REVIEW ARTICLE

# Dual task training as a therapeutic strategy in neurologic physical therapy: a literature review

Tassiana Mendel[1], Wilames Oliveira Barbosa[2], Adriana Campos Sasaki[3]

## ABSTRACT

**Objective:** Discuss the possibilities of dual task in the ambit of neurological rehabilitation. **Methods:** A survey was conducted in PUBMED, MEDLINE, LILACS, and PEDro, using the keywords "dual task" associated with each of the following terms separately: treatment, physical therapy, rehabilitation, exercise, training, divided attention, executive functions, and attentional demands. We selected only clinical trials that used dual task training in adults with neurological disease. **Results:** From the 2,024 articles found, 1,017 were excluded because they are duplicate. Among the remaining 1,007 articles, 998 were excluded after reviewing the abstracts. Nine articles were selected that included patients with stroke, brain injuries, Alzheimer's, and Parkinson's disease. Most articles used gait as the primary task, and in six studies the second task was cognitive. The training programs ranged between a total of 9 and 48 hours of training. **Conclusion:** Dual task training appears to improve gait, cognition, automation skills, and transference of learning, suggesting that this may be a valuable strategy for neurological rehabilitation. Nevertheless, it is still necessary to explain which tasks are more efficient and how long the learning retention lasts.

**Keywords:** Executive Function, Exercise Therapy, Attention, Neurology, Rehabilitation

[1] Physiotherapist, Master's candidate in the Graduate Program in Health Sciences at the Universidade Federal da Bahia - UFBA.
[2] Physiotherapist, Resident in Adult and Elderly Health, Hospital Universitário de Sergipe.
[3] Physiotherapist, PhD in Health Sciences, Assistant Professor at the Universidade do Estado da Bahia - UNEB, and at the Escola Bahiana de Medicina e Saúde Pública.

Mailing address:
Adriana Campos Sasaki
Rua Artur de Sá Menezes, 268
CEP 41810-480
Salvador - BH
E-mail: asasaki@uneb.br

Received on July 9, 2014.
Accepted on September 22, 2015.

DOI: 10.5935/0104-7795.20150039

## INTRODUCTION

The ability to execute two tasks at the same time is necessary and commonly used by human beings in the performance of various activities of daily living.[1,2] This capability represents an evolutionary advantage, since it allows the individual to perform various activities concurrently, with lower neural activation, using less than with doing the same tasks separately.[3] The loss that one - or both - suffers is called dual task interference. Its presence creates disadvantages and may lead to the risk of bodily injury when one of them requires close postural control or screening of environmental risks.[4-6]

Several studies have demonstrated the presence of dual task interference in individuals with a neurological disease or injury, such as Parkinson's, Alzheimer's, Huntington's Disease, multiple sclerosis, traumatic brain injury (TBI), or stroke (CVA).[5-10] It can be expressed in the gait as a decrease in the speed, in the length of the stride, and in the cadence and as an increase in the time of double support.[5,11,12] The interference can also occur in the form of a worse performance of the upper limb, a decrease in the number of words spoken, and an increase in body oscillation, among other things.[13-15]

Three theoretical models were developed in order to explain the dual task interference. The capacity theory - or theory of sharing resources (the capacity model), is based on the assumption that the attention resources are limited, leading to loss in the execution of one or two tasks when the processing capacity is exceeded. The crossed communication theory (the cross-talk model) explains that similar tasks use the same routes, thereby reducing the risk of dual task interference. Finally, the bottleneck theory (the bottleneck model), in contrast to the previous theory, says that similar tasks are competing for the same processing routes, generating loss in performing one or both tasks.[16]

Depending on the type of activities performed, the dual task can be motor, cognitive, or motor-cognitive. A rehabilitation strategy increasingly used is the dual task training, which seeks to facilitate, by means of conducting concurrent functional activities, the allocation of attention resources, thus decreasing the dual task interference.[17,18]

Currently, physiotherapists have focused their attention not only on the motor performance of neurological patients, but also on the cognitive aspects and those related to the environmental context of these individuals.[17] The executive functions, especially the divided attention, verified by the completion of concurrent tasks, have been the target of these professionals' interest both in observational studies as well as in intervention studies. This indicates that the performance in dual tasking can be an important item in both the evaluative approach as well as in the physiotherapeutic intervention. The present study will approach the use of dual tasking exclusively as an intervention strategy.

