ISSN: 2476-5279; International Journal of Musculoskeletal Pain Prevention. 2023;8(3): 904-914.

Tarbiat Modares University

Dual Task Gait Parameters in Older Adults With and Without Fear of Falling: A Systematic Review and Meta-Analysis

ARTICLEINFO

Article Type
Systematic review

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How to cite this article

Vahidi F,. Zandi Sh., Karimizadeh Ardakani M. Dual Task Gait Parameters in Older Adults With and Without Fear of Falling: A Systematic Review and Meta-Analysis. IJMPP. 2023; 8(3): 904-914.

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Article History
Received: May 27,2023
Accepted: Jul 22,2023
ePublished: Oct 20,2023

ABSTRACT

Aims: The aim of this systematic review was to examine the correlation between fear of falling and dual task gait parameters in older adults.

Method and Materials: The present study is a systematic review and meta-analysis. An English search of PubMed, Scopus, and Embase databases was conducted in January 2022, using the four main concepts, namely "Elderly, Fear of falling, Gait, and Dual task". Modified Downs and Black checklist was utilized to assess the quality of the included studies.

Findings: Based on the inclusion and exclusion criteria, 13 articles out of 2368 were included in the review. All the articles were of acceptable quality. On account of the quorum of meta-analysis, it could only be conducted in the velocity parameter (4 studies were included). An analysis of the correlation between the fear of falling and dual task gait velocity based on 95% confidence intervals found a significant difference between dual task gait velocity with and without the fear of falling (P=0.06, I^2=50%, 95% CI: 0.31-0.51).

Conclusion: This study demonstrated that the fear of falling deteriorates some of the dual task gait characteristics in healthy and cognitively intact older adults, and that this reduction can be varied by the difficulty of the dual task (cognitive or manual).

Keywords: Fear of Falling, Falling, Gait, Older Adults, Dual Task

Introduction

Due to enhanced quality of life and hygiene, people's life expectancy is increasing. It has been argued that between 2015 and 2050, the percentage of the population over the age of 60 in the world will have been doubled [1]. It has been estimated that one-third of the people living over the age of 65, experience falls at least once a year, 20% of which leads to severe injuries [2, 3]. One of the main health problems of the elderly is falling, which can cause severe injuries and an increased risk of hospitalization [4]. Worsened health conditions as a result of falls can lead to chronic pain, physical disability, injury, or death [5]. Injury is the fifth leading cause of death in the elderly, and two-third of unexpected deaths are due to falls [6].

Gait performance, such as a person's ability to resist external perturbations or walking speed, can provide insight into a senior's physical capacity and risk of falling during daily life activities [7, 8]. Gait performance relies on cognitive function and sensorimotor. According to the situation, the locomotor system needs to coordinate movements and integrate sensory information in daily situations [9]. Furthermore, the ability to perform simultaneous mental and/or motor challenging activities while walking is necessary to perform daily tasks successfully [10, 11]. Concurrent tasks or dual tasks activities are affected by age, and therefore, cognitive and mobility tasks are negatively influenced [12]. Moreover, the addition of a dual task leads to deterioration in gait outcomes, such as reduced walking speed and cadence and a higher stride time [13, 14] in older adults.

Another risk factor associated

with falling in older adults is the fear of falling [15]. The Fear of Falling (FoF) is defined as low-perceived self-confidence at avoiding falls during relatively nonhazardous activities [16] and is common in community-dwelling older adults with a prevalence of 20.8 to 80% [17-19]. Several studies have compared gait outcomes in the presence and absence of FoF in older adults. They observed that older adults who feared falling had slower gait speed [20, 21], shorter stride length [22], prolonged double support time [20], and longer step width [23]. In other words, the fear of falling reduces gait performance in old people [24]. A systematic review and meta-analysis (2015) showed that the fear of falling is associated with a significant increase in gait variability in spite of its small magnitude [25]. Another systematic review and meta-analysis (2019) revealed that cognitive-motor interference is not significantly different in older adults with and without a fear of falling or fallers and non-fallers [26].

