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Meta-analysis of type and complexity of a secondary task during walking on the prediction of elderly falls

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Aim: Dual-tasking probes divided attention and causes performance changes that are associated with an increased risk for falls in the elderly. There is no systematic review investigating the effect of task type and complexity on the prediction of elderly falls. This article synthesizes research evidence regarding this issue on the contents of dual-tasking walking.

Methods: Relevant studies were systematically identified from electronic databases of Medline, PubMed, CINAHL, Cochrane CENTRAL and PsycINFO, and the reference lists of identified articles. The selection criteria were defined a priori. Two independent reviewers classified task types based on properties for cognitive demand, assessed the methodological quality with a customized checklist, and calculated the odds ratio of fall prediction.

Results: There was one study of reaction time, one of discrimination and decision-making, 10 of mental tracking, three of verbal fluency and five of manual tasks. The methodological heterogeneity was manifested in the selection criteria, faller classification, tasks and measures, resulting in substantial heterogeneity (I^2 87–92%). Meta-analyses resulted in a significant pooled odds ratio 1.33 (95% CI 1.18–1.50). The mental tracking task was the only type that yielded a significant odds ratio 3.30 (95% CI 2.00–5.44). Running meta-analyses separately for simple and difficult mental tracking task showed similar odds ratios.

Conclusion: The mental tracking task yielded significant dual-task-related changes for fall prediction. Most studies successively used an appropriate level of task complexity specific to the specified population of interest. More research is required for definite conclusions regarding the effect of task type and complexity. **Geriatr Gerontol Int 2013; 13: 289–297**.

Keywords: accidental falls, attention, elderly, meta-analysis, odds ratio.

Introduction

Falls are a common problem in the growing population of older people.[1] Therefore, the simple and efficient detection of falls risk in older adults is a major objective of geriatric medicine. The principle of dual-task gait assessment is to compare task performance while walking and simultaneously executing an attention-demanding task with the performance of either one of the single tasks. The Prevention of Falls Network Europe suggested that the dual-tasking paradigm might add value for falls prediction over single-tasking,[2] whereas Beauchet *et al.*[3] in a recent review concluded that changes in performance while dual-tasking were significantly associated with an increased risk for falling in the elderly. The research evidence remains unclear, however, with regard to the influence of task type (e.g. which cognitive domains are taxed) and complexity (i.e. the level of difficulty) of the secondary attention-demanding task during dual-task walking.[4]

Dual-tasking probes divided-attention, which is one aspect of executive function.[4] Changes in performance while dual-tasking are typically interpreted as interference due to competing demands for the attentional resources required for both tasks, and primarily depend on one's capacity to properly allocate attention between the two tasks.[5] Therefore, it is reasonable to propose that because of the different mechanisms involved in executing different attention-demanding tasks, the interference with walking also varies. This proposition is supported by a meta-analysis by Al-Yahya *et al.*, who reported that tasks that involve internal interfering

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factors (e.g. mathematic tasks) seem to disturb gait performance more than those involving external interfering factors (e.g. reaction time tasks).[6] However, to the best of our knowledge, just two studies have directly compared the predictive ability of two types of attention-demanding tasks for falls,[7,8] but these studies had conflicting findings. Whether the predictive ability of dual-task-related changes for falls is systematically related to the type of attention-demanding task remains unclear.

The complexity level within each type of attention-demanding task could also influence how well dual-task-related changes predict falls. Previous research shows that a task that is overly simple for a specific population might not interfere in the processing of attentional resources during walking in that population.[9–11] In regards to the prediction of falls, only Verghese *et al*. documented the better predictive ability of a more complex reciting task than of a simpler reciting task.[12] A suitable complexity level within each type of attention-demanding task that could best predict falls that occur in the elderly population warrants additional research.

In the present article, we aimed to provide a better understanding of the influences of type and complexity of a secondary task during walking on elderly falls, with the hope to benefit both researchers and professionals in determining appropriate assessment materials. We categorized the selected studies based on the type of secondary task(s) used, analyzed the studies' methodological quality and carried out meta-analyses on each task type and complexity level, if appropriate.