Despite the substantial growth in the number of publications on the theme, few studies deal specifically with the use of dual tasking as a therapeutic resource and there is still little systematization regarding this use. Knowing that it is a low-cost resource and extremely rich in possibilities of application, this study is justified to encourage discussions of this issue.

## OBJECTIVE

The objective of this work was to discuss the possibilities of using dual tasking in the rehabilitation of neurological patients.

## METHOD

The bibliographic research was performed in the PEDro, PubMed, LILACS, and MEDLINE databases, in the period between August and September of 2012. There was no restriction as to the language or date of publication. The term 'dual task' was used associated separately with eight other descriptors: treatment, physical therapy, rehabilitation, exercise, training, divided attention, executive functions, attentional demands.

Clinical trials were included that used dual task training in individuals with neurological disease or injury. Exclusion criteria were: absence of a control group, non-randomization of the sample studied, and studies developed with pediatric populations.

## RESULTS

The electronic survey yielded 2,024 articles. Of these, 1,017 were excluded because they were duplicate. After careful analysis of the abstracts, carried out by a single examiner, 998 articles were excluded, leaving only 9, that presented the characteristics necessary to be included and discussed in this study (Figure 1).

Table 1 shows the general characteristics of the articles included in this review. Among the nine articles included, eight were published in the last 5 years.[19-26] The composition of samples ranged between 12 and 92 individuals[20-22] with a total of 303 subjects. The neurological conditions varied, with the most prevalent being stroke and brain injury, with 4 and 2 studies, respectively.[19-21,25-27]

Regarding the interventions to which the individuals were submitted, most authors used gait as the main task, and one article evaluated the control of trunk, with the patients seated.[25] In six studies at least one cognitive activity was applied as a secondary task.[19-24] Only three studies used motor dual tasking.[25-27] The time of each session varied between 30 minutes[23] and 1 hour per day,[21,23,24] and between 4 weeks[27] and 4 months.[20] The total time of intervention varied between 9[25] and 48 hours of training.[23]

To analyze the gains from the practice of dual tasking, the studies used different measures. Some studies evaluated the gait parameters[22,24,26,27] and five studies also evaluated executive functions.[19,21-24] Other variables evaluated were postural control,[21,24,26] the number of falls,[24] and the performance in tasks of everyday living.[19,21] All the studies presented improvement of the variables analyzed post-training in experimental groups. Only one study evaluated retention of the results obtained and the transference to other tasks not included in the intervention.[22]

## DISCUSSION

All the articles selected pointed to the effectiveness of the dual task training in the neurological population. Despite presenting positive effects after the interventions, there was a considerable discrepancy in the choice of measuring methods and of parameters evaluated to demonstrate these results.

Of the studies analyzed, 5 underwent evaluation of some cognitive aspect.[19,21-24] Cognitive impairment is an important risk factor for falls, doubling the risk of this type of event occurring, mainly when the individuals are in multitasking situations.[28] Executive dysfunctions are widely documented in the neurological population.[29,30] In studies conducted with individuals diagnosed with Alzheimer's disease, it was observed that their dual tasking performance was already compromised since the early stages of the disease. This indicates that even when the cognitive deficit is not evident, the problems

