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FACTORS INFLUENCING GAIT IN DUAL-TASK WALKING

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Summary: Gait with an additional task commonly occurs in everyday life, e.g., simultaneously walking and talking on the phone. The dual-task paradigm (comparison of task performance efficiency under single-task conditions and simultaneous performance of both tasks) has found application in gait research. It is a test that allows assessing the quality of gait in clinical settings but also lets us analyse the quality of gait under the conditions of everyday life. It also allows the identification of people at risk of falling. A review of the available literature and research conducted at the Central Laboratory of Motion Analysis at AWF Krakow has been made, which may be useful for identifying factors that increase the risk of falls.

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

INTRODUCTION

Gait is a motor activity that is cyclic and involves repetitive patterns of the lower limbs, trunk and head. It is the primary mode of movement for humans. The dual-task paradigm is widely used in experimental psychology to study the extent of how different mental abilities are independent of each other (if the two tasks do not interfere with each other) or strain shared resources (if they do). Each additional task uses our attention and therefore reduces the performance of the other tasks.

Walking with an extra task is something that we do every day, even when we are not fully aware of it, for example, when we are walking and talking on the phone. The goal was to identify risk factors for falls occurring in gait conditions with an additional task. To find the necessary articles, we have used publicly available databases and used research papers prepared at the Central Laboratory of Motion Analysis at the University of Physical Education in Krakow. We created a narrative review.

MATERIALS AND METHODS

A review of the available literature and research conducted at the Central Laboratory of Motion Analysis at the University of Physical Education in Krakow has been made, which may be useful for identifying factors that increase the risk of falls. Inclusion criteria were: dual-task gait, measurement of walking speed, various topics, and the ability to walk independently. Articles that did not include gait speed were discarded. The study aimed to identify factors affecting gait with the additional task of.

RESULTS

A review of Science Direct, PubMed, and Google Scholar databases and the work carried out at the Central Laboratory of Motion Analysis at the University of Physical Education in Krakow AWF Krakow identified 12 publications, 4 master's theses and 1 doctoral thesis. The following factors affecting gait with an additional task were identified: diseases (stroke, concussion, Parkison Disease, MCI), age, hip alloplastic, gender, history of falls, fear of falling, leg muscle quality, task prioritization, type of surfaces (grass, asphalt, cobblestones) low dose of alcohol, crutches, type of shoes (for example flip-flops). *(Table 1)*

DISCUSSION

Walking with an extra task is an activity that attends us every day. These days it is the subject of many studies, based on which a literature review has been created. The additional task may involve motor activities as well as cognitive ones. We can divide the factors into internal and external. Internal factors are disease, age, and gender. These are factors beyond our control. External factors are additional accessories like crutches, shoes, and alcohol. These factors can be eliminated. Articles examine how an additional task affects gait in diseases such as cognitive impairment, Parkinson's, concussion or after hip alloplasty [1, 2, 3, 4, 5, 6, 7]. The Montero-Odasso et al. study concerned people with cognitive impairment and used fluency and arithmetic dual tasks [1]. The additional task had an impact on reducing the gait speed. Similar results were obtained by Oppewal et al. but the additional task in this study was talking to the instructor. [3]. Lamoth et al. compared people with and without cognitive impairment. In both cases, the additional task of naming as many words as possible starting with a predefined letter influenced the decrease in walking speed [2]. Kelly et al. compared young healthy adults, older healthy adults, and patients with Parkinson’s Disease. An additional task was the Stroop test. In all cases, after the additional cognitive task was applied, gait speed decreased, but the least, by only 4 m/s in older healthy subjects [4].

In addition to diseases, gender may be a factor influencing gait with an additional task. A study by Howell et al. shows that women after concussion have lower walking speed with an additional task than men, despite comparable baseline speed in single-task walking [7]. The results of the Hollmann et al. study do not agree with those of Howell et al. because they showed that despite similar baseline speed in

single tasks, women achieved a higher speed in walking with additional tasks. Differences may arise, for example, from the type of additional task used [9]. In the control group without concussion, there were no significant differences between genders. Priest et al. studied the effect of age on gait while counting backwards. The initial velocity of the young in the single task was higher than in the elderly, but in the dual task, the velocity decreased by the same amount or 0.25 m/s.