Methods

Search strategy and selection criteria

Two independent reviewers, HC and YP, searched articles in the electronic databases of Medline, PubMed, CINAHL, Cochrane Central Register of Controlled Trails and PsycINFO. The search strategy was to use combinations of the following key terms (The bold terms are MeSH terms): (**aged** OR **aged 80 and over** OR elderly OR **frail elderly**) and (**gait**[s] OR **walking** OR ambulation OR **locomotion**) and (**accidental fall[s]** OR fall[s]) and (**attention** OR **cognition** OR dual task[s] OR attention task[s] OR cognitive task[s] OR secondary task[s] OR double task paradigm). The database search was limited to English and human participant articles with publication dates up to May 2011. In addition, the reference lists of the retrieved articles that fulfilled the following inclusion and exclusion criteria were hand-searched.

The articles that were identified in the literature search were independently evaluated by the two reviewers, HC and YP, for the following criteria. The inclusion criteria, in order of priority, included: (i) the dual-task paradigm was used to discriminate fallers and non-fallers or to predict falls; (ii) the postural task of the dual-task paradigm was ground walking; and (iii) the mean age of the sample was 60 years or older. The exclusion criteria, in order of priority, included: (i) dissertation theses, review articles or conference abstracts; (ii) articles that focused on a single population with a specific diagnosis, such as stroke or arthritis; (iii) intervention studies; and (iv) articles that did not report discriminative or predictive values of falls, and the aforementioned values could not be extracted from the article contents.

Classifications of secondary task types

The secondary tasks in each article were grouped according to their task domains. Based on the classification system of secondary tasks by Al-Yahya *et al*.,[6] the following first four types were defined; each is plausibly distinct from the other types at a behavioral and/or cognitive level. An additional type of manual task, which has been commonly used in clinical settings, was added.

- Reaction time tasks: these refer to tasks that involve measuring the elapsed time between a sensory stimulus and a behavioral response.[13] These tasks have typically been used to measure processing speed when slowed processing might underlie a general attentional deficit.[14]
- Discrimination and decision-making tasks: these refer to tasks that require selective attention and response to a specific stimulus or feature. These tasks have typically been used to examine attention and response inhibition.
- Mental tracking tasks: these refer to tasks that require holding information in the mind while carrying out a mental process.[14] These tasks have typically been used to examine sustained attention, information process-sion speed and working memory.[14,15]
- Verbal fluency tasks: these refer to tasks that require spontaneous word production under prespecified search conditions.
- Manual tasks: these refer to balancing tasks of one or both arms, such as cup- or tray-taking tasks.

Data analysis

The methodological quality of each included article was assessed based on a customized checklist (Table 1). To retrieve results that are relevant to the current research questions, the reviewers extracted the aforementioned descriptive data not only from the report numbers, but also from other components of the study, including tables or figures.

The main analysis variable was the odds ratio (OR). In cases that did not report an OR, the mean OR and 95%

Table 1 Summary of descriptive information on included studies, categorized based on the type of secondary task

