The effect of the motor dual-task on static and dynamic postural control and classification of the motor task difficulty - Systematic Review

Abstract. Many daily activities require performing multiple tasks and involve the integration of cognitive and motor skills, on which the outcome depends. Many studies approach the influence of cognitive tasks on gait and postural control, but few studies analyze the effect of another motor task during gait or postural control. This review aims to analyze the motor tasks used in motor dual-tasks studies and classify motor tasks as to their difficulty level. The literature review was conducted according to PRISMA guidelines in the databases: Medline, Web on Science, and Scopus during December 2019, using the key-words: motor dual-task, secondary motor task, gait, and postural control. It included observational studies based on the effects of motor dual-tasking in static and dynamic postural control, published in the last ten years. N = 215 studies were found within the databases, and this review included sixteen studies. One study analyzed gait with secondary motor task of different levels of complexity. Three studies analyzed the primary motor task (gait) at different difficulty levels or conditions. They all found that more complex tasks lead to poorer gait performance. In conclusion, a classification of the motor tasks is suggested according to their complexity level and suggests the need for more studies with motor tasks of different levels of difficulty. The static and dynamic postural control parameters analyzed in this review were negatively affected compared to the simple motor task, regardless of age or clinical condition.

Key-words: motor dual-task, motor task difficulty, gait, postural control

Introduction

Postural control (PC) depends on a complex interaction between the neural and musculoskeletal systems (Huang & Mercer, 2001). An efficient PC is fundamental to the success of most daily tasks. Gait involves bilaterally coordinated limb movements and maintenance of dynamic postural control. People with motor impairment, cognitive decline, or both, have more gait changes in dual-task activities (Woollacott & Shumway-Cook, 2002; Yoge et al., 2008).

The relationship between attention and PC is a developing area of study that has revealed important aspects of the cognitive processing role in PC. The most used methodology to ascertain its relationship is the Dual-Task (DT) paradigm, in which the PC, considered a primary task, and a secondary task, are performed simultaneously (Woollacott & Shumway-Cook, 2002).

The ability to perform a second task while a first one is executed is crucial in most daily activities, especially when some motor act is involved, as a poor gait performance in dual-task can result in a fall (Bouachet et al., 2009).

The attentional demands of a task and the interference effects of concurrent tasks could be influenced by several
factors, such as age, skill level, and the nature of the tasks involved (Huang & Mercer, 2001).

The brain’s ability to organize multi-task interactions is essential to motor control and balance (Plummer et al., 2013). Dual-Task Cost (DTC) occurs when the simultaneous performance of two different tasks results in performance deterioration (Beurskens et al., 2016; Plummer & Eskes, 2015). It is calculated as the percentage of performance decrements in dual-task relative to the single-task.

Some studies assess task performance using the task prioritization concept, in which it is usually assumed that task prioritization can be obtained by means of an external priority instruction on the importance of each task (Plummer & Eskes, 2015). Other authors impose a focus of attention during the task performed and conclude that the focus of attention on the cognitive task while performing the dual-task can favor motor learning (Arce-Cifuentes et al., 2020).

Preserving balance during dual-tasks or multi-tasks is a complex outcome of trunk stability and the sensory-motor and automatic central functions. Therefore, executing simultaneously two tasks demands a higher level of attention, balancing ability, and executive function than a single task performance (Plummer et al., 2013).

The postural control and the motor or cognitive tasks occur at the cortical level, enabling one activity interferes with the other or lead to a reduction in automation (Leone et al., 2017).

There are three theories commonly used to explain the dual-task interference. The capacity sharing, when people share processing capacity or mental resources among tasks. This results in lower capacity for each task, and so the performance of at least one task will be impaired. The other theory is the bottlenecks, task switching, it exists a deterioration in the performance of one or both tasks resulting from serial processing when the two tasks need the same neural processor or networks. The last theory is the cross-talk, where the outcome of the processing required for one task conflicts with the processing required for another task (Pashler, 1994).