A study by Hirashima et al. found no large differences in speed between healthy individuals and those who had experienced injury from falls in their lives [10]. In people with the fear of falling after using an additional task, the speed after reciting alternate letters of the alphabet was significantly reduced [11]. Gait testing with an additional task has important implications for assessing the risk of falls when observing changes in gait speed and indices [6].

In addition to internal factors, external factors have a significant impact on the extra task walk. The study by Nohelova highlights differences in gait speed on different surfaces and due to the type of additional task. Cognitive DT and manual DT have been used here. The subjects achieved the highest speed during the cognitive task on grass and during the manual task on cobblestones. Manual DT resulted in a greater reduction in speed than cognitive DT compared to the speed achieved in ST [14].

Walking with crutches in DT walk performing DIVA test influenced to increase walking speed [15]. A small dose of alcohol increases gait speed [17]. Footwear is also an important factor. The research evaluates the influence of flip-flops on changes in gait indicators with an additional cognitive task. This study did not show large differences [16].

There are many factors, and most of them cause a decrease in gait speed when walking with an additional task. A variety of methodologies were used in all studies: DIVA test, Stroop test, arithmetic task, fluency dual task – for example spelling a five-letter word backwards, conversation with an instructor, avoiding stepping on white lines, a manual dual task, for example, carrying a cup filled with water making it difficult to compare the results. It seems reasonable to conduct further research using the proposed methodology, to clarify the mechanism of automation and the ability to hold attention for a longer period during gait with an additional task. It becomes necessary to collaborate in a multidisciplinary team including physiotherapists, physicians, biomechanists and psychologists. A similar understanding of further research development was presented by Montenero-Odasso et al [1]. Because of the different degrees of attention, it's hard to compare among themselves which factor influences more.

CONCLUSION

Among the factors that could affect the risk of falling under the conditions of walking with an additional task was identified: using a cell phone, consumption of small doses of alcohol, using flip-flop shoes, age, diseases, degenerative changes in the hip joints, post-traumatic conditions, concussions. Among other things, it was observed

that after adding an additional task in subjects with mild cognitive impairment, gait speed decreased and step time increased, while in older participants gait speed decreased and gait speed variability increased.

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Table 1

Studies included in review

Article	Study design	Population characteristicsic	Walking Task	Secondary task	Gait speed (m/s)/(SD) ST	Gait speed (m/s)/(SD) DT
Montero-Odasso et al., 2009 [1]	Dual-tasking and gait in people with Mild Cognitive Impairment.	60 adults with MCI, age 65 and older, fluent in English	Gait velocity test (GV)	fluency dual task arithmetic dual task	0.87 m/s (0.2)	Verbal 0.65 (0.2) m/s Counting 0.63 m/s (0.2)
Lamoth et al., 2011 [2]	Gait stability and variability measures show effects of impaired cognition and dual tasking in frail people.	26 elderly	Participants walked for 3 minutes (about 160 m) in a well-lit, empty 40 m-long corridor at a self-selected speed.	name as many words as possible starting with a predefined letter	Cognitive intact 0.95 m/s (0.21) Cognitive impaired 0.88 m/s (0.27)	Cognitive intact 0.78 ± 0.24 (m/s) Cognitive impaired 0.83 ± 0.20 (m/s)
Oppewal et al., 2019 [3]	The dual-task effect on gait in adults with intellectual disabilities: is it predictive for falls?	31 people, 20 years and older	Gait parameters were measured with the GAITRite Electronic Walkway.	conversation with the test instructor	1,18 m/s (0,23)	1,00 m/s (0,23)
Kelly et al., 2012 [4]	The Effects of Instructions on Dual-Task Walking and Cognitive Task Performance in People with Parkinson's Disease	Healthy young adults from the university and healthy older adults from local exercise classes and the community.	For the walking task, participants were instructed to "Walk as quickly as safely possible" in a taped pathway on level ground. Participants walked with their arms crossed.	Stroop test	Healthy young adults 1.86 m/s Healthy older adults 1.56 m/s Patients with PD 1.33m/s	DTwalk Healthy young adults1.88 m/s Healthy older adults 1.58 m/s Patients with PD 1.28 m/s DTcog Healthy young adults 1.80 m/s Healthy older adults 1.51 m/s Patients with PD 1.22 m/s