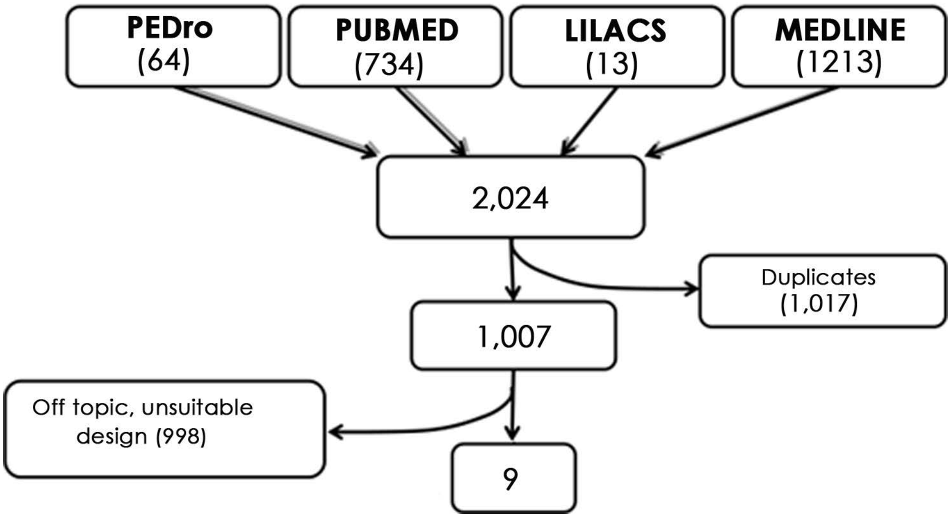


**Figure 1.** Illustration of the electronic search

generated by the dual task interference may occur.[31,32] In the case of acquired injuries, deficits may persist even after the period of rehabilitation, as identified in the study of Lesniak et al, in which hemiparetic individuals presented with attention deficit even a year after their stroke.[33]

Teixeira & Alouche[1] studied individuals with Parkinson's and found positive results in their performance of the cognitive and motor tasking during gait after three repetitions. These results indicate that, despite the injury or neurological disease installed, this population is still able to learn and automate motor skills, thus providing favorable evidence that long and intense intervention periods are not required for positive results to be observed.

Imaging exams help to identify specific neuronal groups activated by certain tasks. Wu & Hallett[3] observed in a functional MRI, that those with Parkinson's had more intense cortical activation than the control group, made up of healthy individuals, when performing dual tasks. After repetition of motor sequences, a reduction was observed in the intensity of activation to levels closer to normal in the group of patients. These results indicate that the recruitment of more cortical tissue happens in an attempt to decrease the dual task interference, generated by executive deficit. To the extent that the automation of movements occurs, reduced interference also occurs without the need to request more neural processing resources.[3]

Four authors used gait as their primary task.[22,24,26,27] This might be due to the strong influence of the dual task interference on ambulation. It is known that in older populations, falls tend to happen during gait, in particular when this happens simultaneously to tasks of everyday living such as talking or carrying an object.[33] Lord et al.[34] reported that victims of stroke have great dissatisfaction in their ability to ambulate in a community environment, whose ideal speed would be at least 80 cm/s.

Petterson et al.[31] have observed decreased gait speed in individuals with Alzheimer's disease. Similar results were found in studies conducted with individuals who have suffered stroke, brain injury, and Parkinson's disease.[2,8,10,35] Other alterations also experienced by this population, due to dual task interference, are the increase in the time of step,[36] step length,[37,38] step variability,[38,39] gait symmetry,[40] and stride length and cadence.[6]

Yang et al.[27] assessed the impact of a motor dual task program in the gait parameters of 25 patients after a stroke. The control group (CG) underwent no rehabilitation program, and the experimental group (EG) was submitted to a program of exercises with motor dual tasking, using the gripping, passing, kicking, and throwing of balls. Shimet al.[26] also evaluated individuals who had suffered a stroke, with the CG exercising to gain range of motion, functional mobility, and gait training, and with the EG performing the same training associated with the motor dual task training with ball activities. In another study with Parkinson's patients, the CG was not submitted to any intervention and the EG was guided to walk while performing subtractions, configuring it as a motor-cognitive dual task.[22] To investigate the impact of dual task training in elderly patients with diagnosis of dementia, Schwenket al.[24] compared the effects of nonspecific low intensity exercises (CG) with that of exercises based on concurrent motor or cognitive dual tasking (EG).