Several studies, included in a systematic review, showed that different cognitive tasks (e.g., working memory, reaction time, etc.) when performed simultaneously during gait (DT), caused impairments in spatio-temporal gait parameters, such as decreased gait speed, compared to the single-task (only gait) (Al-Yahya et al., 2011). Other studies showed worst results on gait performance under dual-task conditions when the individuals performed a second motor task as transfer coins (O’Shea et al., 2002) or carry a tray (Bond & Morris, 2000). Thus, walking while simultaneously performing a cognitive or motor task negatively affects the individual’s gait performance.

Regarding task difficulty, few studies have simultaneously analyzed the population’s complexity of postural or gait and other motor tasks. For that reason, we based the analysis of the task’s difficulty level on the taxonomy model (McSae et al., 2015) and in the classification of the studies included in this review.

There is an ambiguity about the terms task complexity and task difficulty. For some authors, task complexity is a component of difficulty, for others, they are separate concepts. Generally, task difficulty refers to performers experiencing difficulty in executing the task. On the other hand, task complexity can be defined as a result of the interaction between task and performer characteristics, such as the number of task components, concentration, cognitive and physical demands, time pressure, or novelty (Liu & Li, 2012).

Although the amount of research on postural control and dual-tasks has increased in recent years, there are still not many studies that clarify the effect of the difficulty of the static or dynamic postural control tasks on dual-task performance. Besides that, several studies have focused on the effect of the cognitive task component on dual-task. It is challenging to establish conclusions about the influence between concurrent motor and cognitive tasks on postural control, because the studies use different types of tasks, and motor or cognitive tasks performing can require different cognitive resources and motor control (Bayot et al., 2018).

For this reason, the main objective of this review is to analyze the motor tasks used in motor dual-task studies, to classify them as to their level of difficulty, and to determine the effects of task difficulty, both secondary motor tasks and static or dynamic postural control, on dual-task performance.

Methods

This review was conducted according to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement (Moher et al., 2009) and followed the PICOS criteria described in PRISMA (population: humans; intervention: dual-task to evaluate static and dynamic postural control; comparison: none; outcomes: motor dual-task and motor task difficulty to study static and dynamic postural control; study design: all quantitative and qualitative studies in the last ten years).

Data sources and search strategy

The study was conducted independently by two reviewers in the databases: Medline, Web on Science, and Scopus, during December 2019. The search terms used were gait, walking, locomotion, dual-task, multi-task, secondary task, motor dual-task, postural control, postural
balance, postural sway, and their combination with ‘and’ or ‘or’. The combination of keywords and MeSH (Medical Subject Headings) terms were also adapted to each database. Screening of titles and abstracts to determine if the study meets any of the exclusion criteria was performed. The inclusion criteria for the studies were as follows:

i. English language;
ii. Published in the last ten years;
iii. Observational (cohort study) studies;
iv. Studies that analyze the effects of motor tasks in static and dynamic postural control in healthy and ill subjects.

Other design studies and the following criteria were excluded:

i. Articles based only on the effect of cognitive tasks on postural control and/or on dual-task training;
ii. Studies in which the primary task is not postural control;
iii. Studies with quality lower than four in the Newcastle-Ottawa Scale.

The studies that fulfilled all eligibility criteria were evaluated in full-text and included in the systematic review (Figure 1). The authors independently assessed the eligibility and methodological quality of the included studies. In the event of disagreement, a decision was taken by consensus.

Data extraction

Upon selection for review, the following data were extracted from each article: author, date of publication, sample characteristics, the aim of the study, study methodology (tasks and outcome measures), and results.

