life (Gillespie et al., 2009; Lord, Sherrington, Menz, & Close, 2007).

Fear of falling (FOF) refers to a lack of self-confidence in situations in which normal activities can be performed without falling (Tinetti, Richman, & Powell, 1990) and is an important psychological factor that is highly prevalent with rates of over 50% in independent older adults (Scheffer, Schuurmans, van Dijk, van der Hooft, & de Rooij, 2008). FOF has been associated with an experience of falling (Delbaere et al., 2010) but is also commonly found among older adults without a history of falls (Clemson, Kendig, Mackenzie, & Browning, 2015; Oh, Hong, Lee, & Han, 2015; Zijlstra et al., 2007). Moreover, FOF has been associated with various factors, such as female gender and older age (Kempen, van Haastregt, McKee, Delbaere, & Zijlstra, 2009; Scheffer et al., 2008; Zijlstra, van Haastregt, van Eijk, & Kempen, 2005). FOF may lead to negative adverse outcomes, including mobility decline (Lach, Ball, & Birge, 2012; Patil, Uusi-Rasi, Kannus, Karinkanta, & Sievanen, 2014), restriction of ADL (Murphy, Williams, & Gill, 2002), increased risk of falling (Friedman, Munoz, West, Rubin, & Fried, 2002), institutionalisation (Cumming, Salkeld, Thomas, & Szonyi, 2000; Hsu, Alfermann, Lu, & Lin, 2013) and increased requirement for health care (Zijlstra et al., 2007). Therefore, older adults with impaired mobility may have FOF and which may cause a corresponding decrease in mobility and ADL (Viljanen et al., 2012). The

decrease in mobility and ADL in older adults with FOF could be a strategy for avoiding falls (Delbaere, Crombez, Vanderstraeten, Willems, & Cambier, 2004). However, as the rate of decrease in mobility and ADL increases, it may lead to adverse consequences in both the physical and psychological domains (Choi & Ko, 2015; Delbaere et al., 2004). Indeed, decreased mobility and ADL eventually result in loss of independence, falling accidents and FOF (Delbaere et al., 2004; Friedman et al., 2002).

Recently, different studies have used dual-task paradigms to investigate the motor/cognitive interference during simple tasks of ADL and its associations with FOF. Previous studies on the dual-task paradigm have showed that mobility tasks are complex tasks that require a constant recruitment of motor, sensory and cognitive resources in relation to different everyday environments (Al-Yahya et al., 2011; Yogev-Seligmann, Hausdorff, & Giladi, 2008). Specifically, previous studies have showed that walking tasks with a secondary attention-demanding task (e.g. cognitive tasks) may be difficult for older adults (Hall, Echt, Wolf, & Rogers, 2011; Hausdorff, Schweiger, Herman, Yogev-Seligmann, & Giladi, 2008; Hollman, Kovash, Kubik, & Linbo, 2007) due to the additional attention and executive function required to perform the different tasks (Al-Yahya et al., 2011; Yogev-Seligmann et al., 2008).

Some studies have underlined that dual-task activities during walking may be particularly challenging for older adults with FOF (Asai, Misu, Doi, Yamada, & Ando, 2014; Donoghue, Cronin, Savva, O'Regan, & Kenny, 2013; Uemura et al., 2012) or those concerned or anxious about balance (Gage, Sleik, Polych, McKenzie, & Brown, 2003). FOF may increase the cognitive resources involved during locomotion. Consequently, older adults with FOF usually have lesser cognitive resources available for the control of gait and balance compared with older adults without FOF (Gage et al., 2003). Indeed, older adults with FOF under dual-task conditions have a slower walking speed and shorter stride length with lesser

variability in these parameters and increased double-support phase than those seen in older adults without FOF (Donoghue et al., 2013). Moreover, during gait initiation under dual-task conditions, older adults with FOF have longer anticipatory postural control than older adults in the control group (Uemura et al., 2012), as well as increased trunk oscillations (Asai et al., 2014). Additionally, the decline in performance under dual-task conditions was found to be more pronounced in physically impaired older adults with FOF and activity restriction (Donoghue et al., 2013).