There was significant improvement in the spatial parameters of gait such as the length of the stride, and temporal parameters such as the speed and cadence in all the studies sampled in the present study.[24,26,27] Plummer-D'Amato et al,[6] in contrast, observed no alteration in variability in the time of step in individuals who had suffered a stroke. These findings are also in contrast with the results found by You et al.[41] who observed no significant improvements in gait parameters for elderly people. One possible explanation for these changes in ambulation is that these would, in fact, be a result of compensatory mechanisms used in an attempt to alleviate the postural instability experienced by these individuals, thus minimizing the risk of falls since higher speeds require greater control over one's postural balance.[2] As one of the main objectives of physical therapy is recovering mobility, gait is a frequent target of neurological rehabilitation programs.[27]

All the studies of the sample used at least one cognitive activity as a secondary task. These involved mainly verbal fluency and arithmetic operations. In spite of recent studies suggesting that different tasks generate different interferences, there is still no consensus in the literature that indicates the superiority of cognitive over motor tasks in improving dual task performance.[12,33,42]

Only two studies used motor activities as secondary tasks.[25,27] In the study by Yang et al.[27] they used Swiss balls and basketballs, involving activities of gripping, handling, and throwing during ambulation. Lee et al.[25] developed a treatment protocol to be carried out in three two-week stages with gradually increasing difficulty of the dual task activities involving handling cups, throwing balls, and a game with ball and paddle, all while seated. Although requiring voluntary contraction of the muscle system-and hence being classified as motor tasks-they require constant involvement of the nervous system to control the force, the coordination, and the tracking of targets. A similar result was observed by Plummer-D'Amato et al.[6] in a study with individuals who had suffered a stroke, in which it was found that spontaneous speech generated more interference in the gait than vi-

**Table 1.** General characteristics of studies that used dual tasking as a therapeutic resource in the rehabilitation of neurological patients

| Authors, year (country) | Target population (n) | Groups | Type of intervention | Duration and frequency of intervention | Measured outcomes | Results |
|---|---|---|---|---|---|---|
| Yang et al.[27] 2007 (Taiwan) | 25 individuals who suffered stroke | CG (n = 12) EG (n = 13) | CG: had no rehabilitation program; EG: Exercise program based on dual task, with the use of balls (gripping, passing, kicking, throwing, etc). | 3 times/week, for 4 weeks. | Gait parameters during motor dual task (GATIRite). | EG presented improvement in all measures of gait, except for temporal symmetry index. There was no significant difference in the CG. |
| Evans et al.[19] 2009 (United Kingdom) | 19 individuals who suffered brain injury | CG (n = 10) EG (n = 9) | CG: Continued with unspecific rehabilitation EG: Motor-cognitive dual tasking | 2 times of 30 minutes/ day, 5 days/week, for 5 weeks. | Estimated pre-morbidity intellectual level (Spot the Word Test), attention and dual tasking (tests developed by the authors), additional measure of dual tasking capacity (Memory Span & Tracking Task), dual tasking test (Telephone Search with Counting), reports of dual tasking in daily life (Dual-tasking Questionnaire). | Performance improvement of the primary outcome and performance improvement in dual tasking in activities of daily living. |
| Couillet et al.[21] 2010 (France) | 12 individuals who have suffered severe brain injury | AB group (n = 6) BA group (n = 6) | AB: cognitive tasks that did not involve divided attention or working memory; BA: dual task training | 2 phases (AB, BA), each one with 6 weeks, 4 sessions per week for 1 hour each | Specific measures of dual tasking (Divided attention-TAP subtest; Go-no go and digit span), executive tasks and working memory (Flexibility - TAP subtest; Trail-Making test; Stroop test; Brown-Peterson paradigm), divided attention in tasks of daily living (Rating Scale of Attentional Behavior) and non-target measures (Phasic alertness" TAP subtest; Go-no go; digit span). | Significant effect in the dual tasking measurements and in the divided attention item from RSAB. Small effect on executive measures and no significant effect on non-target measures. |
| Lee et al.[25] 2012 (Korea) | 28 individuals who suffered stroke, in the chronic phase | CG (n = 14) EG (n = 14) | CG: Conventional exercise program (CEP), seeking flexibility gain, muscular resistance and strength, and training of ADLs. EG: CEP and motor dual task training (MDT). | CG: 5 sessions of 1 hour/ week, for 6 weeks (CEP) EG: 5 sessions of 1 hour/ week, for 6 weeks (CEP) and 3 sessions of 30 minutes/week, for 6 weeks (MDT). | Control of trunk (Trunk Impairment Scale) and balance (Modified functional reach test) sitting. | Dual task training associated with a conventional exercise program has improved the control of trunk and the balance of seated patients. |
| Pedroso et al.[23] 2012 (Brazil) | 21 elderly with Alzheimer's disease | CG (n = 10) EG (n = 11) | CG: regular practice of physical exercises; EG: a program of physical exercises with cognitive tasks. | Sessions of 1 hour, 3 times/week, for 4 months. | Number of falls (questionnaire), cognitive function (MMSE), cognitive functions (FAB), executive functions (CDT), functional mobility and risk of falls (TUG), and balance in functional tasks (BBS). | Improvement was observed in the performance of the EG in relation to balance and executive functions. The practice of exercises with dual tasking seems to have contributed to the cognitive and motor improvement of the individuals. |
| Schwenk et al.[24] 2010 (Germany) | 61 elderly with dementia | CG (n = 35) EG (n = 26) | CG: nonspecific low intensity exercises; EG: training exercises based on concurrent motor or cognitive dual task. | 2 sessions of 1 hour/ week, for 12 weeks. | Clinical characteristics, gait during dual tasking (GAITRite), cognition (additions and subtractions are done correctly). | The training significantly improved their performance in dual tasking. |
| Fok et al.[22] 2011 (Australia) | 12 individuals with Parkinson's disease | CG (n = 6) EG (n = 6) | CG: not received intervention. EG: motor-cognitive dual task (walking while doing subtractions). | 30 minutes - period not specified | Gait parameters (GAITrite) and rate of correct arithmetic answers. | Immediate and short-term improvement of the stride length and of gait speed in the EG in relation to the CG, except for the correct arithmetic rate. |
| Zheng et al.[20] 2012 (China) | 92 individuals who suffered a stroke | EG (n = 47) CG (n = 45) | CG: Conventional balance training; EG: Conventional cognitive dual task balance training (answering questions and doing arithmetic operations). | 40 minutes/week, 3 times/week, for 8 weeks. | Static Balance (Biodex Balance System). | CG presented significantly greater displacement toward mid-lateral direction with eyes open and closed. |
| Shim et al.[26] 2012 (Korea) | 33 individuals who suffered a stroke. | CG (n = 16) EG (n = 17) | CG: exercises for gaining range of motion, mobility and gait training. EG: exercises for gaining range of motion, mobility, and gait training associated with motor dual task training - activities with a ball | CG: sessions of 30 minutes, 5 days/week, for 6 weeks. EG: sessions of 30 minutes, 5 days/week, for 6 weeks and sessions of 30 minutes, 3 times/ week, for 6 weeks (dual task training) | Gait parameters (GAITrite) | Significant improvement of temporal (speed and cadence) and spatial (step and stride length parameters, support phase of the paretic and non-paretic limb). |