Assessment quality of studies and risk of bias

The methodological quality of observational studies was assessed with the Newcastle-Ottawa Scale. It uses three elements to evaluate the risk of bias in prospective studies: 1) selection of participants (four items: representativeness of the exposed cohort, selection of the non-exposed cohort, ascertainment of the exposure, and demonstration that the outcome of interest was not present at the start of the study); 2) comparability (one item: comparability of cohorts based on the design of the analysis) and 3) outcomes (three items: adequate assessment of outcome, adequate follow-up time, and adequacy of follow-up). A study can be awarded a maximum of 1 point (star) for each numbered item within the selection and outcome categories and a maximum of two points can be given for the comparability category. The maximum score on the Newcastle-Ottawa Scale is 9 (highest quality) (Wells et al., 2019).

The primary reviewer carried out a blinded rating of the methodological quality of the studies, and the second reviewer assessed the methodology quality unblinded. Ambiguous issues were discussed between reviewers, and a consensus was reached.

Result

Figure 1 depicts each step’s selection, eligibility, inclusion, and the number of studies. Database searches resulted in 215 papers, of which 16 were duplicates. Then, of the 199 papers, 138 articles were excluded based on the title and abstract screening during the selection process. The remaining 61 articles were thoroughly examined, and 45 were discarded as the task type did not include motor tasks. After these steps, 16 studies have been included in this review.

The 16 studies were analytic observational studies (prospective cohort studies). The quality of observational studies (cohort studies) is moderate based on the Newcastle-Ottawa Scale (Table 1). Data from the included studies are summarized in Table 2.
Sample Characteristics

Most studies used healthy individuals (Beurskens et al., 2016; Abbruzzese et al., 2014; Asai et al., 2014; Beurskens & Bock, 2013; Makizako et al., 2013; Nordin et al., 2010; Oh-Park et al., 2013; Tang et al., 2015) to analyze postural control in motor dual-tasks. School-age children were compared with young adults (Abbruzzese et al., 2014), young adults with the elderly (Beurskens & Bock, 2013; Makizako et al., 2013; Oh-Park et al., 2013), and older non-fallers with older fallers (Júnior et al., 2017). Only six studies report to clinical conditions, namely Sclerosis Multiple (Mofateh et al., 2017), Stroke (Baldan & Elmauer, 2015; Liu et al., 2018), Ataxia (Demirci et al., 2016), Mild Cognitive Impairment (Hunter et al., 2018), and children with intellectual disability (Kachouri et al., 2019). Five studies use a sample type not making comparisons between groups (Beurskens et al., 2016; Asai et al., 2014; Nordin et al., 2010; Tang et al., 2015; Liu et al., 2018). One study examined the effect of a secondary motor task on walking ability in childhood (Rabaglietti et al., 2019).

Description of motor tasks

In most studies, the principal motor task analyzed was gait (Beurskens et al., 2016; Abbruzzese et al., 2014; Asai et al., 2014; Beurskens & Bock, 2013; Nordin et al., 2010; Oh-Park et al., 2013; Júnior et al., 2017; Mofateh et al., 2017; Baldan & Elmauer, 2015; Liu et al., 2018; Hunter et al., 2018; Kachouri et al., 2019; Rabaglietti et al., 2019).

Only three studies analyzed static and/or dynamic balance as principal motor task (e.g. standing Romberg stance under foam surface; Tandem Stance; Time Up and Go) (Makizako et al., 2013; Tang et al., 2015; Demirci et al., 2016).

The secondary motor tasks used were gross motor tasks, e.g. holding a tray (Abbruzzese et al., 2014; Nordin et al., 2010; Oh-Park et al., 2013) or a cup (Makizako et al., 2013; Tang et al., 2015; Kachouri et al., 2019; Rabaglietti et al., 2019) or fine motor tasks (e.g. buttoning a button (Beurskens & Bock, 2013; Demirci et al., 2016), opening and closing a bag zipper (Demirci et al., 2016), transferring a coin from one pocket to the other (Júnior et al., 2017).

Most studies (Makizako et al., 2013; Nordin et al., 2010; Oh-Park et al., 2013; Tang et al., 2015; Mofateh et al., 2017; Hunter et al., 2018; Kachouri et al., 2019; Rabaglietti et al., 2019) used carrying cups and/or a tray as the secondary motor task. Baldan & Elmauer (2015) and Demirci et al. (2016) used the task of transferring a ball from one hand to another as a secondary motor task.

