

Review Article

Dual-task exercises in older adults: A structured review of current literature

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Abstract

Considerable attention has recently focused on the role of dual-task exercises (DT) in the older adult. The aim was to conduct a review to describe the dual-task exercises that have been shown to be effective in improving balance and other physical characteristics such as decreased falling and walking speed in older adults. Review of intervention studies, in the Pubmed, PEDro, CINAHL and Web of Science databases. The search produced 498 references, 11 of which were identified with the description of the dual-task exercises, finding a wide variety of exercises, as well as great variability of outcome measures, discovering that the dual task is predominantly used for balance and walking speed training. All studies presented at least one group performing a double cognitive-motor task, some studies used the fixed priority modality in one group and variable in another, finding greater improvements in variable prioritisation. It can be said that dual-task training in older adults can improve balance and walking speed, which in turn reduces the risk of falling only if the planned dual-task training meets certain characteristics, such as training in specific concepts crucial in motor learning and dual-task training modalities.

Keywords: Ageing, Balance, Dual task, Risk of falling, Walking speed

Introduction

Today, ageing is considered a politically, economically and healthwise relevant issue; statistics infer that by 2020 the number of people over 60 will be greater than the number of children under five¹. The World Health Organisation (WHO) provides data that estimate that the percentage of the world's population over 60 could double between today and 2050, from 12% of the world's population to 22%¹.

The functional decline that comes with ageing facilitates the decrease in effectiveness or speed of the executive function, which is basic for proper functioning in daily life⁵. Everyday actions such as walking while talking, or reading an ad in the supermarket, can be interfered with in the older adult. When the processing level of two actions begins to deteriorate due to decline in cognitive or executive functions, it becomes a potential threat to an older person's independence⁶. Under "normal" conditions, our brain constantly develops dual-task actions, but in stages of neurological pathologies and in ageing itself, the performance of DT and multiple tasks may be affected, causing problems for the development of daily living activities (DLA).

Previous studies have indicated that performing

two tasks simultaneously can negatively affect walking performance^{7,8}. The literature describes that DT interference affecting walking performance has been observed not only in healthy subjects⁹⁻¹¹, but also in subjects with neurological disorders^{9,12,13}. Therefore, maintaining and improving walking ability in DT situations is an important goal for prolonging functionality.

The current ageing of the population is leading to a greater number of older, octogenarian and beyond, multipathological, polymedicated people with a clearly compromised functional reserve, which puts them at risk of frailty, or makes them

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directly fragile, and at risk of disability and dependency^{3,14}. This leads us to consider that in the following years, there will be an increase in dependency and disability in the population, not only due to demographic change in the population, but also due to various lifestyle factors, which can be perfectly modified³.

These facts lead to the search for strategies and action plans to delay the arrival of the elder's dependence and vulnerability.

The evidence that interventions focused on physical activity are effective in delaying and even reversing frailty¹⁵, points to the importance of using interventions that can be implemented in the community, ones aimed at active and healthy ageing. Because of this, there is growing interest in the study of interventions that show good influence in the treatment and improvement of balance problems, reduction of walking speed and the risk of falls factors associated with aging that influence the appearance of frailty³.

At present, there are protocolised physical activity programmes to reduce the risk of falls¹⁶ and to prevent or improve frailty¹⁷, but these programmes usually include only or mostly physical functions, leaving the cognitive part aside.

The existing literature points to the importance of carrying out DT activities in daily life⁶. The evidence supports that physical and cognitive training counteracts age-related deterioration in physical and mental function, supporting the effectiveness of DT training in age-related functional decline¹⁸, and is used for various objectives: improvement of gait¹⁸, improvement of balance and prevention of falls¹⁹, and cognitive efficiency in ageing²⁰.

However, there is controversy in the literature on DT training, since there are reviews that highlight the diversity of training tasks and evaluation methods employed²¹ and also the variability in the type and complexity of both tasks²².

