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To cite this article: Paolo R. Brustio, Daniele Magistro, Massimiliano Zecca, Monica E. Liubicich & Emanuela Rabaglietti (2018) Fear of falling and activities of daily living function: mediation effect of dual-task ability, *Aging & Mental Health*, 22:6, 856-861, DOI: [10.1080/13607863.2017.1318257](https://doi.org/10.1080/13607863.2017.1318257)

To link to this article: <https://doi.org/10.1080/13607863.2017.1318257>



Published online: 09 May 2017.



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## Fear of falling and activities of daily living function: mediation effect of dual-task ability

Paolo R. Brustio<sup>a</sup>, Daniele Magistro<sup>a,b,c</sup>, Massimiliano Zecca<sup>c,d</sup>, Monica E. Liubicich<sup>e</sup> and Emanuela Rabaglietti<sup>a,e</sup>

<sup>a</sup>Department of Psychology, University of Torino, Torino, Italy; <sup>b</sup>School of Sport, Exercise, and Health Sciences, Loughborough University, Loughborough, UK; <sup>c</sup>National Centre for Sport and Exercise Medicine (NCSEM), Loughborough, UK; <sup>d</sup>Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, UK; <sup>e</sup>SUISM, Centro Servizi, University of Torino, Torino, Italy

### 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  $M = 70.87 \pm 5.16$  years) participated in the study. Data on FOF (using the Falls Self-Efficacy Scale-International), walking ability during both single- and dual-task performances and ADL were collected.

**Results:** Mediation analysis demonstrated the mediation effect of dual-task ability ( $\beta = 0.238, p = 0.011$ ) between FOF and ADL level ( $\beta = 0.559, p < 0.001$ ). 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.

### ARTICLE HISTORY

Received 12 January 2016  
Accepted 6 April 2017

### KEYWORDS

Dual task; fear of falling; ADL; ageing

### Introduction

Changes in physical domains, such as reduction in aerobic endurance, lower body muscular strength and decreased mobility (Brustio, Magistro, & Liubicich, 2015; Chodsko-Zajko et al., 2009; Magistro, Candela, Brustio, Liubicich, & Rabaglietti, 2014), and cognitive domains, such as executive function, visual-spatial, verbal and working memory (Park, O'Connell, & Thomson, 2003), observed in advancing ageing are among the major factors that increase the risk of falls (Montero-Odasso, Muir, & Speechley, 2012; Rubenstein, 2006). Approximately, one-third of individuals aged 65 years or more experience falls at least once a year (Montero-Odasso et al., 2012) with adverse consequences in both physical and psychological domains. This could lead to a decrease in independence of activities of daily living (ADL), which often require multi-tasking, and in quality of life (Gillespie et al., 2009; Lord, Sherrington, Menz, & Close, 2007).

Existing literature has referred to fear of falling (FOF) as a person's loss of confidence in his/her balance capabilities, or as a general concept of low confidence of avoiding falls and being afraid of falling (Legters, 2002). According to the different measures and constructs used to assess it, FOF is an important psychological factor that is highly prevalent in independent older adults, too (Scheffer, Schuurmans, van Dijk, van der Hooft, & de Rooij, 2008).

The reviews of Denkinger, Lukas, Nikolaus, and Hauer (2015) and Scheffer et al. (2008) have shown that FOF is associated with an experience of falling; FOF is also commonly found among older adults without a history of falls. Moreover, these reviews reported some risk factors from cross-sectional and longitudinal studies that have been associated with FOF, such as female gender, older age (Kempen, van Haastregt, McKee, Delbaere, & Zijlstra, 2009; Scheffer et al., 2008; Zijlstra,