Only the study by Abbruzzese et al. (2014) analyzed gait with secondary motor tasks of different levels of complexity (simple motor task: ‘Holding an empty tray with both hands’, ‘Holding an empty pitcher with one hand’; complex motor task: ‘Holding a tray with an unsecured empty cup on top with both hands’, ‘Holding a pitcher with a cup of water secured inside with one hand’; simple dual-task: ‘Gait and Empty tray, held with two hands’, ‘Gait and Pitcher with empty cup secured inside, held with one hand by the handle’; complex dual-task: ‘Gait and Tray with unsecured empty cup on top, held with two hands’, ‘Gait and Pitcher with cup of water secured inside, held with one hand by the handle’).

Three studies analyzed the primary motor task at different levels of difficulty: gait in four different velocities (self-selected comfortable velocity, very slow, slow, and fast) (Asai et al., 2014), walking in four different conditions (wide path and preferred pace, narrow path and preferred pace, wide path and fast pace, obstacles wide path and preferred pace) (Beurskens & Bock, 2013), and three different velocity conditions of gait (slow, normal and fast) (Nordin et al., 2010).

Dual-task outcome measures

The gait variables most analyzed in the motor dual-tasks were gait speed, cadence, stride length, stride width, percent of time in the double support phase, through GAITRite® System (Abbruzzese et al., 2014; Nordin et al., 2010; Oh-Park et al., 2013; Júnior et al., 2017; Liu et al., 2018; Hunter et al., 2018), MTx® System (Beurskens & Bock, 2013), Qualisys® System (Mofateh et al., 2017) or analytical formulas (Asai et al., 2014; Baldan & Elmauer, 2015).

Balance Evaluation-Systems Test (Júnior et al., 2017), Ten Meter Walking Test (TMWT), and the Timed Up and Go Test (TUGT) (Kachouri et al., 2019) were methodologies also used to analyze gait performance.

Static and dynamic balance in one of the studies was analyzed through clinical trial tests such as Single Leg Stance Time; Tandem Stance Time; Four Square Step Test; 360° Degrees of Rotation Time; TUGT completing time (Demirci et al., 2016). In another study, which evaluated balance in motor dual-tasks, the variable analyzed was anterior-posterior sway through triaxial accelerometry (Makizako et al., 2013). This study also analyzed the electromyography of the tibialis anterior and medial gastrocnemius ankle muscles.

In one of the studies, the TUGT performance was analyzed in a single TUGT task and motor dual-task (TUGT while carrying a cup of water) (Tang et al., 2015).
### Table 2.
Results of motor tasks in static and dynamic postural control.