This work aims to review and describe the exercises implemented by the different studies that make use of DT strategies for the intervention of physical factors related to balance in older adults. Evidence on the contents of DT exercises that have been shown to be effective on balance and on other parameters such as walking speed can be used to guide the development of a DT exercise programme, as well as to guide clinicians in deciding what type of exercise to use.

Material and methods

A systematised literature review of documents that included DT activities for implementation in older adults was conducted.

Firstly, the following databases were defined for the review: Pubmed, PEDro, CINAHL and Web of Science. They were chosen because they are databases that index a high percentage of the world's health sciences research production. The search period was planned between 2009 and 2019. Search strategies were defined for each of the bases (Table 1).

Pubmed	(«Task Performance and Analysis»[Mesh] OR dual-task OR «multiple task») AND (older OR elderly OR aging OR «Aged»[Mesh]) AND (balance OR «postural stability» OR «Postural Balance»[Mesh])
PEDro	Advanced search: Abstract & Title: dual-task* balance* Subdiscipline: gerontology Method: Clinical trial
CINAHL	dual-task* aged* postural balance
Web of Science	(dual task AND aged AND balance)

Table 1. Search strategies according to the database.

The bibliographic references of the finally selected articles were also analysed in order to rescue other studies potentially eligible for the review. No exclusion was made for language.

A reviewer made a final selection by reading the content of the articles. We included published intervention studies on the topic of DT, including those studies that used an outcome measure related to balance and walking speed, and that described the DT exercises performed. Only studies that found promising results were considered. Operationally, those studies that involved adults over 60 years old were included, both those that included neurological pathologies and those related to other problems within ageing.

We excluded all those studies that, despite having significant results, did not describe the exercises used as DT.

To perform the analysis of the DT programmes used in the trials, one of the reviewers proceeded to read the selected articles. Data such as demographic characteristics, including age, size and gender of the population, study outcomes, groups and interventions, intervention time and types of DT were extracted from these articles.

The above data selection provides a narrative synthesis of the findings of the included studies, along with a summarising table.

Results

The initial search produced 498 articles, of which 92 were potentially eligible according to the selection criteria. Finally, 11 articles were selected and obtained through the different routes set out in the selection procedure. This documentary search allowed the identification of the exercises that are commonly used for DT and that have obtained evidence in physical parameters like balance and gait speed from the participants of the investigations.

Conceptual description

Most of the studies identified, quantified as outcome measures the gait performance of in DT²³⁻²⁸, and many in turn measured static and dynamic equilibrium with a variety of

Table 2. Description of intervention time, outcome measures, groups and DT intervention.