FOF may be considered a potential health problem comparable to a fall due to the adverse consequences on ADL function, leading to an increased requirement of health care and its related costs (Zijlstra et al., 2007). Moreover, FOF may have important implications in the successful performance of dual-task activities, which have been associated with an increased risk of falling (Muir-Hunter & Wittwer, 2015). Taken together, the above findings suggest that FOF is a complex problem in ageing people, with negative outcomes for both their independence in ADL and management of dual-task activities. However, ADL may be considered as complex tasks, as they require people to perform more activities at the same time. Consequently, the ability to divide attention between two or more simultaneous tasks is an important aspect of functional movement during ADL (Shin & An, 2014). For example, in everyday life, people may walk and talk at the same time while carrying an object or moving from one location to another and simultaneously monitoring the environment. Thus, dual-task ability may be representative of actual daily situations, due to the ecological need in the performance of ADL(Guedes et al., 2014). According to this interpretation, we believe that in these situations, the ability to manage different tasks and, in particular, dual-task ability is essential not to decrease the performance in the ADL. In fact, dual-task activities depend on executive function (Chu, Tang, Peng, & Chen, 2013), which includes the individual's ability to carry out and successfully perform and manage ADL (Yogev-Seligmann et al., 2008).We

hypothesised that dual-task activity may play a role in the relationship between FOF and ADL. However, to our knowledge, no studies have evaluated the relationships among FOF, dual-task performance and ADL limitations. Clarification of the relationships among these variables, which are crucial in ADL, may be useful in the implementation of specific prevention strategies for preventing falls in older adults.

To address this question, the aim of the study was to explore the associations among FOF, dual-task performance of a mobility task and ADL in a sample of older adults. Specifically, the aim of our study was (1) to test the effects of FOF on ADL under dual-task mobility conditions, (2) to evaluate the impact of FOF on mobility performance under dual-task conditions, and (3) to investigate the relationship between FOF and ADL. We assumed that there was a possible mediation role of dual-task performance involved in the relationship between FOF and ADL, and thus, we aimed to find direct and indirect associations between FOF and ADL. Moreover, walking performance during dual-task performance was expected to be slower in all older adults than that during single-task performance, and difficulty in performing dual-task activities was expected to be more in older adults with FOF than in those without a FOF. Finally, we hypothesised that older adults with FOF will have more restriction in ADL.

Method

Participants

Originally, 89 potential participants agreed to participate in the present study. The subjects were recruited in Northern Italy. The inclusion criteria were as follows: age, between 60 and 80 years or older; ability to independently perform ADL; no self-reported neurological or musculoskeletal conditions affecting mobility; having a mini-mental state examination (Folstein, Folstein, & McHugh, 1975) score higher than 24 and being able to understand the instructions and perform simple arithmetic exercises.

Thirteen subjects were excluded because they did not meet the inclusion criteria. Finally, 76 older adults (mean age, *M* = 70.87 years, SD = 5.16 years; 51 females) were enrolled in this study. The Ethical Committee of the University of Torino approved the study procedures, and all participants were informed that participation in the study was voluntary and confidential and did not receive any incentive to participate. All the selected individuals agreed to participate and gave their written informed consent before data collection in accordance with Italian law.

Measures

The participants attended a single data collection session on a single day. Demographic data, including age, gender, the number of years of education, family status and previous employment, were recorded using a self-report questionnaire.