Individual's strategies used while performing a dual task are explained by the Task Prioritization Model [27]. Inhibiting or ignoring irrelevant information from the environment is difficult for older adults with higher levels of FoF in the balance control process [28]. Studies have suggested that fear of falling hinders the automaticity of walking, along with an attendant need for increased cognitive involvement. Due to diminished resources for attentional and executive functions as people age, the effect might be further aggravated when performing a secondary or dual task [29, 30].

Dual tasks and the fear of falling are both important risk factors for predicting falls. Many studies have investigated the correlation between the fear of falling and dual task outcomes in the elderly, examining mixed parameters. Moreover, there is no comprehensive reference for gathering these data together. The importance of this correlation and the growth of research in this field require a review of the literature. The current systematic review was conducted to evaluate this correlation.

Method and Materials

Search strategy and selection criteria

A systematic search was conducted in electronic databases including PubMed, Scopus, and Embase up to January 2022, without date, language, or study design restriction. The search included four main concepts, namely elderly, fear of falling, gait, and dual task, and their relevant keywords. The methodology of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was followed in this review [31]. The results were then extracted to EndNote X8.

Two reviewers screened the titles and abstracts of the found articles for eligibility identification. The primary criteria for screening the title and abstract were as follows: 1) articles written in Persian and English; 2) human participants with the mean age of ≥ 65; 3) healthy older adults without any specific disease affecting their gait and their cognitive condition; 4) original papers including Radomised Cotrol Trial (RCT's), cross-sectional studies, longitudinal studies, cohort studies, and observational studies; 5) FoF and dual task gait as outcomes. The studies that gathered data during functional walking measures, stair ascending/descending, obstacle negotiation, gait initiation/termination, perturbations walking, loaded walking, turning, stepping task, and running were excluded. Subsequently, the two reviewers independently assessed the full-text of the identified potentially eligible articles to determine the final included works (Figure 1). Any disagreement on the inclusion was resolved by discussion and through arbitration by a third reviewer.

Data extraction

One reviewer extracted information concerning the authors, date of publication, setting, study design, sample size and demographic information, assessment of the fear of falling, dual task, and gait parameters from the full review and imported it to an excel sheet. A second reviewer checked the extraction accuracy. We emailed for further information, and some of the authors responded, but none of them could be used in the review. The main data extracted from included articles are shown in Table 1 and 2.

Quality assessment

The methodological quality of the included studies was assessed using a customized 15-point checklist based on that developed by Downs and Black (1998) [32], which had been used previously in reviews of studies of this designs [13, 14, 33]. This checklist comprises four main criteria, including reporting, external validity, internal validity, and internal validity (confounding).

Data synthesis and analysis

Studies reporting means and standard deviation for at least one dual task gait parameter were included in the meta-analysis if possible. The differences between FoF and non-FoF dual task performance were represented as the raw Mean Difference (MD) with a 95% Confidence Interval (CI). Random-effect model analysis was performed with review manager software (version 5.4) due to the significant

