Journal for Health Sciences, Volume 13, Issue 1 (2023), pp. 34–43.
https://doi.org/10.32967/etk.2023.012

DUAL-TASK WALKING AND FALLS IN THE ELDERLY

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Summary: Dual-task walking is a common activity in everyday life. The dual-task paradigm is a procedure in experimental psychology that involves examining the performance of two tasks separately and simultaneously, allowing researchers to determine the extent to which different mental abilities compete for information-processing resources in the brain. This information can help identify whether tasks interfere with each other. This study aimed to analyse publications, gather knowledge on gait with an additional task, and determine the impact of dual-task conditions on gait parameters among the elderly. In October 2022, we conducted a comprehensive review of available literature in databases such as Pubmed, Cochrane, and Google Scholar, as well as research carried out at the Central Laboratory of Motion Analysis of the University of Physical Education in Krakow. We identified 11 publications on dual-task gait in the elderly, focusing exclusively on healthy individuals. Studies on the effects of training on dual-task gait were not included in our analysis. Research conducted to date in older adults has shown that dual-task conditions have a negative effect on gait speed, step frequency, gait cycle time, and gait variability indices, among other parameters.

Keywords: *dual-task paradigm, gait with additional tasks, spatiotemporal parameters of gait, additional cognitive task, DIVA-gait test, risk factors for falls*

INTRODUCTION

Dual-task walking is a common occurrence in everyday life, and it involves executing two tasks simultaneously. The dual-task paradigm is a procedure in experimental psychology that examines the performance of executing a set of two tasks, once executed separately and once simultaneously, to investigate the extent to which different mental abilities compete for information-processing resources in the brain and if they interfere with each other [1]. Assessing dual tasks can provide information about gait, its automatism, and the risk of falls, which may not be fully captured in single-task conditions [2]. Studies report that the dual-task paradigm is a sensitive way of predicting fall risk [3, 4].

The risk of falling incidents increases with age and frailty index, leading to significant healthcare costs globally. Falls can cause post-fall syndrome, which reduces physical activity, leads to reduced functioning and loss of motoric confidence, and increases the risk of further falls [5]. Approximately 28-35% of people aged 65 and over suffer from falls annually, which increases to 32-42% in their 70s. The risk of falls rises significantly with age and frailty level. Falls are the confirmed cause of 20-30% of mild-to-severe injuries, accounting for 10-15% of all emergency department visits, and 40% of all deaths from injuries [5].

This study aimed to analyse publications, gather knowledge on gait with an additional task, and determine the impact of dual-task conditions on gait parameters among the elderly. This is essential, especially given that walking is a common daily activity, and falling among elderly people poses a significant problem that can have an impact on people of all ages.

MATERIALS AND METHODS

In October 2022, a review of the available literature was conducted using various databases such as Pubmed, Cochrane, and Google Scholar, along with research carried out at the Central Laboratory of Motion Analysis at the University of Physical Education in Krakow. The keywords "gait", "dual task", and "elderly" were used to search these databases. For this study, only clinical trials and randomised controlled trials were considered, and only studies on healthy adults over the age of 60 were included. However, publications aimed at investigating the effect of training on dual-task gait have not been included in this study.

RESULTS

After conducting a literature search using the aforementioned keywords, we identified 213 results in the Pubmed database, 133 in the Cochrane database, and 45 in the Google Scholar database. Out of these, we analysed 11 publications on dual-task gait in healthy adults aged over 60, which met our inclusion criteria. The methodologies employed in these studies varied in terms of walking path lengths, type (overground or treadmill), walking time, and the additional task itself. Common additional tasks included serial subtraction of the number 7, naming animals, citing words starting with a chosen letter, counting backwards, and listening to emotionally loaded sounds.

Gait speed, measured at the preferred natural speed, was found to decrease significantly when the second task was added, with only one publication reporting an increase in this value [6]. Of the four publications that focused on step cadence, one showed a decrease in cadence when the second task was added, while the others showed an increase [6]. Stride length consistently decreased across all studies when the additional task was introduced, with the exception of treadmill walking, where stride length slightly increased [7]. Both stride length variability and stride time variability increased when an additional task was added to the gait.

Table 1 presents the methodological differences among the studies included in this review. It is important to note that this review only considered clinical trials and randomised controlled trials that examined healthy adults aged over 60 and did not include studies on the effect of training on dual-task gait.

DISCUSSION

Multitasking while walking is a common occurrence in everyday life rather than an exception, as shown in previous studies [8, 9, 10]. However, comparing results between studies can be challenging due to differences in methodologies and variations in cognitive load [11]. Furthermore, the choice of the task may impact the accuracy of the results depending on individual knowledge and interests [11]. Identifying a reliable and sensitive test that can be replicated across various clinical settings is essential [4].

Gait speed is recognised as a primary gait indicator due to its simplicity and high clinical relevance, with a minimum value of 0.8 m/s needed for functioning in society [12, 13]. However, fear of falling while performing complex cognitive tasks can significantly lower gait speed values below the required threshold [14].