FOF was assessed using the Falls Efficacy Scale (Delbaere et al., 2010; Yardley et al., 2005), which is a self-report questionnaire containing 16 items about the level of the individual's concern regarding falling in different ADL (Delbaere et al., 2010; Yardley et al., 2005). Each item is scored on a four-point scale (1 = 'not at all concerned'–4 = 'very concerned'), with a total score ranging from 16 to 64. Higher scores indicate a high concern of falling. The test–retest reliability and intra-class coefficient of this scale have been estimated to be 0.96 and 0.96, respectively (Yardley et al., 2005).

A 10-m walking test (single task) was used to assess the mobility of the subjects. The subjects were instructed to walk at their self-selected comfortable pace on a 10-m-long walkway without assistance. The performance time was measured as the time taken to walk the middle 6 m (Montero-Odasso et al., 2009), from when the subjects crossed the 2-m mark to when the same crossed the 8-m mark (Steffen, Hacker, & Mollinger, 2002). We decided to use the middle 6 m to give the subjects time to accelerate and decelerate (Asai et al., 2014; Montero-Odasso et al., 2009). For the dual-task test, the participants performed the 10-m

walking test as above and were instructed to simultaneously count backwards in increments of three from a randomised number from 80 to 99 (dual task). No instructions were given regarding which task to prioritise during the dual-task performance. The same evaluator tested all the participants. A stopwatch was used for the data collection, and the time was recorded in seconds, which was taken as the task score.

The Groningen Activity Restriction Scale (GARS) (Kempen, Miedema, Ormel, & Molenaar, 1996) was used to measure the level of disability (physical impairment) in ADL and the instrumental activities of daily living (IADL). The GARS consists of 18 items on daily activities. Specifically, the scale contains 11 items referring to ADL and personal care and 7 items to IADL. Each item was scored on a four-point scale (1 = 'I cannot do it without someone else's help'–4 = 'yes, I can do it fully and independently without any difficulty'), with a total score ranging from 18 to 72. Higher scores indicate a high level of difficulty experienced by a person in taking care of themselves and the performance of household activities. The internal estimated reliability was 0.98 and 0.92 for older men and women, respectively (Kempen et al., 1996).

Statistical analyses

The sociodemographic characteristics and mobility performance were tabulated for the entire sample and presented as the mean (standard deviation) or frequency (percentage).

To quantify the dual-task ability of the subjects, we calculated the dual-task cost (DTC) as the difference between the scores for the single-task and dual-task performances (Hausdorff et al., 2008). A positive value of DTC indicates slower performance during the dual-task activity. Conversely, a negative value indicates a better performance during the dual-task activity. Finally, to test the relationship between FOF and ADL through DTC, we performed a mediation analysis according to the approach described by Baron and Kenny (1986). We first determined the direct effects of the FOF scores on the GARS scores using

regression analyses. Second, if the relationship was significant, we included the mediator in the model and verified the main effect between the independent variable (FOF scores) and the mediator (DTC). Third, we checked the mediating effect of mobility on the relationship between the independent variable (FOF scores) and the outcome (GARS scores). Finally, we checked the mediation model with regard to the dependent variable. We used the Sobel test to verify the mediation model.

According to Delbaere (2010), the sample was divided into low (no-fear), moderate (moderate-fear) and high (fear) groups using the cut-off points on the Falls Efficacy Scale of 16–19, 20–27 and 28–64 points, respectively. A 3 × 2 ANOVA with the group (no fear, moderate fear and fear) as the between-subject factor and walking conditions (single-task test; dual-task test) as the within-subject factor was performed to evaluate the difference of FOF on the walking conditions. The different levels of FOF were determined by significant group × condition interactions.

A one-way ANOVA was conducted to determine whether the ADL ability (GARS score) was different for groups with different levels of FOF (no-fear, moderate-fear and fear groups). A post hoc analysis with a Bonferroni adjustment was computed to identify statistically significant age comparisons. The Statistical Package for Social Sciences (SPSS 20.0 for Windows; IBM Corp., Armonk, NY, USA) was used for all statistical analyses. The statistical significance level was set at $p < 0.05$.