sual-spatial and memory tasks. These data lead to questioning the degree of motor or cognitive participation in each of the tasks employed in this modality of rehabilitation.

Only one study mentioned retaining the the resulting capacities produced with the dual task training,[22] indicating that, in addition to the learning potential and automation of motor sequences, these patients have the capacity to maintain the results for a period of time, being evaluated only 30 minutes after the end of the intervention. Brauer et al.[42]

suggested the conduction of studies that examine the effect of interventions in the long term and subsequent evaluations to these interventions, in order to further investigate the effect of retention.

Also reported was an improvement in the performance of tasks not trained after intervention, indicating that this population can transfer the acquired skills to tasks not included in interventions.[22] Similar results were found in a study conducted with individuals with Parkinson's, in which improvement of visual spatial performance was observed after verbal and numeric task training.[42] The transference of ability is important because it is impossible to cover all tasks of daily living that can be performed while walking in one dual task training.[42]

The present study provides evidence of the efficacy and effectiveness of dual task training and its repercussions on the gait, cognition, and transference skills for learning, automation, and retention capacity. Despite the advances provided by reviewing those articles, it is also important to consider that several limitations were found. The limited number of studies with good methodological quality and the size of the samples compromised the reliability of the results found. The great diversity of parameters and tests used for measuring the results obtained also created difficulties for the comparisons between studies. This is why there is a need for new studies with greater methodological rigor for a more precise assessment of the effects of that strategy on the neurological population, and that can clarify which tasks are better, the minimum period of intervention, and the extension of the retention period for gains.