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Aim of the study</th>
<th>Methodology</th>
<th>Dual Task</th>
<th>Outcome</th>
<th>Task duration</th>
<th>Number of trials</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbruzzese et al. (2014)</td>
<td>To analyze the effects of complexity, type of task, and age on the ability to walk while performing concurrent manual tasks between school-aged children and young adults.</td>
<td>Gait</td>
<td>Gait in 4 speeds; Self-selected comfortable speed.</td>
<td>VF, FM</td>
<td>ND</td>
<td>3 trials under each DT</td>
<td>The children had a more variable step length and step time than adults in all walking conditions. Gait variability is greater in the most complex motor tasks.</td>
</tr>
<tr>
<td>Asai et al. (2014)</td>
<td>To assess trunk movements during cognitive-task gait and manual-task gait.</td>
<td>Gait</td>
<td>OptoGait-System (10m): Gait velocity, Stride length, Stride time</td>
<td>VF, FM</td>
<td>ND</td>
<td>1 trials under each DT</td>
<td>The trunk oscillation was lower in the motor DT than in the simple gait task.</td>
</tr>
<tr>
<td>Baldan &amp; Elmayeri (2015)</td>
<td>To examine the role of different secondary task demands on gait in young adults and assess the associated neural activation patterns.</td>
<td>Gait</td>
<td>Evaluated through arithmetic formulas: Gait speed</td>
<td>Gait+SP, Gait+ST, Gait+CP, Gait+CT</td>
<td>4.6m during 10m.</td>
<td>1</td>
<td>The motor task affected walking performance in young adults; reduced gait velocity and stride length, increased stride time.</td>
</tr>
<tr>
<td>Beurskens &amp; al. (2016)</td>
<td>To analyze the effect of motor and cognitive tasks on clinical balance.</td>
<td>Gait</td>
<td>Holding an empty pitcher with one hand (SP); Holding an empty tray with both hands (ST); Holding a pitcher with a cup of water secured inside with one hand (CP); Holding a tray with an unsecured empty cup on top with both hands (CT).</td>
<td>Gait+SP, Gait+ST, Gait+CP, Gait+CT</td>
<td>ND</td>
<td>1 trials under each DT</td>
<td>Gait variability is greater in the most complex motor tasks.</td>
</tr>
<tr>
<td>Domenici et al. (2016)</td>
<td>To analyze the Single Leg Stance Time Tandem Stance Time.</td>
<td></td>
<td></td>
<td>3 trials under each DT</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
null
To evaluate whether gait pattern changes between single-velocity and DT conditions were associated with risk of falling in older people. Nordin et al. (2010) Older people: n=230 Gait in 1 trial for each DT, i.e. the cognitive task "Count" and the manual task "Cup". Walking+ using both hands GAITRite® Step-length, Step-width, Double-support-time, Gait speed. Cup (a saucer with a coffee-cup) GAITRite® Step-length, Step-width, Double-support-time, Gait speed. Tray (a rectangular wooden tray) Tray-Cup (the tray with the saucer and cup on top) GAITRite® Step-length, Step-width, Double-support-time, Gait speed. Walking+ Carrying a glass of water; Walking+ Carrying a ball on a round tray; Carrying a glass of water+b-all on a round tray. Gait Speed Gait Speed TUG could identify prefrail elderly adults: n=865 (71.5±8.1 years) compared to single-task TUG. TUGG could identify prefrail individuals or older adults: n=705 (79.5±6.4 years) compared to single-task TUG. Stopwatch: Time to complete TUG test Carrying a cup of water ND TUGG Carrying a cup of water TUGG Time to complete TUG test 1 trial for each DT
ND

Legend: AP: anteroposterior; BESTest: Balance Evaluation – Systems Test; CP: complex pitcher; CT: complex tray; DTC: Dual-Task Cost; ND: no data; MCI: Mild Cognitive Impairment; ML: mediolateral; MS: Multiple Sclerosis; RMS: root-mean-square; rpm: revolutions per minute; RTs: Reaction Times; SLS: Single Leg Stance Time; SP: simple pitcher; ST: simple tray; STV: stride time variability; TST: Tandem Stance Time; TUGT completing time: Timed Up and Go Test completing time; 4SST: Four Square Step Test; 360° DRT: 360° Degrees of Rotation Time.

Discussion

Dual-task paradigms usually are used for two different purposes: to investigate the attentional demands of a motor task and to examine the effects of concurrent cognitive or motor tasks on motor performance. (Huang & Mercer, 2001).

In this review, we found that the principal motor task analyzed was the gait (Beurskens et al., 2016; Abbruzzese et al., 2014; Asai et al., 2014; Beurskens & Bock, 2013; Nordin et al., 2010; Oh-Park et al., 2013; Júnior et al., 2017; Mofateh et al., 2017; Liu et al., 2018; Hunter et al., 2018; Kachouri et al., 2019). Most secondary motor tasks refer to gross or fine motor tasks, such as carrying a tray or holding a cup during gait (Makizako et al., 2013; Nordin et al., 2010; Oh-Park et al., 2013; Tang et al., 2015; Mofateh et al., 2017; Hunter et al., 2018; Kachouri et al., 2019), buttoning a button (Beurskens & Bock, 2013; Demirci et al., 2016), opening and closing a bag zipper (Demirci et al., 2016), and transferring a coin from one pocket to the other (Júnior et al., 2017). These secondary motor tasks are tasks commonly used in the natural context of daily life activities.