Results

There were 24 participants (31.6%) in the no-fear group, 37 (48.7%) in the moderate-fear group and 15 (19.7%) in the fear group (see Table 1 for more details on the sociodemographic data of all participants and of the different groups).

Table 2 and Figure 1 show the results of the mediation model. The main effect of the predictor (FOF scores) on the outcome (GARS scores) was statistically significant

($\beta = 0.640$, $p < 0.001$), and the mediator had a positive effect on the GARS score ($\beta = .431$, $p < 0.001$). After introducing the mediator (DTC), we noticed a decrease in the relationship between the predictor and the outcome ($\beta = .554$, $p < 0.001$), as well as a significant decrease of the coefficient between the mediator and the outcome ($\beta = .241$, $p = 0.011$). The Sobel test indicated that the mediation model was partially mediated ($z = 1.98$, $p < 0.05$).

Table 3 and Figure 2 shows the mean scores and standard deviations for the no-fear, moderate-fear and fear groups from the single- and dual-task tests. ANOVA analysis showed significant differences for group [F (2, 73) = 8.661, $p < 0.001$, $\eta^2 = 0.192$], condition [F (1, 73) = 90.825, $p < 0.001$, $\eta^2 = 0.554$] and for the interaction group × condition [F (2, 73) = 7.386, $p = 0.001$, $\eta^2 = 0.168$]. Focusing on the main effect of group, the post hoc analysis with Bonferroni adjustment revealed significant differences between the no-fear and fear groups ($p < 0.001$) and between the moderate-fear and fear groups ($p < 0.001$) but not between the no-fear and moderate-fear groups ($p > 0.05$). Considering the significance observed for condition, the walking performance was better in the single-task test than in the dual-task test in the no-fear group [from 4.50, 95% CI (4.09–4.91) to 5.57, 95% CI (4.82–6.32) seconds; F (1, 23) = 37.566, $p < 0.001$, partial $\eta^2 = 0.620$], in the moderate group [from 4.70, 95% CI (4.39–5.03) to 5.74, 95% CI (5.14–6.35) seconds; F (1, 36) = 43.055, $p < 0.001$, partial $\eta^2 = 0.545$] and in the fear group [from 5.47, 95% CI (4.96–5.98) to 7.98, 95% CI (7.04–8.94) seconds; F (1,14) = 17.309, $p = 0.001$, partial $\eta^2 = 0.553$]. According to the significant interaction of group × condition, the effect of the dual-task performance was not uniform among the groups. Indeed, we noticed a larger increase in dual-task performance in the fear group than that in the moderate-fear and no-fear groups.

ANOVA analysis of GARS score yielded a statistical significance for the different levels of FOF [F (2, 73) = 13.734, $p < 0.001$]. The GARS scores increased from the no-fear group (18.95 ± 1.51), to the moderate-fear group (20.38 ± 2.44), to the fear group (24.0 ±

5.12). Bonferroni post hoc analysis revealed that the increase from the no-fear to fear groups [5.042, 95% CI (2.65–7.42)] was statistically significant ($p < 0.001$), as well as the increase from the moderate-fear to fear groups [3.61, 95% CI (1.40–5.83), $p < 0.001$] but not the increase from the no-fear to moderate-fear groups [1.42, 95% CI (–0.47 to 3.32), $p > 0.05$].

Discussion

The aim of the study was to explore the cross-sectional associations among FOF, dual-task performance in a mobility task and ADL in a sample of older adults. To address this question, we evaluated the effect of FOF on dual-task performance during a walking task and ADL ability, as well as the possible mediation role of DTC in the relationship between FOF and ADL ability.