## CONCLUSIONS

The current studies in question indicate that dual task training has a positive impact in the gait, even without a large number of repetitions or extended period of intervention. Positive effects were also observed on the cognitive and automating skills, and the transference of learning. These findings provide some evidence for this strategy to be employed in neurological rehabilitation programs in order to improve the ability to multitask. There are no protocols that indicate specific tasks and the appropriate period for the dual task training, but it is recommended that professionals be guided by scientific evidence and the particularities of each patient, taking into consideration their social environment and the common tasks in their routine in order to contribute to their functional capacity and participation.

## REFERENCES

1. Teixeira NB, Alouche SR. O desempenho da dupla tarefa na doença de Parkinson. Rev Bras Fisioter. 2007;11(2):127-32. DOI: http://dx.doi.org/10.1590/S1413-35552007000200007
2. O'Shea S, Morris ME, Iansek R. Dual task interference during gait in people with Parkinson disease: effects of motor versus cognitive secondary tasks. Phys Ther. 2002;82(9):888-97.
3. Wu T, Hallett M. Neural correlates of dual task performance in patients with Parkinson's disease. J Neurol Neurosurg Psychiatry. 2008;79(7):760-6. DOI: http://dx.doi.org/10.1136/jnnp.2007.126599
4. Wang Y, Zhang W, Lesch MF, Horrey WJ, Chen C, Wu S. Changing drivers' attitudes towards mobile phone use through participative simulation testing and feedback. Inj Prev. 2009;15(6):384-9. DOI: http://dx.doi.org/10.1136/ip.2008.021196
5. Jacobs JV, Kasser SL. Effects of dual tasking on the postural performance of people with and without multiple sclerosis: a pilot study. J Neurol. 2012;259(6):1166-76. DOI: http://dx.doi.org/10.1007/s00415-011-6321-5
6. Plummer-D'Amato P, Altmann LJ, Saracino D, Fox E, Behrman AL, Marsiske M. Interactions between cognitive tasks and gait after stroke: a dual task study. Gait Posture. 2008;27(4):683-8. DOI: http://dx.doi.org/10.1016/j.gaitpost.2007.09.001
7. Thompson JC, Poliakoff E, Sollom AC, Howard E, Craufurd D, Snowden JS. Automaticity and attention in Huntington's disease: when two hands are not better than one. Neuropsychologia. 2010;48(1):171-8. DOI: http://dx.doi.org/10.1016/j.neuropsychologia.2009.09.002
8. Catena RD, van Donkelaar P, Chou LS. Cognitive task effects on gait stability following concussion. Exp Brain Res. 2007;176(1):23-31. DOI: http://dx.doi.org/10.1007/s00221-006-0596-2
9. Lonie JA, Tierney KM, Herrmann LL, Donaghey C, O'Carroll RE, Lee A, et al. Dual task performance in early Alzheimer's disease, amnestic mild cognitive impairment and depression. Psychol Med. 2009;39(1):23-31. DOI: http://dx.doi.org/10.1017/S0033291708003346
10. Yogev-Seligmann G, Giladi N, Brozgol M, Hausdorff JM. A training program to improve gait while dual tasking in patients with Parkinson's disease: a pilot study. Arch Phys Med Rehabil. 2012;93(1):176-81. DOI: http://dx.doi.org/10.1016/j.apmr.2011.06.005
11. Nascimbeni A, Gaffuri A, Penno A, Tavoni M. Dual task interference during gait in patients with unilateral vestibular disorders. J Neuroeng Rehabil. 2010;7:47. DOI: http://dx.doi.org/10.1186/1743-0003-7-47
12. Canning CG. The effect of directing attention during walking under dual-task conditions in Parkinson's disease. Parkinsonism Relat Disord. 2005;11(2):95-9. DOI: http://dx.doi.org/10.1016/j.parkreldis.2004.09.006