	Participant Sample size (ratio of♀)	Mean age ± SD	Inclusion and exclusion criteria	Falls Definition and fall rate	Dual tasks & Results Walking task odds ratio and 95% CI	Secondary task odds ratio and 95% CI
Reaction time tasks ($n = 1$)						
Faulkner *et al.*, 2007[16]	370 (52.3%)	78 ± 3	Those who were judged to walk with significant pain or injury risk were excluded	Retrospective 1-year ≥2 falls 10.0%	Turn walk 10 + 10 m (walking time) 1.23 (0.98–1.53)	Push-button task in response to an auditory tone (reaction time) 0.84 (0.65–1.08)
Discrimination and decision-making tasks ($n = 1$)						
Faulkner *et al.*, 2007[16]	370 (52.3%)	78 ± 3	Those who were judged to walk with significant pain or injury risk were excluded	Retrospective 1-year ≥2 falls 10.0%	Turn walk 10 + 10 m (walking time) 1.21 (0.99–1.48)	Visuo-spatial decision task (reaction time) 0.91 (0.70–1.19)
Mental tracking tasks ($n = 10$)						
Shumway-Cook *et al.*, 2000[7]	30 (60.0%)	Fallers 78.4 ± 5.8 Non-fallers 86.2 ± 6.4	Those who did not have known neurological or musculoskeletal diagnosis that could account for imbalance and falls, and who could walk without personal help for 9.1 m	Retrospective 6-month ≥2 falls 50.0%	Timed Up and Go (walking time ≥15 s) 56.00* (5.13–611.74)	Counting backward by threes
Stalenhoef *et al.*, 2002[17]	287 (60.0%)	Men 77.2 ± 4.9 Women 78.5 ± 5.2	Those with serious cognitive impairment, illiteracy, severe somatic or psychiatric disease or admission into a nursing clinic or hospital were excluded	Prospective 36-week ≥2 falls 16.0%	Straight walk 3 m	Two simple calculations (abnormal score) 1.5 (0.7–3.3)
Verghese *et al.*, 2002[12]	59 (57.6%)	79.6 ± 6.3	Those with severe visual loss, who were non-English or non-Spanish speaking, and who were institutionalized were excluded	Prospective 1-year ≥1 fall 22.0%	Turn walk 6 + 6 m (walking time ≥33 s) 13.75* (2.26–83.56)	(Complex) recite 26 alphabet letters alternatively
Beauchet *et al.*, 2007[18]	187 (84.4%)	84.8 ± 5.2	(Senior housing) Those with a fall history, acute illness, severe cognitive impairment, severe depressive symptoms, major diagnoses or who used walking aids were excluded	Prospective 1-year first fall 28.9%	Straight walk 10 m	Counting backward by ones (more counts during walking than during sitting) 53.08* (20.65–136.43)
Beauchet *et al.*, 2008[19]	187 (84.4%)	84.8 ± 5.2	(Senior housing) Those with a fall history, acute illness, severe cognitive impairment, severe depressive symptoms, major diagnoses or who used walking aids were excluded	Prospective 1-year first fall 28.9%	Straight walk 10 m (walking time ≥19.6 s) 1.9 (0.9–4.2)	Counting backward by ones
Beauchet *et al.*, 2008[20]	213 (83.6%)	84.4 ± 5.5	(Senior housing) Those with acute illness, severe cognitive impairment, severe depressive symptoms, major diagnoses or who used walking aids were excluded	Prospective 1-year ≥2 falls 9.4%	Straight walk 10 m (decrease in walking speed during dual-tasking) 3.33* (1.29–8.56)	Counting backward by ones
Kressig *et al.*, 2008[21]	57 (77.2%)	85.0 ± 6.6	(Inpatients) Those who were in a stable non-terminally ill health condition and able to walk 12 m without assistive device	Prospective 29.6 ± 25.9 days first fall 17.5%	Straight walk 12 m (coefficient of strike time variation ≥10%) 8.6* (1.9–39.6)	Counting backward by ones
Herman *et al.*, 2010[22]	262 (60.3%)	76.3 ± 4.3	Those who were diagnosed with a disease likely to directly impact gait, with acute illness or with major depression were excluded	Prospective 2-year ≥1 fall 50.0%	Continuous walk for 2 minutes (swing time variability) 1.26* (1.03–1.55)	Counting backward by threes