Regarding the first aim of the study, we tested the mediation model on the associations among FOF, ADL and DTC. Specifically, we investigated the effect of FOF on ADL through DTC. We assumed that we would be able to observe the possible mediation role of DTC in the relationship between FOF and ADL and thus find direct and indirect associations between FOF and ADL. Our results showed that DTC plays a mediation role in the relationship between FOF and ADL. In fact, we found that FOF had both direct and indirect effects on ADL through the mediation of DTC. Moreover, our data showed that older adults with a low FOF had a better DTC, with a positive effect on the ADL ability, which is a significant index of disability and frailty in ageing people (Blind for review; Blind for review). Our model could lead to a practical consequence to help prevent the drop in ADL typically observed in old age (Chodzko-Zajko et al., 2009). Physical intervention programmes may decrease FOF (Blind for review; Huang, Chung, Chen, Chin, & Wang, 2016; Sjosten, Vaapio, & Kivela, 2008; Zijlstra et al., 2005) and decrease DTC (Agmon, Belza, Nguyen, Logsdon, & Kelly, 2014); thus, we hypothesised that interventions focused on decreasing FOF (e.g. psychological or physical interventions) and DTC may have positive

effects by maintaining or improving ADL functionality, which is linked with successful ageing.

With regard to our second aim, consistent with our hypothesis, we observed a different level of performance between the single- and dual-task tests among all the groups. Specifically, we observed that on average, the walking performance was all lower in the FOF groups when simultaneously counting backwards (dual-task test) compared with that when walking alone (single-task test). The above findings are in accordance with the results from previous studies and underline that an additional cognitive task may decrease the walking ability in older adults (Blind for review ; Hall et al., 2011; Hollman et al., 2007), as well as the involvement of cognitive function during walking (Al-Yahya et al., 2011). One interpretation for higher reduction of walking performance during the dual-task performance may reflect the more cautious walking pattern adopted by older adults during dual-task performance (Donoghue et al., 2013). Interestingly, the decrease in walking performance under dual-task conditions was more pronounced in the fear group compared with that in the no-fear and moderate-fear groups. In fact, our results showed a decrease in walking performance as FOF increased. In contrast, the data supported the idea of a negative association between FOF and dual-task performance (Asai et al., 2014; Donoghue et al., 2013) and showed a decrease in walking performance under dual-task conditions in older adults with FOF. The decrease in dual-task performance observed in older adults with FOF may be related to the reduction of the attentional resources available to successfully perform two or more different tasks (Gage et al., 2003). The results observed in the fear group, which was the group with a high concern of falling, may indicate difficulty managing the two different required tasks, one being the successful performance of the walking test and the other being the cognitive task. Additionally, our findings expand on the prior literature due to the different scale used to evaluate the FOF groups. Finally, our data were in agreement with

the existing literature (Choi & Ko, 2015; Cumming et al., 2000; Lawson & Katherine, 2014; Murphy et al., 2002) and showed that the fear group has a greater impairment in ADL compared with the no-fear and moderate-fear groups. The direct correlation between FOF and restriction in ADL may be related to a possible strategy by older adults with FOF to avoid possible risk factors. However, during the ageing process, FOF may lead to functional decline and, consequently, to a restriction in ADL (Friedman et al., 2002; Mendes da Costa et al., 2012; Yogev-Seligmann et al., 2008), which has important implications for successful ageing and negative consequences on the quality of life. Previous studies (Friedman et al., 2002; Mendes da Costa et al., 2012; Murphy et al., 2002) have reported that restriction in ADL affects about 46%–56% older adults with FOF, underlining the necessity of intervention programmes focused on decreasing FOF and increasing ADL ability.

Despite these findings, our study presents some limitations. The sample size of the study did not allow us to extend our conclusion to the general older population. Indeed, the older adults involved in the present study were relatively young (age range: 60–80 years) and did not have cognitive or physical impairments. Additionally, our secondary demanding task included only the performance of a specific cognitive task (i.e. counting backwards in increments of three). Future studies will be needed to confirm our model using a different secondary task (e.g. manual task or decision-making task). Finally, we only focused on the mobility performance of the subjects under dual-task conditions and not on the cognitive performance. Future studies will need to investigate both mobility and cognitive performance to better describe the physical and cognitive impairments during dual-task performance among older adults with FOF.