13. Pohl PS, Kemper S, Siengsukon CF, Boyd L, Vidoni ED, Herman RE. Dual-task demands of hand movements for adults with stroke: a pilot study. Top Stroke Rehabil. 2011;18(3):238-47. DOI: http://dx.doi.org/10.1310/tsr1803-238
14. Bensoussan L, Viton JM, Schieppati M, Collado H, Milhe de Bovis V, Mesure S, et al. Changes in postural control in hemiplegic patients after stroke performing a dual task. Arch Phys Med Rehabil. 2007;88(8):1009-15. DOI: http://dx.doi.org/10.1016/j.apmr.2007.05.009
15. Brodsky MB, McNeil MR, Martin-Harris B, Palmer CV, Grayhack JP, Abbott KV. Effects of divided attention on swallowing in healthy participants. Dysphagia. 2012;27(3):307-17. DOI: http://dx.doi.org/10.1007/s00455-011-9367-8
16. Kalron A, Dvir Z, Achiron A. Walking while talking-difficulties incurred during the initial stages of multiple sclerosis disease process. Gait Posture. 2010;32(3):332-5. DOI: http://dx.doi.org/10.1016/j.gaitpost.2010.06.002
17. Melzer I, Tzedek I, Or M, Shvarth G, Nizri O, Ben-Shitrit K, et al. Speed of voluntary stepping in chronic stroke survivors under single- and dual-task conditions: a case-control study. Arch Phys Med Rehabil. 2009;90(6):927-33. DOI: http://dx.doi.org/10.1016/j.apmr.2008.12.012
18. Plummer-D'Amato P, Altmann LJ, Behrman AL, Marsiske M. Interference between cognition, double-limb support, and swing during gait in community-dwelling individuals poststroke. Neurorehabil Neural Repair. 2010;24(6):542-9. DOI: http://dx.doi.org/10.1177/1545968309357926
19. Evans JJ, Greenfield E, Wilson BA, Bateman A. Walking and talking therapy: improving cognitive-motor dual-tasking in neurological illness. J Int Neuropsychol Soc. 2009;15(1):112-20.
20. Zheng J, Wang X, Xu Y, Yang Y, Shen L, Liang Z. Cognitive Dual-Task training improves balance function in patients with stroke. HealthMed. 2012;6(3):840-5.
21. Couillet J, Soury S, Lebornec G, Asloun S, Joseph PA, Mazaux JM, et al. Rehabilitation of divided attention after severe traumatic brain injury: a randomised trial. Neuropsychol Rehabil. 2010;20(3):321-39. DOI: http://dx.doi.org/10.1080/09602010903467746
22. Fok P, Farrell M, McMeeken J. The effect of dividing attention between walking and auxiliary tasks in people with Parkinson's disease. Clin Rehabil. 2011;25(5):396-407. DOI: http://dx.doi.org/10.1177/0269215510387648
23. Pedroso RV, Coelho FG, Santos-Galduróz RF, Costa JL, Gobbi S, Stella F. Balance, executive functions and falls in elderly with Alzheimer's disease (AD): a longitudinal study. Arch Gerontol Geriatr. 2012;54(2):348-51. DOI: http://dx.doi.org/10.1016/j.archger.2011.05.029
24. Schwenk M, Zieschang T, Oster P, Hauer K. Dual-task performances can be improved in patients with dementia: a randomized controlled trial. Neurology. 2010;74(24):1961-8. DOI: http://dx.doi.org/10.1212/WNL.0b013e3181e39696
25. Lee YW, Lee JH, Shin SS, Lee SW. The effect of dual motor task training while sitting on trunk control ability and balance of patients with chronic stroke. J Phys Ther Sci. 2012;24(4):345-9. DOI: http://dx.doi.org/10.1589/jpts.24.345
26. Shim S, Yu J, Jung J, Kang H, Cho K. Effects of motor dual task training on spatio-temporal gait parameters of post-stroke patients. J Phys Ther Sci. 2012;24(9):845-8. DOI: http://dx.doi.org/10.1589/jpts.24.845
27. Yang YR, Wang RY, Chen YC, Kao MJ. Dual-task exercise improves walking ability in chronic stroke: a randomized controlled trial. Arch Phys Med Rehabil. 2007;88(10):1236-40. DOI: http://dx.doi.org/10.1016/j.apmr.2007.06.762