Indicators of gait variability in the subject, such as stride time variability and stride length variability, were also considered and calculated according to the formula: $V = s/m*100\%$, where V is variability, s is the standard deviation, and m is the mean [11]. Studies have shown that both of these variabilities are more strongly correlated with fall risk than the mean value of gait speed [15]. While some studies have reported stride time variability under 5% for adults [16], others have found stride length and time variability less than 6% [17]. None of the publications we have identified indicated that Stride length variability didn’t surpass this 6%. In the elderly group with manifested fear of falling, stride time variability was at 5.7% when an additional gait task was introduced, and changes in the variables can be used to prognosticate future fall risk [14, 19]. It is worth pointing out that the results of the study conclude that lower speed with lower step cadence and lower stride length may result in an increased risk of falls [18].

The mean dual-task effect is included within the essential measures of the dual-task paradigm [20]. The measured impact of the dual-task indicates whether there has been an improvement or a deterioration in the subject’s conditions [11]. It is calculated by the values of gait speed and the number of errors in the cognitive task and for the values of gait speed and reaction time using the following formula: $mDTE = (\alpha DTE-\beta DTE)/2$, where mDTE is the mean dual-task effect, αDTE is the double task effect of indicator α, and βDTE is the double task effect of indicator β [11]. The dual-task effect is used to define the effect of the additional task on each gait indicator. To calculate the dual-task effect for each indicator, the following formula is used: $\alpha DTE = (\alpha DT-\alpha ST)/\alpha ST*100\%$, where αDTE is the dual-task effect for indicator α, αST is the value of the indicator under single-task conditions, αDT is the value of the indicator under dual-task conditions [11]. Young people tend to give higher priority to walking, while elderly people tend to prioritise an additional task. Unfortunately, we are not sure at what exact age the shift takes place [20]. The mean dual-task effect allows for measuring a person’s attention for both the gait and the cognitive task simultaneously [4]. Cognitive tasks influence the dual-task effect more than motor tasks [21]. Plummer and Eskes pointed out that relative measures are necessary to correctly assess gait with an additional task [4]. However, unfortunately, in many studies this index is not calculated.

Other parameters, such as swing speed and swing time, single and double support time, step length time and width, stride time and stride width, and stride width variability, have been included in various studies. This is an area that may be developed in future publications.

CONCLUSION

Research on the elderly population has shown that dual-task conditions have a significant impact on gait parameters. When an additional cognitive or motor task is introduced during walking, we observe a decrease in gait speed, stride length, and an increase in step cadence, step length variability, and step time variability. These changes in gait pattern may be attributed to the competition for attentional resources between the walking task and the additional task, leading to a shift in prioritisation towards the secondary task. The alterations in gait parameters under dual-task conditions have been linked to an increased risk of falls in older adults. Therefore, it is crucial to consider the effects of dual-task conditions when evaluating gait performance in the elderly.

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Table 1

Characteristics of the included studies with methodology and results continued

Study	Sample size (% female)	Mean age (Years)	Population characteristics	Walking test	Classification of secondary test	Gait speed (m/s) Single task	Gait speed (m/s) Dual - task	Cadence (steps /min) Single-task	Cadence (steps /min) Dual-task	Stride length (m) Single-task	Stride length (m) Dual-task	Stride-length variability (%) Single-task	Stride-length variability (%) Dual-task	Stride-time variability (%) Single-task	Stride-time variability (%) Dual-task
Agner et al. 2015 [6]	n=32 of whom 16 elderly (62,5%)	85.5±0.6 (elderly)	The elderly in need of care group	Walk at a self-selected walking speed (20 m)	Arithmetic task	0.73 ± 0,23*	0.83 ± 0,28*	103.56 ± 13.1*	111.08 ± 13.9*	n	n	n	n	n	n
Beauchet et al. 2004 [22]	n=38 (90%)	82.6 ± 7.1	Older adults	Walking at usual speed (10 m)	Arithmetic task	Not reported (n)	n	23.88 ± 6.7*	28.60 ± 9*	n	n	n	n	n	n
					Verbal fluency task				30.9 ± 9.9*	n	n	n	n	n	n
Dubost et al. 2006 [23]	n=45 (53,3%)	65,3 ± 3,2	Older adults	Walking at a self-select speed (15 m)	Verbal fluency task	1.35 ± 0.10*	1.21 ± 0.17*	n	n	n	n	n	n	n	n
Hagner-Derengowska et al. 2016 [24]	n=53 100%	64.5 ± 6.7	Postmenopausal women	Free walking	Simple Verbal fluency tasks	0.81 ± 0.76–0.86	0.80 ± 0.74–0.85	n	n	n	n				
					Complex Verbal fluency tasks		0.76 ± 0.68–0.84*	n	n	n	n	n	n	n	n
Hamacher et al. 2018 [25]	n= 25 52%	70 ± 6	Older adults	Walked back and forth (22 m, 3 min)	Arithmetic task	1.32 ± 0.16*	1.18 ± 0.18*	n	n	1.39 ± 0.14*	1.30 ± 0.16*	n	n	n	n