In summary, our study highlighted the role of dual-task ability in the relationship between FOF and ADL ability during the ageing process. In agreement with the results from previous studies, we found lower performance under dual-task conditions and more ADL

limitation in older adults with FOF compared with those with no fear or moderate fear. During the ageing process, FOF has a complex role in everyday activities and has important implications in the successful performance of dual-task activities and ADL. Identification of the relationships among FOF, dual-task activity and ADL may provide information that could be used to improve successful ageing. These results could be used to develop specific intervention programmes for successful ageing.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Word count: 3749

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Table 1. Sociodemographic characteristics of the study participants.

	All (n = 76)	Fear of falling group		
		No-fear (n = 24)	Moderate-fear (n = 37)	Fear (n = 15)
Age, years	70.87 (5.16)	68.7 (0.65)	71.88 (5.11)	71.82 (5.29)
Gender				
Male	25 (32.9)	13 (54.2)	9 (24.3)	3 (20.0)
Female	51 (67.1)	11 (45.8)	28 (75.7)	12 (80.0)
Years of education	8.51 (3.57)	10.87 (3.47)	8.16 (3.67)	6.93 (2.63)
History of falling				
Yes	44 (62.0)	15 (68.2)	21 (61.8)	8 (53.3)
No	27 (38.0)	7 (31.8)	13 (38.2)	7 (46.7)
Family status				
Married/living as married	55 (72.4)	22 (91.7)	26 (70.3)	7 (46.7)
Single/separated/divorced	1 (1.3)	0 (0.0)	1 (2.7)	0 (0.0)
Widow	20 (26.3)	2 (8.3)	10 (27.0)	7 (53.3)

Note: Data are presented as the mean (SD) for continuous variables (e.g. age and years of education) and frequency (%) for categorical variables.

Table 2. Regression coefficients between GARS score (outcome), FOF score (predictor) and DTC (mediator).

Predictors	Outcome variables		
	GARS score		
	B	SE B	ß
Step 1			
FOF score	0.347	0.049	0.640**
Step 2			
FOF score	0.304	0.050	0.559**
DTC	0.568	0.219	0.238*

Notes. Mediation effect: $R^2 = 0.459$, Adj $R^2 = 0.444$, F (2, 73) = 31.005, $p < 0.001$. FOF score indicates the score on the Falls Efficacy Scale; DTC indicates the dual-task cost; GARS score indicates the score on the Groningen Activity Restriction Scale. *$p < 0.05$ and **$p < 0.001$.

Table 3. Performance results from the single- and dual-task tests and ANOVA outcomes.

	Fear of falling groups			Group	Condition	Group × Condition
	No fear	Moderate fear	Fear			
Single task (s)	4.50 (0.66)	4.83 (0.86)	5.47 (1.57)	$F = 3.918$	$F = 90.825$	$F = 4.428$
				$p = 0.024$	$p < 0.001$	$p = 0.015$
Dual task (s)	5.59 (1.16)	5.74 (1.49)	7.98 (3.12)			
				Partial $\eta^2 = 0.097$	Partial $\eta^2 = 0.554$	Partial $\eta^2 = 0.108$