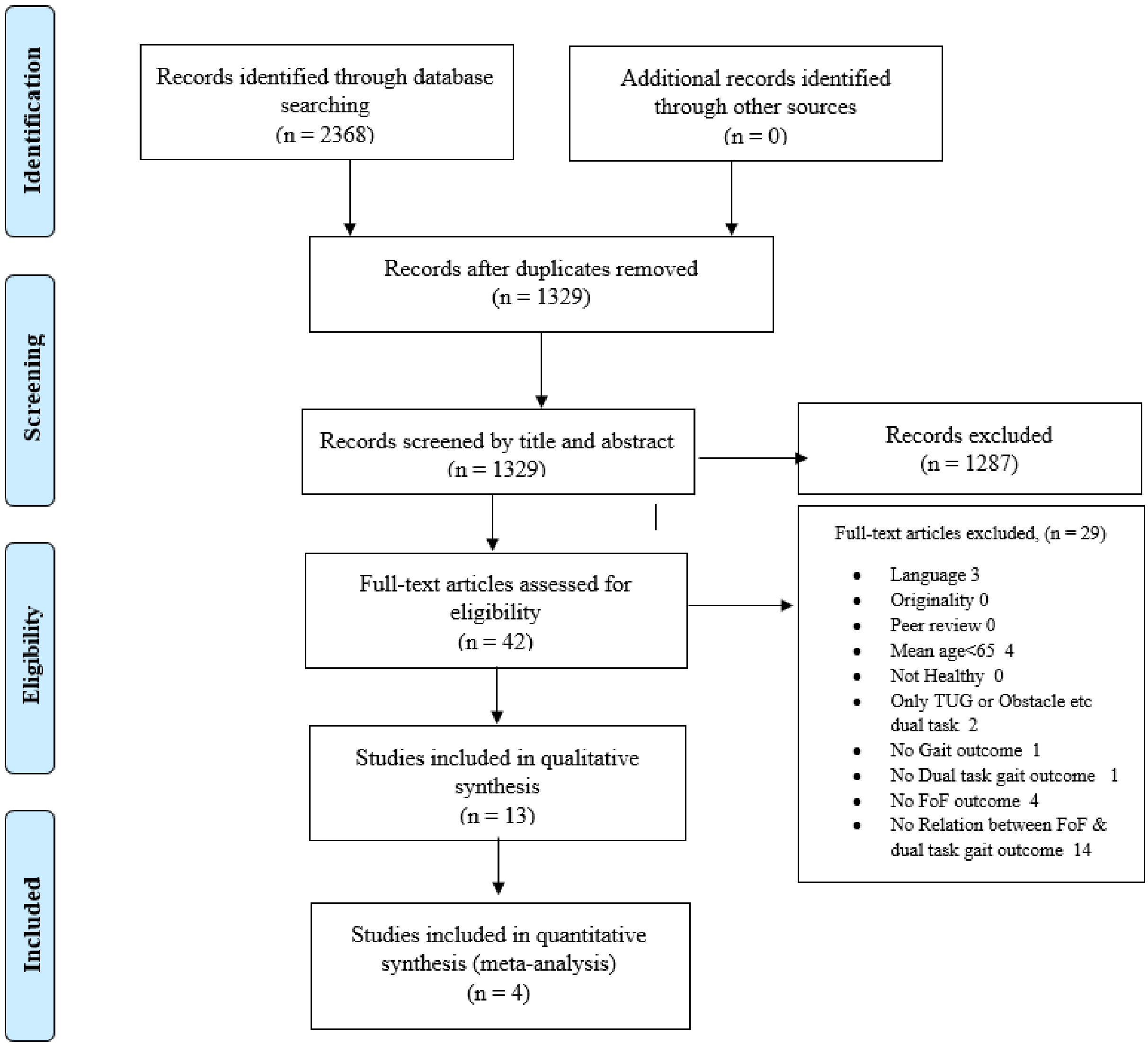

Figure 1) Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart

Table 1) Quality sssessment of studied articles

First author (year) (Ref.)	Reporting								External validity		Internal validity			Internal validity (confon-dong)		
	aim of study	main outcomes	patient characteristics	intervention	principle confounders	main findings	estimates of random variability	actual probability values	Asked subject represents entire population	Participated subject represents entire population	Staff, places and facilities	statistical tests	main outcome measures	patients from same population	adjustment for confounding factors	total
Gage (2003) [38]	1	1	1	1	1	0	1	1	0	0	1	1	1	0	0	10
Reelick (2009) [40]	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	12
Hadjistavropoulos (2012) [46]	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0	11
Donoghue (2013) [39]	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	12
Asai (2014) [41]	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	12
Wollesen (2017) [37]	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	12
Brustio (2018) [42]	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	12
Callisaya (2018) [34]	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	12
Holtzer (2019) [35]	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	12
Van Schooten (2019) [43]	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	12
Wollesen (2019) [36]	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	12
Kneis (2020) [44]	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	11
Wang (2021) [45]	1	1	1	1	1	1	1	1	0	0	1	1	1	0	1	12