Table 1

Characteristics of the included studies with methodology and results continued

Study	**Sample size** (% female)	**Mean age** (Years)	**Population characteristics**	**Walking test**	**Classification of secondary test**	**Gait speed** (m/s) **Single-task**	**Gait speed** (m/s) **Dual-task**	**Cadence** (steps /min) **Singl-e task**	**Cadence** (steps /min) **Dual-task**	**Stride length** (m) **Single-task**	**Stride length** (m) **Dual-task**	**Stride-length variability** (%) **Single-task**	**Stride-length variability** (%) **Dual-task**	**Stride-time variability** (%) **Single-task**	**Stride-time variability** (%) **Dual-task**
Nadkarni et al. 2010 [26]	n= 20 of whom 10 elderly	74,3 ± 7 (older adults)	Older adults	Walk at preferred velocity (10 m)	Verbal task	1.20 ± 0.22	1.16 ± 0.27*	109.40 ± 7.3*	110.2 ± 7.6*	1.33 ± 0.20 *	1.26 ± 0.24 *	n	n	n	n
					The spatial attention task		1.17 ± 0.23*		110.9 ± 9.1*		1.27 ± 0.21 *				
Reelick et al. 2009 [14]	n=94 Fear of falling group (FoF): 29 (51,7%) No fear of falling group (NFoF): 65 (26,2%)	FoF: 80.6 ± 4.2 NFoF: 80.5 ± 3.7	Older adults	Walk at preferred velocity (10 m)	Arithmetic task	0.81 ± 0.16 * (FoF) 1.06 ± 0.19* (NFoF)	0.75 ± 0.21* (FoF) 1.0 ± 0.26* (NFoF)	n	n	n	n	2.8 ± 1.80 * (FoF) 2.6 ± 1.80 * (NFoF)	4.6 ± 2.60* (FoF) 3.5 ± 3.50* (NFoF)	3.0 ± 1.7* (FoF) 1.9 ± 1.0* (NFoF)	4.0 ± 2.4* (FoF) 3.4 ± 3.6* (NFoF)
					Verbal fluency task		0.79 ± 0.23* (FoF) 1.0 ± 0.26* (NFoF)	n	n	n	n		4.6 ± 2.50* (FoF) 4.0 ± 4.90* (NFoF)		5.7 ± 8.5 (FoF) 4.6 ± 8.8* (NFoF)
Rizzo et al. 2015 [27]	n=104 (63%)	80.6 ± 4.9	Older adults without dementia	Walking at normal speed.	Sound stimulation task	0.98 ± 0.21	Increase of 0,03	105.10 ± 9.9	increase of 2,41*	n	n	n	n	n	n

Table 1

Characteristics of the included studies with methodology and results continued

Study	Sample size (% female)	Mean age (Years)	Population characteristics	Walking test	Classification of secondary test	Gait speed (m/s) Single-task	Gait speed (m/s) Dual-task	Cadence (steps /min) Single-task	Cadence (steps /min) Dual-task	Stride length (m) Single-task	Stride length (m) Dual-task	Stride-length variability (%) Single-task	Stride-length variability (%) Dual-task	Stride-time variability (%) Single-task	Stride-time variability (%) Dual-task
Simoni et al. 2013 [7]	n=14 (48%)	75 ± 0.8	Older adults	Walking overground (O) or Treadmill (T)	Verbal fluency task	1.3 ± 0.03* (O) 0.9 ± 0.01* (T)	1.0 ± 0.05* (O) 0.9 ± 0.02* (T)	112 ± 1.6* (O) 116 ± 2.0* (T)	95 ± 3.7* (O) 113 ± 1.7* (T)	Right 1.37 ± 0,03* (O) 0.98 ± 0,02* (T) Left 1.37 ± 0,03* (O) 0.98 ± 0,02* (T)	Right 1.28 ± 0.03* (O) 0.99 ± 0.02* (T) Left 1.28 ± 0.03* (O) 1 ± 0.02* (T)	n	n	n	n
Soangra et al. 2017 [28]	n=14 of whom 7 elderly	71,14 ±6,51 (only elderly)	Healthy older adults	Walk at their self-selected pace (15–20 min)	Arithmetic task	1.17 ± 0.16 *	1.08 ± 0.19*	n	n	n	n	n	n	n	n
Van Iersel, et al. 2007 [29]	59 (30,5%)	73,5 ± 3,4	physically fit elderly people who had good mobility	Walk at preferred speed	Arithmetic task No 1	1.46 ± 0.18 *	1.41 ± 0.24 *	117.60 ± 7.6	114 ± 12	1.50 ± 1.16	1.47 ± 4,18	1.46 ± 1.7*	1.80.6 *	1.3 ± 62.3*	1.6 ± 0.6*
					Arithmetic task No 2		1.34 ± 0.26 *		110 ± 15.5		1.45 ± 4,20		2.20.7*		2.0 ± 1.0*
					Verbal fluency task		1.23 ± 0.26		105 ± 16.9		142 ± 0,19		2.60.70*		2.3 ± 1.1*