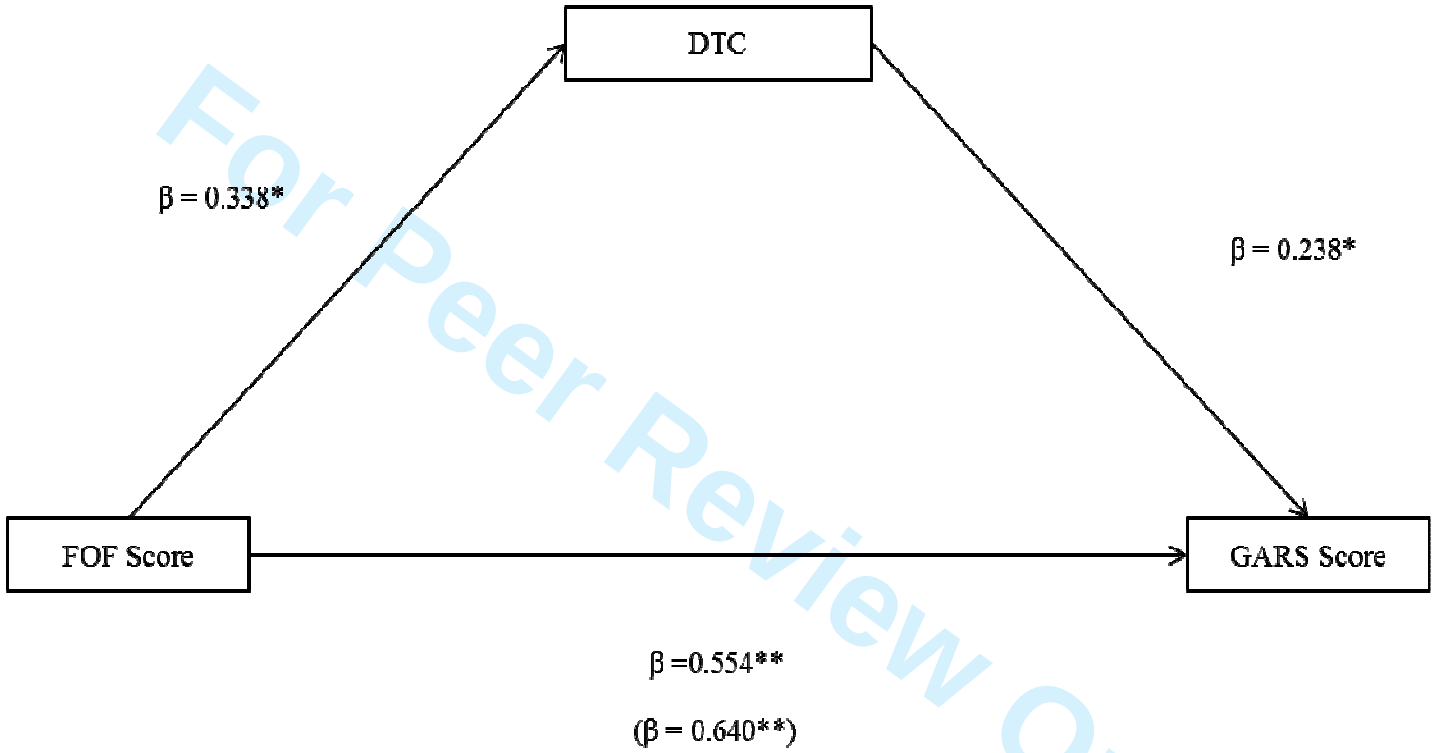
Notes: Data are presented as the mean (*M*) and standard deviation (SD); Single-task indicates the 10-m walking test; dual-task indicates the 10-m walking test while counting backwards in increments of three.

Figure captions

Figure 1 Mediation model among GARS score (outcome), FOF score (predictor) and DTC (mediator). *Notes:* Data are collapsed across the participants (n = 76). FOF score indicates the score on the Falls Efficacy Scale; DTC indicates the dual-task cost; GARS score indicates the score on the Groningen Activity Restriction Scale. Sobel test: $z = 1.98$; *$p < 0.05$ and **$p < 0.01$.

Figure 2 Results of the 10-m walking test for both the single- and dual-task performances in the no-fear (black solid), moderate-fear (dashed solid) and fear groups (white solid).

Running head: FEAR OF FALLING ADL AND MEDIATION ROLE OF DUAL-TASK 1



Running head: FEAR OF FALLING ADL AND MEDIATION ROLE OF DUAL-TASK 1