Table 2) Summary of included studies characteristics

First author (year)	Sample size (female%)	Mean age (SD)	Study design	Sample characteristics	Fear of falling	Gait task	Dual task
Gage (2003) [38]	15 (80)	67.5 (3.9)	not reported	free of neurological and orthopedic conditions that might affect gait and/or cognitive function	Single question	7.2 min walk at a self-determined velocity	Prob RT test
Reelick (2009) [40]	94 (34)	80.53 (3.85)	community-based longitudinal study	age ≥ 75 years, ability to independently walk 10 m for at least five times (use of a walking aid was allowed) and ability to understand short instructions	Single question and ABC-NL	walking 10 min at a preferred velocity	1.Subtracting by 7 starting from 100 2. Naming animal species
Hadjistavropoulos (2012) [46]	107 (66.4)	76.8 (14.3)	cross sectional study	65 years of age or older, ability to complete and comprehend questionnaires in the English language, and ability to come to the university laboratory for research participation	SAFFE_fear	six separate walks on the GAITRite at a self-selected speed	Carrying an inclinometer tray
Donoghue (2013) [39]	1307 (55)	71.3 (65-93)	Longitudinal Study	age ≥65 years, no history of Parkinson's disease, Alzheimer's disease or dementia, MMSE score of ≥18 and ability to complete the gait assessment without the use of physical aids and with a minimum of eight steps	Single question	two walks at their normal pace (4.88)	recite alternate letters of the alphabet (A-C-E, etc.)
Asai (2014) [41]	117 (56.4)	73.7 (4.0)	cross sectional study	ability to independently perform activities of daily living and absence of self-reported neurological or musculoskeletal conditions affecting mobility or balance	Single question	walk on a smooth 20-min walkway at self-selected comfortable speed	1.Count backward by 1 from 100 2.carry a ball on a round tray with the dominant hand only
Wollesen (2017) [37]	95 (76.8)	71.6 (5.05)	a single blind randomized controlled trial	independent-living; age 65–80 years, able to walk without a walking aid and capable of attending the group training.	FES-I	30-sec walking test at self-selected constant speed	30-sec visual-verbal Stroop tests
Brustio (2018) [42]	76 (67.1)	70.87 (5.16)	cross sectional study	age between 60 and 80 years; ability to walk independently; no self-reported neurological or musculoskeletal conditions affecting mobility or balance; having a MMSE score higher than 24 and being able to understand the instructions and perform simple arithmetic exercises.	FES-I	10-m walking test at self-selected comfortable pace without assistance	count backwards in increments of three from a randomised number from 80 to 99

Continued Table 2) Summary of included studies characteristics

First author (year) [Ref.]	Sample size (female%)	Mean age (SD)	Study design	Sample characteristics	Fear of falling	Gait task	Dual task
Callisaya (2018) [34]	424 (55.2)	77.8 (6.4)	cross sectional study	people aged ≥ 65 years participating in the longitudinal Central Control of Mobility in Aging (CCMA)	Single question	complete one trial on a computerized mat at normal walking speed	reciting alternate letters of the alphabet
Holtzer (2019) [35]	75 (50.57)	77.52 (6.41)	cross sectional study	potential participants were identified from population lists of lower Westchester County, NY	Single question	walk around the electronic walkway at their normal pace for three consecutive loops	reciting alternate letters of the alphabet
Van Schooten (2019) [43]	204 (56.4)	79.8 (5)	cross sectional study	living in the community, and able to walk 20 m without a walking aid	FES-I	6-m walking duration	1.carrying a tray with an apple and a full glass of water 2.name their favourite piece of music or song
Wollesen (2019) [36]	222 (73.8)	72.18 (5.08)	cross sectional study	independent living, age 65–85 years, and the ability and mobility [Short Physical Performance Battery (SPPB) > 9; ability to walk without walking aids]	FES-I	a 30-s walking test at a self-selected constant speed	30-s visual-verbal Stroop tests
Kneis (2020) [44]	17 (35)	(7.5-7.9)	a 3-armed cross-sectional pilot study	SENs who regularly perform moderate physical activity at a local sports club	FES-I	a 10-m walkway: walking at preferred gait speed	counting from 50 backward in steps of 2
Wang (2021) [45]	122 (76)	77.75 (8.11)	longitudinal study	Community older adults, able to walk a distance of at least 1.8 m (~6 feet) without assistance and the use of walking-assistive device	FES-I	4.57 m (15 feet) at a self-selected speed under each condition	counting backward by 1, starting from 100