Study	Duration of intervention	Outcome measures	Intervention groups	DT
Liu Y, Yang Y, et al. 2017 ²³	30 min, 3 times/week, 4 weeks	• progress on a task • cognitive-motor DT walking • motor-driving DT. • stride • cadence Measured with the GAITRite system	1. TFC 2. DTC 3. DTM	DTC: walking while doing mathematical operations, repeating word sequences, searching for names, etc. DTM: walking, while holding something, or manipulative actions.
Konak H, Kibar S, Ergin E. 2016 ²⁹	45 min, 3 times/week, 4 weeks Individualised	• Static balance, assessed with posture on one leg • Dynamic balance and mobility: BBS, TUG and walking speed • ABC	1. Group balance in a single task 2. Balance group in DT	DT exercises: postures on two feet, semi-tandem, tandem, support on one foot; dynamics such as tandem walking or turning, heel or toe support, accompanied by cognitive tasks, such as counting backwards, naming objects that had been described in detail before
Azadian E, Torbati H, et al. 2015 ⁶	45 min, 3 times/week, 8 weeks	• Simple support • Double support • Running speed (6 min) • Cadence • Stride	1. DTC: 2. EF 3. One control group	DT: first 6 sessions, only motor tasks (one task); from the 7th – 12th session, motor task with a simple cognitive task; from the 13th – 24th session, more difficult cognitive tasks.
Peirone E, Gorla P, Anselmino A. 2014 ³¹	50 min, 3 times/week, 7 wks. Traditional physiotherapy + 30 min, 6 times/week 7 wks.	• BEST • ABC • GAS	1. Intervention group DT 2. Control group	DT: standing on an unstable surface with eyes closed, with different support bases, plus a second manipulative motor task or cognitive task.
Bharti, Kumar C. 2014 ³²	45 min, 3 times/week, 4 weeks	• TPOMA	1. DT intervention group with fixed priority 2. DT intervention group with variable priority	DT: balance tasks such as posture maintenance, walking activities, plus secondary tasks such as subtraction, auditory and visual discrimination. Prioritisation according to group.
Lemke N, Werner C, Wiloth S, et al. 2018 ²⁴	10-15 min, 2 times/week, 10 weeks	DT performance in 3 conditions: • Trained DT • DT semi-trained • Untrained DT	1. Control group (non-specific low intensity exercises) 2. Intervention group (specific training of DTs)	DT: walk plus arithmetic activity, they started with one task and when they were confident, a simple arithmetic activity was added, which progressed in difficulty.
Plummer-D'Amato P, Cohen Z, Daee N, Lawson S, et al. 2012 ²⁵	45 min, 1 time/week, 4 weeks	• TUG • Speed in 6 metres in a single task • DT gait speed • ABC	1. Control group, single task training 2. Intervention group, DT training.	DT: balance and gait exercises, maintaining postures, walking on a foam beam, etc., plus number randomisation, word association, reciting and memory work. Change of prioritisation.
Andrade LP, Gobbi L, Coelho F, et al. 2013 ³⁰	1 hour, 3 times/week, 16 weeks	• TUG • BBS • Postural control in DT	1. Control group (no activity during the study) 2. DT intervention group	DT: motor tasks such as: walking, bouncing a ball, exercising with weights, plus cognitive tasks such as: pronouncing animal names, counting backwards, naming shapes and colours.
Silsupadol P, Shumway-Cook A, et al. 2009 ¹⁹	45 min, 3 times/week, 4 weeks	• Running speed under single task conditions • Gait speed under DT conditions • BBS • ABC	1. Group control balance training of a single task 2. Fixed priority intervention group DT 3. Variable priority intervention group DT	DT: standing on an unstable surface, standing in tandem, walking with a narrow support base, walking backwards; more cognitive tasks such as naming objects, remembering numbers. Using the prioritisation that corresponded to each group.
Yamada M, Aoyama T, Tanaka B, et al. 2010 ²⁷	50 min, 1 time/week, 24 weeks	• Running speed under task conditions • Gait speed under DT conditions • TUG • Balance on one leg • Functional scope	1. Control group training with a task 2. DT training control group.	DT: sitting, they performed a motor activity of taking steps, plus the cognitive task of verbal fluency such as naming animals, words that begin with a certain letter, etc.
Strouwen C, Molenaar E, Keus S, et al. 2019 ²⁸ Strouwen C, Molenaar E, Keus S, et al. 2014 (RCT protocol) ³⁴	30 min, 4 weeks, 6 weeks Only with accompaniment by physiotherapy twice a week.	• DT Gait speed • ABC • PDQ-39 • FOGQ	1. Consecutive task training. 2. Integration of DT.	DT is more cognitive activity such as: verbal fluency, discrimination and decision making, mental and reaction time monitoring. Functional tasks of DT.

BBS = Berg Balance Scale; TUG = Time Up and Go; ABC = Activities-specific Balance Confidence Scale; BEST= Balance Evaluation System Test; GAS= Goal Attainment Scaling; TPOMA= Tinetti Performance Oriented Mobility Assessment; PDQ-39 = Parkinson's Disease Questionnaire for quality of life; FOGQ = Freezing of Gait Questionnaire; CTF = Conventional Physical Therapy; DT = Dual Task; DTC = Dual Task Cognitive; DTM = Dual Task Motor; EF = Executive Function; CTT= Consecutive Task Training; DTI = Dual Task Integration.