Table 1 *Continued*

	Participant Sample size (ratio of♀)	Mean age ± SD	Inclusion and exclusion criteria	Falls Definition and fall rate	Dual tasks & Results Walking task odds ratio and 95% CI	Secondary task odds ratio and 95% CI
Nordin *et al.*, 2010[8]	192 (72.2%)	79.0	Those who could walk 10 m without assistive device and without cognitive impairment	Prospective 1-year ≥1 fall 48.0%	Straight walk 10 m (change in mean step width ≥16.8 mm) 2.5* (1.1–5.7)	Counting backward by threes
Yamada *et al.*, 2011[23] [Faster group]	258 (approx. 61.4%)	approx. 77 ± 8	No inclusion/exclusion criteria	Prospective 1-year ≥1 fall 18.2%	Straight walk 15 m (dual-task cost ratio of walking time) 1.03* (1.01–1.04)	Counting backward by ones
Verbal fluency tasks ($n = 3$)						
Lundin-Olsson *et al.*, 1997[24]	58 (72.0%)	80.1 ± 6.1	(Sheltered accommodation) Those who could walk with or without aids and could follow simple instructions	Prospective 6-month ≥1 fall 36.2%	Indoor walking (Number of stop walking) 15.91* (3.02–83.88)	Conversation
Verghese *et al.*, 2002[12]	59 (57.6%)	79.6 ± 6.3	Those with severe visual loss, were non-English or non-Spanish speaking, and were institutionalization were excluded	Prospective 1-year ≥1 fall 22.0%	Turn walk 6 + 6 m (Walking time ≥20 s) 7.03* (1.68–29.43)	(Simple) recite 26 alphabet letters
Bootsma-van Der Wiel *et al.*, 2003[25]	380 (65.0%)	85	No inclusion/exclusion criteria	Prospective 1-year ≥1 fall 41.6%	Two turn walks 3 + 3 m (Change in number of stop walking) 0.98 (0.65–1.47)	Recite animal or profession names
Manual tasks ($n = 5$)						
Lundin-Olsson *et al.*, 1998[26]	42 (71.4%)	79.7 ± 6.1	(Sheltered accommodation) Those who could walk with or without aids and could follow simple instructions	Prospective 6-month ≥1 fall 33.3%	Timed Up and Go (Change in walking time ≥4.5 s) 10.11* (2.00–50.98)	Carry a glass of water (surface 5 cm from edge)
Lundin-Olsson *et al.*, 2000[27]	35 (approx. 71.8%)	approx. 82	(Sheltered accommodation) Those who could walk with or without aids, follow simple instructions, and had negative Stop Walking While Talking	Prospective 6-month ≥1 fall 22.8%	Timed Up and Go (Change in walking time ≥4.5 s) 12.50* (1.69–92.25)	Carry a glass of water (surface 5 cm from edge)
Shumway-Cook *et al.*, 2000[7]	30 (60.0%)	Fallers 78.4 ± 5.8 Non-fallers 86.2 ± 6.4	Those who did not have any known neurological or musculoskeletal diagnosis that could account for imbalance and falls and who could walk without personal help for 9.1 m	Retrospective 6-month ≥2 falls 50.0%	Timed Up and Go (Walking time ≥14.5 s) 91.00* (7.35–1126.95)	Carry a glass of water (surface 5 cm from edge)
Nordin *et al.*, 2010[8]	230 (72.2%)	79.0	Those who could walk 10 m without assistive device and without cognitive impairment	Prospective 1-year ≥1 fall 48.0%	Straight walk 10 m (Change in mean step width ≥3.7 mm) 0.2* (0.1–0.5)	Carry a coffee cup and saucer
Yamada *et al.*, 2011[23] [Fastest group]	230 (approx. 61.4%)	Approx. 77 ± 8	No inclusion/exclusion criteria	Prospective 1-year ≥1 fall 20.0%	Straight walk 15 m (Dual-task cost ratio of walking time) 1.07* (1.04–1.10)	Carry a tray with a ball

*Statistically significant.