Article	Study design	Population characteristicsic	Walking Task	Secondary task	Gait speed (m/s)/(SD) ST	Gait speed (m/s)/(SD) DT
Timmerans et al., 2018 [5]	Dual-Task Walking in Challenging Environments in People with Stroke	30 participants had a first-ever stroke ≥ 3 months before study entrance	Participants walked in three different environments a plain walking environment and two challenging walking environments.	counting backwards	Plain 0.90 m/s Walking environment – challenging physical 0.58m/s Walking environment – challenging projected 0.76 m/s	Plain 0.76 m/s Walking environment – challenging physical 0.52 m/s Walking environment challenging projected 0.62 m/s
Doctoral thesis Agnieszka Kreska-Korus [6]	Selected gait indices with an additional cognitive task in qualified hip alloplastic patients	31 people, including 18 qualified for total hip alloplastic, and 13 healthy people	Walking twelve times an 8-meter measuring path measured using System BTS Smart.	DIVA test	Lower limb qualified for hip alloplastic 0.91 m/s Opposite limbs to limbs qualified for hip alloplastic 0.91 m/s	Lower limb qualified for hip alloplastic 0.85 m/s Opposite limbs to limbs qualified for hip alloplastic 0.88 m/s
Howell et al., 2017 [7]	Dual-task gait differences in female and male adolescents following sport-related concussion.	35 participants diagnosed with a concussion	Participants completed 5 single-task walking trials (walking without a cognitive demand) and 5 dual-task walking trials (walking while concurrently completing a cognitive test).	(1) spelling a five-letter word backwards, (2) subtracting (3) reciting the months	Gait speed Female Concussion 1,07 m/s Control 1,23 m/s Male Concussion 1,08 m/s Control 1,17 m/s	Gait speed (m/s) (mean) Female Concussion 0,79 m/s Control 0,94 m/s Male Concussion 0,86 m/s Control 0,92 m/s
Priest et al., 2008 [8]	Observational study examining the effect of a dual task in older and younger adults (age-related differences)	23 older and 19 younger women Mean age younger group: 22,7 older group: 79,8	Gait velocity and variability in stride velocity were measured with GAITRite® instrumentation: walking at a self-selected velocity.	counting backwards	Younger subjects: 1,5 m/s Older subjects: 0,75 m/s	Younger subjects: 1,25 m/s Older subjects: 0,5 m/s

Article	Study design	Population characteristicsic	Walking Task	Secondary task	Gait speed (m/s)/(SD) ST	Gait speed (m/s)/(SD) DT
Hollman et al., 2011 [9]	Gender differences in dual-tasking gait.	44 healthy adults aged 67-91 Mean women age:76.8 Mean men age: 77.1	Gait parameters were quantified with GAITRite instrumentation. Participants walked under walking at a self-selected velocities .	spelt a five-letter word backward	Men 1,27 m/s (0,24) Women 1,25 m/s (0,23)	Men 0,96 m/s (0,23) Women 1,05 m/s (0,17)
Hirashima et al., 2015 [10]	Dual tasking over an extended walking distance is associated with falls among community-dwelling older adults	92 patients 16 were injured because of falls, or they fell more than one time during the 12-month follow-up.	Walk down a 10 m walkway and return three times (60 m in total) at their usual speed.	avoiding stepping on the unequal 10 cm-wide lines	Faller Distance 20 m 1.06 m/s Distance 40 m 1.06 m/s Distance 60 m 1.03 m/s Non–faller Distance 20 m 1.02 m/s Distance 40 m 1.04 m/s Distance 60 m 1.03 m/s	Faller Distance 20m 0.94 m/s Distance 40 m 0.93 m/s Distance 60 m 0.94 m/s Non – faller Distance 20 m 0.92 m/s Distance 40 m 0.93 m/s Distance 60 m 0.94 m/s
Donoghue et al., 2012 [11]	Effects of fear of falling and activity restriction on normal and dual task walking in community-dwelling older adults	1307 participants, age 65 and older, MMSE score of 18	Gait assessment took place using a 4.88 m computerized walkway with embedded pressure sensors (GAITRite1, CIR Systems Inc., New York, USA).	recite alternate letters of the alphabet	No fear of falling 1.28 m/s (0.19) Fear of falling 1.20 m/s (0.22) Fear of falling with activity restriction 1.13 m/s (0.25)	No fear of falling 1.04 m/s (0.24) Fear of falling 0.96 m/s (0.27) Fear of falling with activity restriction 0.93 m/s (0.26)
Beurskens et al., 2015 [12]	Association of dual-task walking performance and leg muscle quality	20 participants	Participants walked with their own footwear at self-selected, comfortable walking speeds, initiating and terminating each walk a minimum of 2 m before and after a 10-m walkway	subtractions by 3 starting from 100	1.45 m/s	1.14 m/s