van Haastregt, van Eijk, & Kempen, 2005), physiologic outcomes, including mobility decline (Lach, Ball, & Birge, 2012; Patil, Uusi-Rasi, Kannus, Karinkanta, & Sievanen, 2014) and restriction of ADL (Murphy, Williams, & Gill, 2002), increased requirement for health care (Zijlstra, van Haastregt, van Eijk, van Rossum, Stalenhoef, & Kempen, 2007), increased risk of falling (Friedman, Munoz, West, Rubin, & Fried, 2002) and institutionalization (Cumming, Salkeld, Thomas, & Szonyi, 2000; Hsu, Alfermann, Lu, & Lin, 2013). Therefore, in some older adults with impaired mobility, a FOF may cause specific decrease in mobility and ADL (Viljanen, Kulmala, Rantakokko, Koskenvuo, Kaprio, & Rantanen, 2012). Indeed, one of the major consequences of FOF is the restriction and avoidance of activities (Cumming et al., 2000; Delbaere, Crombez, Vanderstraeten, Willems, & Cambier, 2004). Many older adults with FOF restrict the range of their activities in an attempt to avoid fall-related morbidity and possible social embarrassment. While in the short term the reduction or avoidance of activities may protect against falls, in the long term activity restriction (leading to decrease in mobility and ADL) may contribute to the reduction of physical and psychological health of older adults (Choi & Ko, 2015; Delbaere et al., 2004) and eventually result in loss of independence, falling accidents and increased 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, Dawes, Smith, Dennis, Howells, & Cockburn, 2011; Yogeve-Seligmann, Hausdorff, &

Giladi, 2008). Specifically, these 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, Yamada, Nagai, Tanaka, Mori, & Ichihashi, 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).

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 for health care and its related costs (Zijlstra et al., 2007). Moreover, FOF may have important implications for 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 their management of dual-task activities. ADLs too may be considered as complex tasks, as they require people to perform more activities at the same time. During these multi-task activities, executive functions (referring to the cognitive ability involved in the planning and execution of goal-directed behaviours, attention, abstract reasoning and judgment (Lezak, 2004)) are highly involved. Indeed, in older adults the decline in executive functions has been associated with ADL difficulties (Johnson, Lui, & Yaffe, 2007) and linked with higher FOF (Uemura et al., 2012). 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, Dias, Pereira, Silva, Lustosa, & Dias, 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 between FOF, dual-task performance and ADL limitations. To address this question, this study explored the associations between

FOF, dual-task performance of a mobility task and ADL. Our hypothesis is that older adults with a high level of concern of falling have poorer mobility performance and are more likely to report ADL difficulties than those with lower levels of concern. Moreover, a poor performance in dual-task condition mediates this effect.

## Method

### Participants

Originally, 89 older adults agreed to participate in the present study. The participants were recruited in Northern Italy. The inclusion criteria were as follows: age between 60 and 80 years; ability to walk independently; no self-reported neurological (e.g. Alzheimer's disease, Parkinson's disease) or musculoskeletal (e.g. orthopaedic) conditions affecting mobility or balance; having a mini-mental state examination score (Folstein, Folstein, & McHugh, 1975) 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. Specifically, five participants did not meet the age cut-off, two used a walking aid, three reported neurological/musculoskeletal diseases, and three had a mini-mental state examination score lower than 24.

Seventy-six older adults (mean age  $M = 70.87$  years,  $SD \pm 5.16$  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 gave their written informed consent before data collection in accordance with Italian law.

### Measures

The participants attended a single data collection session. Sociodemographic data, including age, gender, number of years of education, family status and history of falls, were recorded using a self-report questionnaire. Family status was categorised dividing the sample as living with another person (e.g. married/living as married) or alone (single/separated/divorced). Participants who fell in the previous 12 months were categorised as having a history of falling. Table 1 shows the details of all sociodemographic data of all participants.

FOF was assessed using the Falls Efficacy Scale (FES-International; Delbaere, Close, Mikolaizak, Sachdev, Brodaty, & Lord, 2010; Yardley, Beyer, Hauer, Kempen, Piot-Ziegler, & Todd, 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 Likert scale (1 = 'not at all concerned'–4 = 'very concerned'), with a total score ranging from 16 to 64. Higher scores indicate a higher 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). Using the cut-off points of the FES-International, the sample was divided into three groups: 'no-concern' (16–19), 'moderate-concern' (20–27) and 'concern' (28–64) (Delbaere et al., 2010).