Samples that include healthy individuals should be homogeneous since when comparing school-age children with adults or young people with the elderly, there is already a bias due to the physical, psychological, and physiological changes that come from aging. For example, children apply different anticipatory strategies than adults, making last-minute adjustments, while adults plan well ahead of upcoming obstacles (Schott & Klotzbier, 2018), since the level of development and maturation are different.

The Abbruzzese et al. (2014) study verified that children had a more variable step length and step time than adults in all walking conditions. The same was verified in the study of Vallis & McFadyen (2005). The authors found reductions in gait speed and step length in children (9 to 12 years old), only two steps and one step prior to obstacle circumvention, respectively, while adults maintain a constant speed and step length. Cherng, Liang, Hwang & Chen
(2007) showed that young children (4 to 6 years old) decrease their stride length and increase the variability of temporal and spatial gait parameters when walking and carrying a tray with or without marbles on it. Other studies showed children with impaired motor performance when walking in DT situations compared to young adults (Krampe et al., 2011), suggesting that children do not demonstrate adulthood-like use of sensory information in balance control before 12 years old (Peterson et al., 2005).

Makisako et al. (2013) found that the cognitive task had a more significant impact than the motor task in decreasing lower limb muscle activity and increasing anterior-posterior trunk acceleration during a Romberg stance in older people compared to young adults.

Junior et al. (2017) showed that walking while transferring coins from one pocket to the other causes a decrease in speed and cadence, shorter step length, longer stride time, and single support time, and increased variability compared to the single-task (gait) in older people.

In clinical conditions, the gait velocity and gait performance in DT were significantly worse than in a concurrent motor task only (Hunter et al., 2018; Kachouri et al., 2019). In addition, both studies (Baldan & Elmauer, 2015; Liu et al., 2018) that assessed the effect of motor dual-task in subjects with stroke also found deteriorating gait performance in motor dual-task compared to single-task (gait). Demirci et al. (2016) showed that the 4SST took greater time to be completed when concurrently performed with a secondary motor task, buttoning up the shirt button, in subjects with ataxia.

These results show that static and dynamic postural control was negatively affected while simultaneously performing a secondary motor task in clinical conditions. Other studies corroborate these results; for example, Marchese et al. (2003) showed that during motor dual-task, motor sequence of thumb opposition to the other fingers during quiet stance, the postural sway deterioration was more evident in subjects with Parkinson’s Disease than in healthy subjects. O’Shea et al. (2002) showed a decline in speed gait when performing another motor task, transferring coins from one pocket to another. Besides that, they decreased the coin transference rate between the standing and walking conditions in subjects with Parkinson’s Disease.

A complex motor task can require more attention and reduce residual attention capacity. In this situation, the competition for attention to perform different tasks is expected to happen (Laesoe et al., 2008). Few studies (Abbruzzese et al., 2014; Asai et al., 2014; Beurskens & Bock, 2013; Nordin et al., 2010) have analyzed the motor tasks’ difficulty level. When the task becomes more complex, and walking is challenged, the focus of attention shifts toward the motor task to maintain gait stability. The types of motor tasks used as the concurrent motor task vary across studies (carrying a cup or tray, transferring coins or balls). Each motor task imposes distinct biomechanical constraints on the upper limbs and trunk, which can cause a greater and presumably also different constraint in the gait. Beurskens & Bock (2013) investigated the role of differently challenging walking conditions in DT and showed that the age-related increase of DTC is considerably greater with the visual demand than with the motor task demand, being more evident when walking on a narrow or obstacles path. Nordin et al. (2010) assessed gait with three different velocities and demands motor tasks: carrying a cup in one hand, carrying a tray using both hands, and carrying a tray with the filled cup using both hands. In this last dual-task, none of the gait parameters was related to the risk of falling, suggesting the cup task was more challenging because the other motor tasks did not affect gait and fall risk.