Article	Study design	Population characteristicsic	Walking Task	Secondary task	Gait speed (m/s)/(SD) ST	Gait speed (m/s)/(SD) DT
Yogev-Selgimann et al., 2010 [13]	This study investigated the effects of task prioritization on walking in young and older adults to evaluate the "default" prioritization scheme used.	40 young adults Mean age: 26.8years 17 older adults Mean age: 72 years Totally sample size: 57	Participants were instructed to walk at their preferred pace on level ground in a well-lit, obstacle-free, 30-m-long corridor for 1 minute under 4 conditions: (1) usual walking with no dual task, (2) no priority, (3) cognitive priority, and (4) gait priority.	Recall as many words as possible beginning with a predefined letter for 1 minute	Young adults 1,45 m/s (0,14) Older adults 1,35 m/s (0,24)	Dual-task no – priority Young1,28 m/s Older 1,18 m/s Gait priority Young1,36 m/s Older 1,22 m/s Cognitive priority Young1,24 m/s Older 1,15 m/s
Nohelova et al. 2021 [14]	Gait variability and complexity during Single and Dual-Task Walking on Different Surfaces	Twenty-nine healthy young adults aged 23.31 ± 2.26 years (18 females, 11 males)	Walk 45 m at a preferred walking speed as straight as possible, outdoor environment on three different surfaces	Manual-Carrying a Cup Dual-Task Cognitive—Subtracting	Asphalt 1.54 m/s Cobblestones 1.53 m/s Grass 1.55 m/s	Cognitive DT Asphalt 1.51m/s Cobblestones 1.52 m/s Grass 1.53 m/s Manual DT Asphalt 1.48 m/s Cobblestones 1.52 m/s Grass 1.50 m/s
Master thesis Wiktoria Szumniak [15]	Selected indicators of gait with crutches under conditions of an additional cognitive task.	20 women, between the ages of 18 and 29, healthy, no previous experience of walking on crutches	Walking twelve times an 8-meter measuring path with a gait on crutches in a preset pattern using BTS G-WALK.	DIVA test	0.68 m/s	0.73 m/s
Master thesis Iwona Błażko [16]	Influence of flip-flops on changes in gait indicators	20 students Median age: 24	Selected gait indicators were tested using the BTS G-WALK and the DIVA-gait test.	DIVA test	Without shoes 1,16 m/s (0,17) With flip-flops 1,16 m/s (0,18)	Without shoes 1,19 m/s (0,17) With flip-flops 1,20 m/s (0,20)

Article	Study design	Population characteristicsic	Walking Task	Secondary task	Gait speed (m/s)/(SD) ST	Gait speed (m/s)/(SD) DT
Master thesis Karolina Ryś [17]	Effects of low-dose alcohol on selected gait indices with an additional cognitive task in young women.	10 young women, good mental and physical health, age in the range of 18- 26 years	Walking twelve times an 8-meter measuring path using BTS G-WALK.	DIVA test	Without an alcohol 1,29 m/s After alcohol consumption 1,26 m/s	Without an alcohol 1,47 m/s After alcohol consumption 1,42 m/s