Study	Population	n	Age (years and standard deviation)	Sex (n)
Liu Y, Yang Y, et al. 2017 ²³	Post-stroke.	28	50.2 11.2	NR
Konak H, Kibar S, Ergin E. 2016 ²⁹	Adults with osteoporosis.	42	45-88	3=men 39=women
Azadian E, Torbati H, et al. 2015 ⁶	Older adults with balance problems.	30	73.8	NR
Peirone E, Gorla P, Anselmino A. 2014 ³¹	Adults with acquired brain damage.	16	39.62 13.89	9= men 7= women
Bharti, Kumar C. 2014 ³²	Institutionalised older adults with impaired balance.	30	≥65	Does not describe
Lemke N, Werner C, Wiloth S, et al. 2018 ²⁴	Adults with dementia.	105	82.7 6.2	29= men 76= women
Plummer-D'Amato P, Cohen Z, Daee N, Lawson S, et al. 2012 ²⁵	Older adults.	17	65-83	1=man 16= women
Andrade LP, Gobbi L, Coelho F, et al. 2013 ³⁰	Older adults with Alzheimer's.	30	78.6 7.1	NR
Silsupadol P, Shumway-Cook A, et al. 2009 ¹⁹	Older adults with impaired balance.	23	76.0 4.65	6= men 17= women
Yamada M, Aoyama T, Tanaka B, et al. 2010 ²⁷	Older adults.	53	67-97	NR
Strouwen C, Molenaar E, Keus S, et al. 2019 ²⁸	Adults with Parkinson's disease.	121	65.93 9.22	NR

NR= Not reported

Table 3. Description of demographic characteristics such as population, age, gender and sample size.

scales or measurements, including support on one foot^{6,27,29}, Time Up and Go (TUG)^{25,27,29,30} and the Berg Balance Scale (BBS), which was used by three studies^{26,29,30}. Other scales, such as the Balance Evaluation System Test (BEST)³¹ and the Tinetti scale³², were used to a lesser extent.

Regarding the structure of the studies, all presented at least one group that performed cognitive-motor DT. Many determined that a fixed priority DT is performed, which means that the participant is asked to try to pay equal attention to both tasks³¹. In at least one of the studies, both groups did DT exercises, one with fixed priority and another with variable priority, finding greater improvement in those participants in the variable priority group³². We found two studies which had three groups, a control and two intervention groups, with DT activities with differentiated characteristics^{6,26} to a lesser extent. We identified a single study in which the control group did not carry out any intervention³⁰.

The duration and time of intervention was very varied, finding a higher number of interventions that lasted 4 weeks^{23,25,26,29,32}. The longest interventions were 24 weeks²⁷ and 16 weeks³⁰. The rest of the interventions had a duration of between 6 and 10 weeks (Table 2).

Characteristics of the scope and population

The interventions were developed in diverse settings, in community dwelling people^{27,33} and people living in care homes^{24,32}.

Concerning age, only three studies accepted people of average adult age, all of them adults with neurological^{23,31} and skeletal²⁹ pathologies, while the rest of the studies had only an older adult population. As regards sex, those studies that identified it had a predominance of females^{19,24,25,29} (Table 3).

Discussion

Most of the studies compiled and analysed mainly assess the yield of the gait performance in DT, followed by balance; and some assess specific characteristics of walking.

One noteworthy aspect is that almost all studies considered the use of cognitive-motor DT physical activity; some began with the use of motor-motor exercises, progressing to cognitive-motor^{6,29}; and finally some studies did not consider motor-motor DT exercises, but instead began directly with cognitive-motor DT exercises^{31,32}.