28. Taylor ME, Delbaere K, Mikolaizak AS, Lord SR, Close JC. Gait parameter risk factors for falls under simple and dual task conditions in cognitively impaired older people. Gait Posture. 2013;37(1):126-30. DOI: http://dx.doi.org/10.1016/j.gaitpost.2012.06.024
29. Muir SW, Speechley M, Wells J, Borrie M, Gopaul K, Montero-Odasso M. Gait assessment in mild cognitive impairment and Alzheimer's disease: the effect of dual-task challenges across the cognitive spectrum. Gait Posture. 2012;35(1):96-100. DOI: http://dx.doi.org/10.1016/j.gaitpost.2011.08.014
30. Bensoussan L, Viton JM, Schieppati M, Collado H, Milhe de Bovis V, Mesure S, et al. Changes in postural control in hemiplegic patients after stroke performing a dual task. Arch Phys Med Rehabil. 2007;88(8):1009-15. DOI: http://dx.doi.org/10.1016/j.apmr.2007.05.009
31. Pettersson AF, Olsson E, Wahlund LO. Effect of divided attention on gait in subjects with and without cognitive impairment. J Geriatr Psychiatry Neurol. 2007;20(1):58-62. DOI: http://dx.doi.org/10.1177/0891988706293528
32. Coelho FG, Andrade LP, Pedroso RV, Santos-Galduroz RF, Gobbi S, Costa JL, et al. Multimodal exercise intervention improves frontal cognitive functions and gait in Alzheimer's disease: a controlled trial. Geriatr Gerontol Int. 2013;13(1):198-203. DOI: http://dx.doi.org/10.1111/j.1447-0594.2012.00887.x
33. Leśniak M, Bak T, Czepiel W, Seniów J, Członkowska A. Frequency and prognostic value of cognitive disorders in stroke patients. Dement Geriatr Cogn Disord. 2008;26(4):356-63. DOI: http://dx.doi.org/10.1159/000162262
34. Lord SE, Rochester L, Weatherall M, McPherson KM, McNaughton HK. The effect of environment and task on gait parameters after stroke: A randomized comparison of measurement conditions. Arch Phys Med Rehabil. 2006;87(7):967-73. DOI: http://dx.doi.org/10.1016/j.apmr.2006.03.003
35. Dennis A, Dawes H, Elsworth C, Collett J, Howells K, Wade DT, et al. Fast walking under cognitive-motor interference conditions in chronic stroke. Brain Res. 2009;1287:104-10. DOI: http://dx.doi.org/10.1016/j.brainres.2009.06.023
36. Ada L, Dean CM, Hall JM, Bampton J, Crompton S. A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomized trial. Arch Phys Med Rehabil. 2003;84(10):1486-91. DOI: http://dx.doi.org/10.1016/S0003-9993(03)00349-6
37. Allali G, Dubois B, Assal F, Lallart E, Souza LC, Bertoux M, et al. Frontotemporal dementia: pathology of gait? Mov Disord. 2010 Apr 30;25(6):731-7. DOI: http://dx.doi.org/10.1002/mds.22927
38. Kizony R, Levin MF, Hughey L, Perez C, Fung J. Cognitive load and dual-task performance during locomotion poststroke: a feasibility study using a functional virtual environment. Phys Ther. 2010;90(2):252-60. DOI: http://dx.doi.org/10.2522/ptj.20090061
39. Rochester L, Hetherington V, Jones D, Nieuwboer A, Willems AM, Kwakkel G, et al. Attending to the task: interference effects of functional tasks on walking in Parkinson's disease and the roles of cognition, depression, fatigue, and balance. Arch Phys Med Rehabil. 2004;85(10):1578-85. DOI: http://dx.doi.org/10.1016/j.apmr.2004.01.025
40. Sheridan PL, Solomont J, Kowall N, Hausdorff JM. Influence of executive function on locomotor function: divided attention increases gait variability in Alzheimer's disease. J Am Geriatr Soc. 2003;51(11):1633-7. DOI: http://dx.doi.org/10.1046/j.1532-5415.2003.51516.x
41. You JH, Shetty A, Jones T, Shields K, Belay Y, Brown D. Effects of dual-task cognitive-gait intervention on memory and gait dynamics in older adults with a history of falls: a preliminary investigation. NeuroRehabilitation. 2009;24(2):193-8.
42. Brauer SG, Morris ME. Can people with Parkinson's disease improve dual tasking when walking? Gait Posture. 2010;31(2):229-33.