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

**Table 1.** Sociodemographic characteristics of the study participants.

	All ( <i>n</i> = 76)	Fear of falling group		
		No-concern ( <i>n</i> = 24)	Moderate-concern ( <i>n</i> = 37)	Concern ( <i>n</i> = 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)
Single task, s	4.79 (1.03)	4.50 (0.66)	4.83 (0.86)	5.47 (1.57)
Dual task, s	6.13 (2.04)	5.59 (1.16)	5.74 (1.49)	7.98 (3.12)
GARS score	20.64 (3.41)	18.95 (1.51)	20.38 (2.44)	24.0 (5.12)

Note: Data are presented as the mean (SD) for continuous variables (e.g. age and years of education) and frequency (%) for categorical variables. Single-task indicates the 10-m walking test; dual-task indicates the 10-m walking test while counting backwards in increments of three; GARS score indicates the score on the Groningen Activity Restriction Scale.

walkway without assistance. The performance time was measured as the time taken to walk the middle 6 m (Montero-Odasso, Bergman, Phillips, Wong, Sourial, & Chertkow, 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 6m 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 with the time 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 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 Likert 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. Lower scores indicate a higher 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).

Using age, gender, education years and history of falls as covariates, a  $3 \times 2$  ANCOVA with the group (no-concern; moderate concern; concern) 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  $\times$  condition interactions.

Using age, gender, education years and history of fall as covariates, an ANCOVA was conducted to determine whether the ADL ability (GARS score) was different for groups with different levels of FOF (no-fear; moderate-fear; fear). A post hoc analysis with a Bonferroni adjustment was computed to identify statistically significant age comparisons.

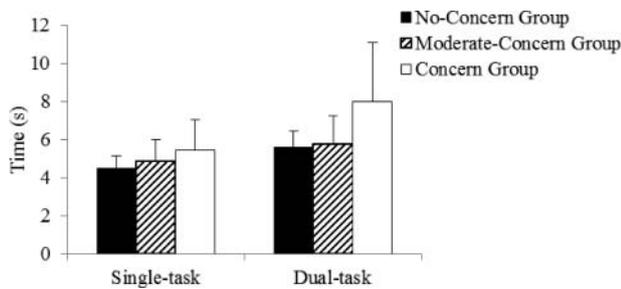
To quantify the dual-task ability of the subjects, the dual-task cost (DTC) was calculated as the difference between the scores for the single-task and dual-task performances (Hausdorff et al., 2008). A positive value of DTC indicates better performance during the dual-task activity. Conversely, a negative value indicates a slower performance during the dual-task activity. To test the relationship between FOF and ADL through DTC, a mediation analysis was performed according to the approach described by Baron and Kenny (1986). First, the direct effects of the FOF scores on the GARS scores were determined using regression analyses. Second, if the relationship was significant, the mediator was included in the model and the main effect between the independent variable (FOF scores) and the mediator (DTC) was verified. Third, the mediating effect of mobility on the relationship between the independent variable (FOF scores) and the outcome (GARS scores) was checked. Finally, the Sobel test was used to verify the mediation model.

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-concern group, 37 (48.7%) in the moderate-concern group and 15 (19.7%) in the concern group (see Table 1 for more details on the sociodemographic data of all participants and of the different groups).

Figure 1 shows the mean scores and standard deviations for the no-concern, moderate-concern, and concern groups, from the single- and dual-task tests. The ANCOVA analysis showed significant differences for the group [ $F(2, 67) = 7.358$ ,  $p < 0.01$ ,  $\eta^2 = 0.188$ ], condition [ $F(1, 63) = 4.061$ ,  $p < 0.05$ ,  $\eta^2 = 0.057$ ] and for the interaction group  $\times$  condition [ $F(2, 73) = 7.358$ ,  $p < 0.01$ ,  $\eta^2 = 0.180$ ]. Focusing on the main effect of the group, the post hoc analysis with Bonferroni adjustment



**Figure 1.** Results of the 10-m walking test for both the single- and dual-task performances in the no-concern (black solid), moderate-concern (dashed solid) and concern groups (white solid).