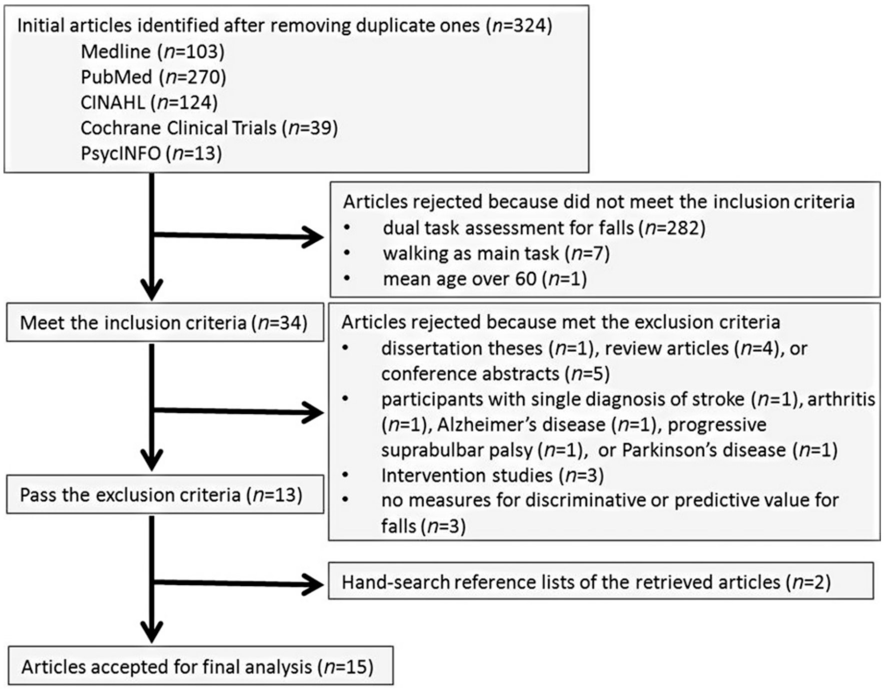

Figure 1 Flow diagram of the article selection process.

confidence interval (CI) were calculated by hand.[7,24–27] In cases in which only crude OR or both crude and adjusted OR were reported,[12,16–18,21,22] we analyzed crude OR for two reasons. First, different studies used various variables for adjustment, making the comparison between studies difficult. Second, crude OR is easier to apply in clinical applications than adjusted OR. In one study, the variable used to predict falls was walking speed, which resulted in an OR lower than 1.[20] We considered the use of the variable "decrease in walking speed" with an OR higher than 1 to be more appropriate, and therefore used the reported OR value for "decrease in walking speed" in a review article by the same research group.[3] Just three studies did not provide data for crude OR. In these cases, the reported adjusted OR was used in the present review.[8,19,23]

To examine whether the overall effect was modified by the type of secondary task, we carried out subgroup meta-analyses on studies with different types of secondary task. The results are presented as an OR with a 95% CI and respective P-values for null hypothesis tests (i.e. overall OR is not significant). Heterogeneity between the studies was investigated by calculating the Q-value and I^2 statistic, which quantifies the proportion of variation that is a result of heterogeneity rather than chance. As a result of the statistically significant heterogeneity among the studies, a random-effects model of the generic inverse variance method was used. Furthermore, we investigated the influence of complexity level of each type of secondary task on falls prediction by exploring the complexity level used by each study and the related results reported in each study. To contrast the complexity levels, meta-analyses were carried out only if a sufficient number of studies were identified for each complexity level within each type of secondary task.

Results

Characteristics of selected studies

The study selection is shown on a flow diagram (Fig. 1). Table 1 summarizes the articles included in the present review according to their secondary task categorization. The number of participants ranged from 30 to 380, and all of the articles included more female than male participants. The selection criteria for population samples varied between articles. Six articles set exclusion criteria of potential gait imbalance as a result of diseases[7,18–20,22] or the subjective judgment of the experimenters,[16] and six articles excluded participants with severe cognitive impairment, depression or psychiatric disease.[8,17–20,22] Just two articles excluded participants with a history of falls.[18,19] Six articles examined frail older participants living in senior housing facilities,[18–20,24,26,27] one article focused on inpatients,[21] and all of the other articles invited community-dwelling elderly.

Falls rates ranged from 9.4% to 50.0%. Two of the 15 articles collected falls information retrospectively,[7,16] whereas the other 13 articles used a prospective design. Apart from the article that focused on inpatients,[21] periods of fall collection ranged from 6 months to 2 years. The definition of fallers ranged from suffering from the first fall event,[18,19,21] a single fall[8,12,22–27] to recurrent falls.[7,16,17,20] A straight walkway was used in seven articles, a return route was used in five articles,[12,16,22,25] and a sit-to-stand movement plus a return route was used in the remaining three articles.[7,26,27] Most of the articles considered walking performance measures to be potential predictors of falls, whereas Stalenhoef *et al.*[17] and Beauchet *et al.*[18] considered measures of secondary task performance as potential predictors of falls, and Faulkner *et al.*[16] used both measures of walking and secondary tasks.