Rabaglietti et al. (2019) suggest that walking performance under a dual-task depends on the difficulty level; they found similar differences in the dual-task performance between children with 7-9 years and 10-13 years. Abbruzzese et al. (2014) found a higher variability in gait in the most complex motor tasks (holding a pitcher with a cup of water secured inside with one hand and holding a tray with an unsecured empty cup on top with both hands) compared to a simple task (holding an empty pitcher with one hand and holding an empty tray with both hands). The dual-task costs related to performing complex motor tasks during walking are higher in school-age children than young and healthy adults. Also, the temporal changes in spatial gait, decreasing gait speed, cadence, step duration and increasing time spent in double support, occurred under simultaneous motor task conditions.

Only Oh-Park et al. (2013) studied task prioritization. They stated that motivation could influence the walking performance while holding a tray with instructions to focus on keeping the tray as steady as possible. They showed that while focusing attention on keeping the tray, gait performance and tray stability were compromised during dual-task compared to single tasks and differed between the age groups. Other studies (Kelly et al., 2010; Remaual et al., 2013; Yogev-Seligmann et al., 2010) have also reported that the instructed focus of attention can affect dual-task performance.

Although the secondary motor tasks and methodologies are heterogeneous, only one study analyzed motor tasks with different complexities (Abbruzzese et al., 2014) and three studies analyzed the primary motor task (gait) in different conditions (Asai et al., 2014; Beurskens & Bock, 2013; Nordin et al., 2010). Then, based on the taxonomy model for classifying motor tasks (McIsaac et al., 2015) and in the single and dual-tasks used in studies of this review, we suggest the classification of motor tasks difficulty level presented in
Many studies do not consider the task’s perception of difficulty or novelty by the performer of the task. Furthermore, in this review, few studies analyzed the motor tasks with different difficulty levels, making it difficult to compare and classify the tasks’ difficulty levels.

In clinical practice, the use of the dual-task paradigm can improve motor and cognitive performance. It can be used to identify individuals’ motor and cognitive abilities by combining motor and cognitive demands while performing two or more tasks simultaneously. For example, studies reported that cognitive and motor dual-task training could improve the single and dual-task walking performance in the elderly (Kuo et al., 2022) and promote the dynamic balance performance of children (Hoshyari et al., 2022).

Criteria such as appropriateness of tasks to age and clinical condition, tasks similar to daily life situations, calculation of dual-task cost, assessing single-task performance in the baseline condition, tasks similar to daily life situations, calculation of dual-task cost, assessing single-task performance in the baseline condition.
seline, randomization of the task order, giving clear instructions, use of homogeneous samples, the same data collection methods and the same study variables of gait and static postural control, are suggested to be included future studies. In addition, we suggest more studies to analyze the effect of a secondary motor task with different difficulty levels on static and dynamic postural control tasks because most studies focus on the cognitive task. Besides, more challenging tasks can help detect early signs of decline in postural control (Laessoe et al., 2008).

Conclusions

According to the results of the present review, the association of secondary motor tasks with other motor activities, such as static or dynamic postural control tasks while performing other motor tasks, negatively affects the postural control performance during motor dual-tasks, regardless of the age group or the clinical condition.

The motor tasks were classified according to the complexity and novelty of the tasks, based on the tasks found in studies included in this review, and on the existing taxonomy model for classifying tasks. However, we conclude that the classification of task’s difficulty or complexity depends on the author’s interpretation and performer characteristics, making it challenging to build a standard classification of tasks.

We suggest more studies with motor tasks and different difficulty levels because the effects of motor tasks on gait and static postural control are scarce and use various methodologies. Therefore, further studies are necessary to analyze the effect of a secondary motor task on gait and postural control tasks.

Declaration of interest

No conflicts of interest to declare.

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