revealed significant differences between the no-concern and concern groups ( $p < 0.001$ ) and between the moderate-concern and concern groups ( $p < 0.001$ ), but not between the no-concern and moderate-concern 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 concern group [from 5.47, 95% CI (4.61–6.32) to 7.98, 95% CI (6.38–9.59) seconds;  $F(1,10) = 7.399$ ,  $p < 0.05$ , partial  $\eta^2 = 0.425$ ]. In contrast, walking performance was not statistically significantly different between the single-task test and the dual-task test both in no-concern [from 4.47, 95% CI (4.19–4.76) to 5.52, 95% CI (5.00–6.05) seconds;  $F(1,18) = 1.730$ ,  $p > 0.05$ , partial  $\eta^2 = 0.088$ ] and moderate-concern group [from 4.71, 95% CI (4.43–4.99) to 5.78, 95% CI (5.31–6.25) seconds;  $F(1,31) = 1.499$ ,  $p > 0.05$ , partial  $\eta^2 = 0.046$ ]. According to the significant interaction of group  $\times$  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 concern group than that in the moderate-concern and no-concern groups.

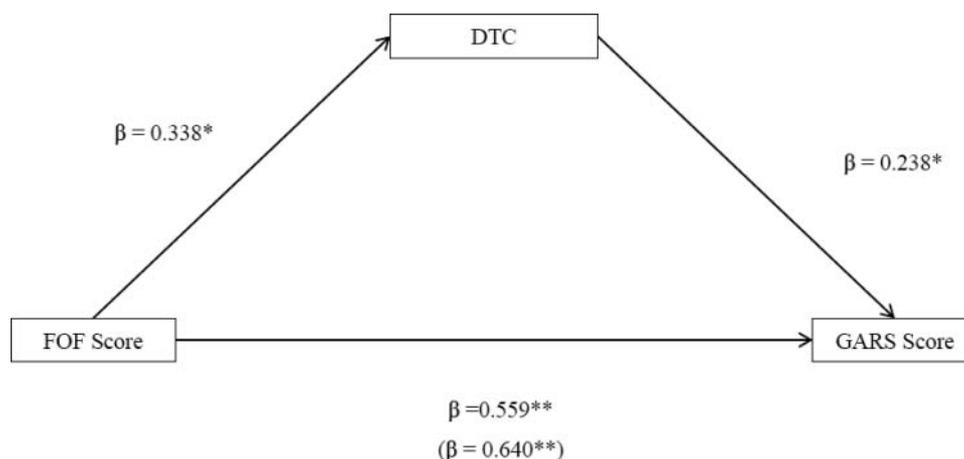
ANCOVA analysis of GARS score yielded a statistical significance for the different levels of FOF [ $F(2, 67) = 10.570$ ,  $p < 0.001$ ]. The GARS scores increased from the no-concern group ( $18.95 \pm 1.51$ ), to the moderate-concern group ( $20.38 \pm 2.44$ ), to the concern group ( $24.0 \pm 5.12$ ). Bonferroni post hoc analysis revealed that the increase from the no-concern to concern groups [4.6, 95% CI (2.02–7.17)] was statistically significant ( $p < 0.001$ ), as well as the increase from the moderate-concern to concern groups [3.51, 95% CI (1.27–5.75),  $p < 0.001$ ] but not the increase from the no-concern to moderate-concern groups [1.08, 95% CI (–0.99 to 3.31),  $p > 0.05$ ].

Figure 2 shows 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 ( $\beta = 0.427$ ,  $p < 0.001$ ). After introducing the mediator (DTC), we noticed a decrease in the relationship between the predictor and the outcome ( $\beta = 0.559$ ,  $p < 0.001$ ), as well as a significant decrease of the coefficient between the mediator and the outcome ( $\beta = 0.238$ ,  $p = 0.011$ ). The Sobel test indicated that the mediation model was partially mediated ( $z = 1.98$ ,  $p < 0.05$ ).

## Discussion

The aim of the study was to explore the cross-sectional associations among FOF, DT performance and ADL in older adults.