an inertial sensor (LEGSys)[45] were used once. In total, 18 different gait parameters were assessed in the included studies.

Gait Velocity

Twelve studies examined dual task gait velocity [34, 35, 37-46]. They all showed that dual task velocity is lower in older adults with FoF in comparison with that in older adults without FoF. Numerical data of dual task velocity (mean ± SD) was available only in four studies [39-41, 45]. In one paper, the samples were separated into subgroups based on FoF, with and without activity restrictions [39]. In two studies, two different types of dual tasks were examined, namely arithmetic and verbal [40], cognitive and manual [41]. The meta-analysis was applied to them (figure 2). Publication bias was assessed visually using funnel plot (Figure 3). Publication bias did not appear in the dual task gait velocity. The result demonstrated that older adults with FoF had a lower dual task velocity than no-FoF ones (Appendix 1).

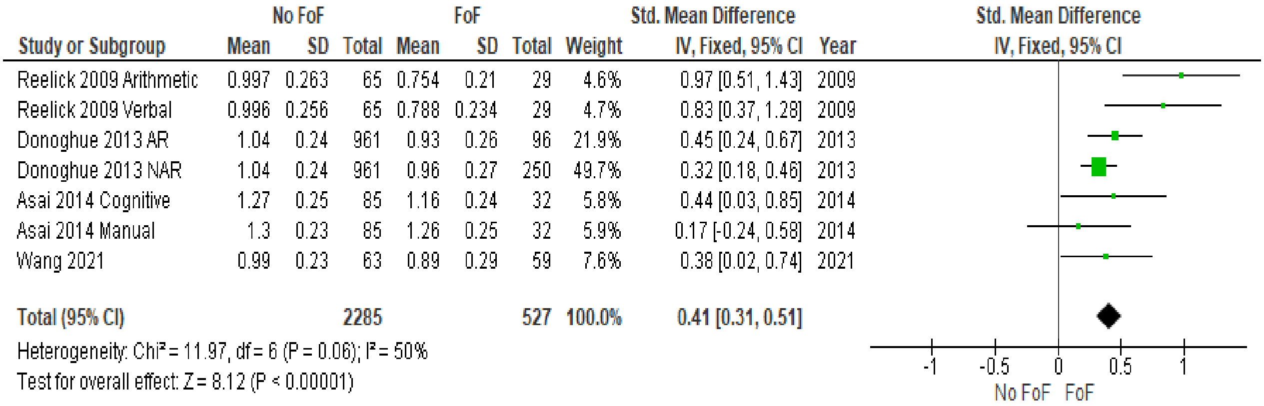

Figure 2) Forest plot of the effect of fear of falling on dual task gait velocity in older adults

differences in the mean reported by different articles. I^2 and Q were measured in order to assess heterogeneity among the studies. For assessing publication bias, we considered the funnel plot asymmetry.