On the other hand, there is a variability of tasks used and training approaches and, at the same time, a great diversity of methods to evaluate the results, which makes it difficult to make comparisons. However, it is important to consider that studies show that DT training strategies are clinically relevant on multiple levels, mainly at the motor level and especially on balance and gait^{35,36}.

Walking speed can be considered a good indicator of functional balance and risk of falls in older adults^{37,38}. Since walking speed and the ability to increase it is important

for the activities of daily living, studies report that an improvement of 0.10 m/s in walking speed for a single task is considered a substantial change in older adults³⁷. The studies included in the review report improvements that exceed the indicated value. It is relevant to note that all studies present such improvements in all participants, both in those who performed training activities in a single task, and among those who performed training programmes in DT. However, the results of DT training are superior to single task training for the improvement of walking speed under single or DT conditions^{26,29,31}.

The results reported are interesting, bearing in mind that it has been shown that the performance capacity of DT decreased in older adults, due to the impact on the prefrontal cortex while performing two tasks³⁹. Despite this, studies indicate that the performance capacity of DT can be improved by increasing the neuroplasticity of the brain (the basis of motor learning)⁷. At the same time, we must keep in mind a crucial principle in motor learning, namely the training in specific concepts using frequent repetitions of specific task exercises to improve their performance⁴⁰. Therefore, performing a specific type of repeated exercise may be an effective approach to develop such neuroplasticity.

Furthermore, the practice of two tasks simultaneously is indispensable for the improvement of task coordination skills as well as motor and cognitive performance in DT conditions^{40,41}. The Silsupadol Findings correspond to the premise that older adults can improve their walking performance in DT conditions only after concrete training, and that training in single-task conditions may not be generalisable to observe an improvement of walking performance in the context of DT¹⁹.

With respect to balance training in DT, it should be noted that explicit instruction regarding the focus of attention should be included when balance is trained under DT, since the use of variable prioritisation instruction showed faster acquisition and greater transfer compared to older adults trained in fixed prioritisation^{42,43}.

It is important to consider the transferability of training performed in DT, since the degree of transference that occurs after DT training may be limited and indicates that the effects of cognitive motor training may be specific²⁴. The transferability of trained tasks to those that are not, would be more likely when training and evaluation tasks involve related demands requiring similar skills⁴⁴. Kramer's theory contemplates that the improvements in new DT possibilities are given by the development of improved DT processing skills and that these skills can be transferred to other DT contexts that are not directly trained but that share similarities⁴¹.

In several studies conducted on healthy older adults transferability behaved heterogeneously, with some research showing no transferability^{19,45} and other studies showing adequate transferability^{41,42,44,46,47}. The modalities of DT training appear to play an important role in transfer,

showing that variable prioritisation training leads to greater transfer effects than fixed prioritisation training²⁴.

Among the limitations, the existing heterogeneity in the exercises, the lack of specification and classification of the difficulty of the secondary task, a sample size under 30 in some studies^{25,31,33} and the lack of transferability^{19,45} of the performance to the untrained activities, require careful consideration of the results obtained. However, the main strength of this review lies in the descriptive analysis of DT programmes used in interventions focused on the older adult with balance problems and risk of falling, and not just in an analysis of the results, thus providing a view to the clinician of the type of DT he or she might select at the time of an intervention.

Conclusions

DT exercises in older adults can have an adequate influence on the improvement of balance and walking speed, influencing, in turn, the reduction of the risk of falls. However, this is so only if the planned DT training is carried out in older adults who maintain a minimum of cognitive activity; if it is carried out considering the adequate level of attention; if variable prioritisation is included; and if the activities in which transfer is intended are considered. The use of these parameters in the application of DT seems to be the most promising line.

Further study of the effect of DT in older adults is required, examining what the most appropriate characteristics for a DT programme are and with adequate sample sizes and uniform outcome measures.

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