We observed a different level of performance between the single- and dual-task tests among the groups. Specifically, we observed that, on average, the walking performance was lower when simultaneously counting backwards (dual-task test) compared with that when walking only (single-task test). The above findings underline that an additional cognitive task may decrease walking ability in older adults (Brustio, Magistro, Rabaglietti, & Liubicich, 2015; Hall et al., 2011; Hollman et al., 2007) due to the involvement of cognitive function during walking (Al-Yahya et al., 2011). Interestingly, the decrease in walking performance under dual-task conditions was more pronounced in the concern group compared with that in the no-concern and moderate-concern groups. These results supported the idea of a negative association between FOF and dual-task performance (Asai et al., 2014; Donoghue et al., 2013). The decrease in dual-task performance, observed in older adults with concern about falling, may indicate a difficulty managing two different required tasks, one being the performance of the walking test and the other being the cognitive task. It is possible that older people with concern of falling adopted a more cautious walking pattern to avoid fall (Donoghue et al., 2013) due to the reduction of the attentional resources available to successfully perform two or more different tasks (Gage et al., 2003). Additionally, to the best of our knowledge our findings expand current literature providing clear evidence of the role of FOF and dual-task performance with regards to the ADL. A strength of our study is that FOF was not assessed by a simple question about FOF, as in previous studies (Asai et al., 2014; Donoghue et al., 2013;



**Figure 2.** Mediation model among GARS score (outcome), FOF score (predictor) and DTC (mediator).

Uemura et al., 2012) but by the FES-I that is able to discriminate between different levels of 'concerns' about falling.

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 concern group has a greater impairment in ADL compared with the other groups. This decline in ADLs ability may be related to a possible strategy by older adults with FOF to avoid certain activities adopting a more inactive lifestyle. At the same time, as people age, FOF may lead to functional decline and, consequently, to a restriction in ADL (Friedman et al., 2002; Mendes da Costa, Pepersack, Godin, Bantuelle, Petit, & Leveque, 2012; Yogev-Seligmann et al., 2008), which has important implications for successful ageing and negative consequences for quality of life.

Finally, the mediation model on the associations among FOF, ADL and DTC 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. On the other hand, our data showed that older adults with a low concern about falling also had a lower DTC, with less difficulty with ADL's, a significant index of disability and frailty in ageing people (Candela, Zucchetti, & Magistro, 2013; Candela, Zucchetti, Ortega, Rabaglietti, & Magistro, 2015). Our model could help preventing the drop in ADL typically observed in older age. Indeed, 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. Physical intervention programmes may decrease the FOF (Brustio, Magistro, Ivaldi, Caglio, Rabaglietti, & Liubicich, 2015; Huang, Chung, Chen, Chin, & Wang, 2016; Sjosten, Vaapio, & Kivela, 2008; Zijlstra et al., 2005) and decrease the DTC (Agmon, Belza, Nguyen, Logsdon, & Kelly, 2014); thus, we hypothesised, based on our results, that interventions focused on decreasing FOF (e.g. physical or cognitive interventions) and DTC may have positive effects by maintaining or improving ADL functionality, which is linked with successful ageing.

Despite of these findings, our study presents some limitations. The sample size of the study did not allow us to extend our conclusions 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 decrements of three). Future studies are needed to confirm the validity of our model in a longitudinal way and using a different secondary task (e.g. manual tasks or decision-making tasks), common in everyday life, to better understand the role of dual-task conditions in the relationship between FOF and ADL ability. Finally, we only focused on the mobility performance of the subjects under dual-task conditions and not on the cognitive performance. Future studies 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 a lower performance under dual-task

conditions and more ADL limitations in older adults with FOF compared with those with no concern or moderate concern. 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 the possibility of a successful, better ageing. A clarification of the relationships among these variables may be useful in the implementation of specific prevention strategies for preventing FOF and the decline in ADL ability in older adults.

## Acknowledgment

The authors would like to express their gratitude to all the participants of the study.

## Disclosure statement

The authors declare that there are no conflicts of interest.

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