Findings

Out of 2368 articles found by titles, abstracts, and keywords, 1039 duplicated ones were removed. Out of remained 1329 articles, 41 articles were included through the initial inclusion criteria. In the following screen of the full-texts, the studies were mainly excluded since they did not examine the correlation between FoF and dual task gait outcome. Therefore ,thirteen studies met the inclusion criteria and were included in this systematic review. It should be noted that the articles by Callisaya (2018)[34] and Holtzer (2019)[35] were subsamples of the one longitudinal study "Central Control of Mobility in Aging" (CCMA). Furthermore, the study by Wollesen (2019)[36] was a secondary analysis of the data from her work published in 2017[37]. The included studies' quality assessment is shown in Table 1. Ten studies scored 12/15, two studies 11/15, and the last one scored 10/15. Table 2 summarizes the 13 studies included in this systematic review. Studied population ranged from 15 participants[38] to 1037 participants[39], who were more frequently women with a prevalence ranging from 34% [40] to 80%[38]. The mean age ranged between 67.5 ± 3.9[38] and 80.55 ± 3.95 [40] years. Fear of falling was assessed through employing four different methods: almost half of the studies used the single question "Are you afraid of falling?" answering yea/no[34, 35, 38-41], nearly another half of the studies used the Fall Efficacy Scale-International (FES-I)[36, 37, 42-45], the Survey of Activities and Fear of Falling in the Elderly (SAFFE-fear) was used in one study[46], and in Reelick study, the Activity-specific Balance Confidence scale (ABC-NL) was utilized as well as the single question[40]. Both manual and cognitive tasks were used as secondary tasks while walking. Three studies employed the manual task, including carrying an inclinometer tray [46], carrying a ball on a round tray [41], and carrying a tray with an apple and a full glass of water [43]. The cognitive task was used in 12 studies, including subtracting by different amounts [40-42, 44, 45], reciting alternate letters of the alphabet[34, 35, 39], the visual-verbal Stroop test[36, 37], the Prob RT test[38], naming a favorite piece of music or song[43], and naming as much animal species as possible[40].

In order to assess gait characteristics, studies used various devices. Four studies used a digital stopwatch[34, 41-43], five studies utilized electronic walkways including the GaitRite system (n=4)[34, 39, 40, 46] and Zeno system (n=1)[35], two studies used a treadmill [36, 37]. An OpenGo Sensor Insoles [44], an inclinometer [46], a SwayStar [40], and

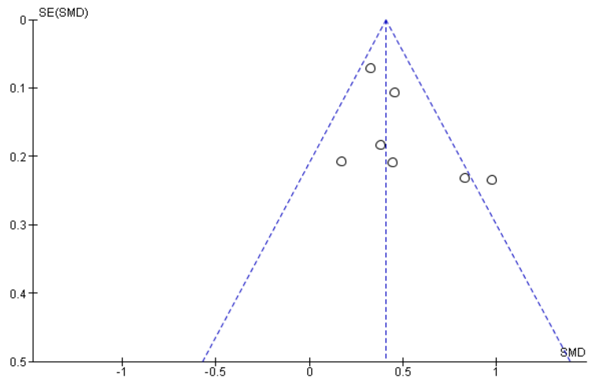

Figure 3) Funnel Plot of the effect of fear of falling on dual task gait velocity in older adults

Two studies measured dual task stride time. No correlation was found between dual task stride time and FoF [44, 45]. Four studies measured dual task stride time variability [39-41, 44], but the correlation between dual task stride time variability and FoF was only examined in two studies [39, 40]. There were no agreements between the result of these two studies.

While four studies assessed dual task stride length [38, 39, 45, 46], the correlation between FoF and dual task stride length was only examined in two studies. They both showed that the presence of FoF leads to a lower dual task stride length in older adults [39, 45]. Two studies examined the correlation between dual task stride length variability and FoF. There were no agreements between the result of these two studies [39, 40].

Three studies measured dual task step width [36, 37, 39]. However, the correlation between dual task step width and FoF was only examined in two studies. They both reported that the presence of FoF leads to an increased dual task step width in older adults [36, 39] .

Discussion

This systematic review aimed to assess the correlation between dual task gait outcomes and the fear of falling in older adults. The results demonstrated that the presence of FoF leads to a deterioration in some of the dual task gait outcomes.

Two systematic reviews and meta-analyses reported that gait speed decreases with the addition of a dual task in healthy older adults [13, 14]. Makino et al. showed that seniors who feared falling, with or without a history of falls, have a slower gait velocity compared with no-FoF ones [20]. It has been previously reported that concern about falling is the strongest predictor of gait speed under all conditions (single task fast and preferred speed, dual ask cognitive and manual), independent of physiological fall risk or cognitive function [43].

There is evidence that the gait variability is negatively affected by the presence of FoF [25] and the addition of a dual task [14]. Reelick et al. reported a significant correlation between FoF and dual task stride time variability and dual task stride length variability [40]. On the other hand, Donoghue et al. found no correlation between them [39]. This discrepancy in their results could be due to the difference in the sample size and higher mean age in the study by Reelick. Therefore, further research is needed to assess this correlation.

Makino et al. found that FoF is associated with shorter stride length regardless of fall history [20]. However, a systematic review and meta-analysis showed no significant difference between single and dual task stride length in older adults [14]. Wang et al. and Donoghue et al. indicated that older adults who feared falling had a shorter dual task stride length. Both studies used cognitive tasks to assess dual tasks, but utilized different tools for assessing FoF (single question and FES-I) [39, 45]. The strength of the study by Donoghue is its large sample size [39]. In the investigation by Wang, groups were matched based on individual characteristics. Therefore, the effect of confounding factors was minimized on the fear of falling and walking dual tasks, including age, cognitive status, and gender. Thus, it could be concluded that its results are largely reliable [45]. Further research is needed in this area.While Smith et al. showed that stride time significantly increases with the addition of a dual task [14], no correlation was found between FoF and dual task stride time in the latest studies [44, 45]. Nevertheless, the results reported by Kneis et al. might not be suitable to be generalized due to their small sample size, easy dual task (counting backward by 2), and limited range of FES-I scores [44]. However, Wang et al. carried out propensity score matching with age, CES-D, MSSE, and BMI [45]. Overall, more research is required in this field. We found that the presence of FoF leads to an increased dual task step width in older adults [36, 39]. In this regard, Nordin et al. indicated that changes in step width while dual task walking can predict future falls in the elderly [47]. Moreover, several studies have demonstrated that increased step width is associated with FoF [23, 39].

Our study has certain limitations; primarily, it should be noted that this review included only a limited number of studies, highlighting the need for further research in this area. Secondly, only the articles written in English were included in this study (three eligible studies were excluded in full-text screening), which increases the probability of language bias in this review. Additionally, the studies examining walking during activities, such as turning, perturbation, and obstacle crossing while performing Timed Up and Go Test (TUG) and Activity-Based Curriculum (ABC) tests were excluded from our work. Ultimately, there were limitations in accessing numerical data due to the lack of properly reported data or differences in statistical normal values.

Conclusion

In conclusion, some of the dual task gait outcomes (speed, step width, stride time variability, and stride length variability) deteriorate with the increase in the fear of falling in older adults. This deterioration can be influenced by the type of dual task (manual or cognitive) and difficulty of the task (counting backward by 7 or 1). While previous research mainly focused on the correlation between FoF and single task gait outcomes, almost all of the daily activities contain a certain level of dual tasking. Therefore, it is essential to determine the relation between dual task gait outcomes and the fear of falling as important risk factors and predictors of future falls.

Acknowledgements

None declared by authors

Authors Contribution: All authors have their own responsibilities in this review manuscript. All authors read the final draft of the manuscript and confirmed it.

Conflict of Interests: None declared by the authors

Ethical Permission: PROSPERO registration number was obtained as CRD42021271225

Funding/Supports: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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