All of the articles reported a deteriorated performance during dual-tasking as a potential predictor of falls, with two exceptions. Nordin *et al.* used the absolute value of changes in gait performance rather than specifying the direction of gait changes during dual-tasking.[8] Beauchet *et al.* reported that more counts in the arithmetic secondary task during walking than during sitting was strongly associated with falls.[18] However, in another article with the same set of experimental data, Beauchet *et al.* reported a deteriorated walking performance during dual-tasking with a marginally significant OR for fall prediction.[19]

Influence of type of secondary task

Figure 2 shows the specific OR and the pooled OR computed with the meta-analysis technique. The reaction time tasks, and the discrimination and decision-making tasks were used by only one study each, and the OR were marginally significant. Of the 10 studies of mental tracking tasks, the occurrence of falls was significantly associated with dual-task-related performance in eight studies. The pooled OR for falling was 3.30 (95% CI 2.00–5.44), which had relatively small variance. Of the three studies of verbal fluency tasks, the occurrence of falls was significantly associated with dual-task-related performance in two studies. The pooled OR for falling was high, 4.22 (95% CI 0.65–27.55), but insignificant because of the large variance. There were five studies that used manual tasks, and the occurrence of falls was significantly positively associated with dual-task-related performance in four studies. The pooled OR was 3.20 (95% CI 0.76–13.52), but insignificant in predicting elderly falls because of the large variance. There was substantial heterogeneity within each domain (87–92%). The pooled OR for falling when the analysis included all studies was 1.33 (95% CI 1.18–1.50).

Influence of complexity of secondary task

Because only a single paper used reaction time tasks, and discrimination and decision-making tasks, the influence of task complexity on falls prediction was not analyzed for these two types of tasks. Under the categorization of mental tracking tasks, the studies of Beauchet *et al.*[18–20] and Kressig *et al.*[21] with institutionalized participants, and of Yamada *et al.*[23] (with no inclusion and exclusion criteria) all used a very simple task, counting backwards by ones. The other studies with community-dwelling participants utilized more difficult tasks, such as counting backwards by threes,[7,8,22] two simple calculations[17] and alternate reciting of the alphabet.[12] All of the aforementioned studies, but two, found a significant OR.[17,19] As the simple and difficult mental tracking tasks were used by five studies each, meta-analyses were carried out to compare these two complexity levels. The results showed a pooled OR of 1.03 (95% CI 1.02–1.05) for the simple tasks and 1.39 (95% CI, 1.15–1.68) for the difficult tasks (Fig. 3), suggesting that most studies successfully used an appropriate level of task complexity for the specified population of interest.

Under the categorization of verbal fluency tasks, Lundin-Olsson *et al.* studied institutionalized participants and used a very simple secondary task, natural conversation.[24] Verghese *et al.* asked community-dwelling elders to recite the alphabet.[12] Both Lundin-Olsson *et al.* and Verghese *et al.* found a significant OR. Bootsma-van Der Wiel *et al.* invited a group of very old people with a significant cognitive impairment to carry out relatively difficult reciting tasks, and the OR was not significant.[25]

Under the categorization of manual tasks, Lundin-Olsson *et al.* recruited institutionalized participants and used a relatively simple secondary task, carrying a glass of water with the surface of liquid 5 cm from the top edge.[26,27] Shumway-Cook *et al.* focused on community-dwelling participants and used a more complex manual task, carrying a full cup of water.[7] Nordin *et al.* studied a group of relatively fit older adults, and used a complex coffee cup and saucer-taking task.[8] Yamada *et al.* did not set inclusion and exclusion criteria, and used a manual task of carrying a tray with a ball on top of it.[23] All of the aforementioned studies showed a significant OR.

Discussion

The present review was carried out to investigate the influence of the type and complexity of a secondary task on falls prediction in the older population. The structured search yielded 324 articles that reported the task performance of older people during the combination of a postural task and a cognitive task. Just 15 original journal articles, which reported the predictive ability of dual-task-related changes during dual-task walking for accidental falls among a general group of older participants, were selected for the present study. According to the categorization of secondary tasks, there was one reaction time task study, one discrimination and decision-making task study, 10 mental tracking task studies, three verbal fluency task studies, and five manual task studies.

Significant heterogeneity was found (homogeneity rejected, $P < 0.001$), which might be a result of the

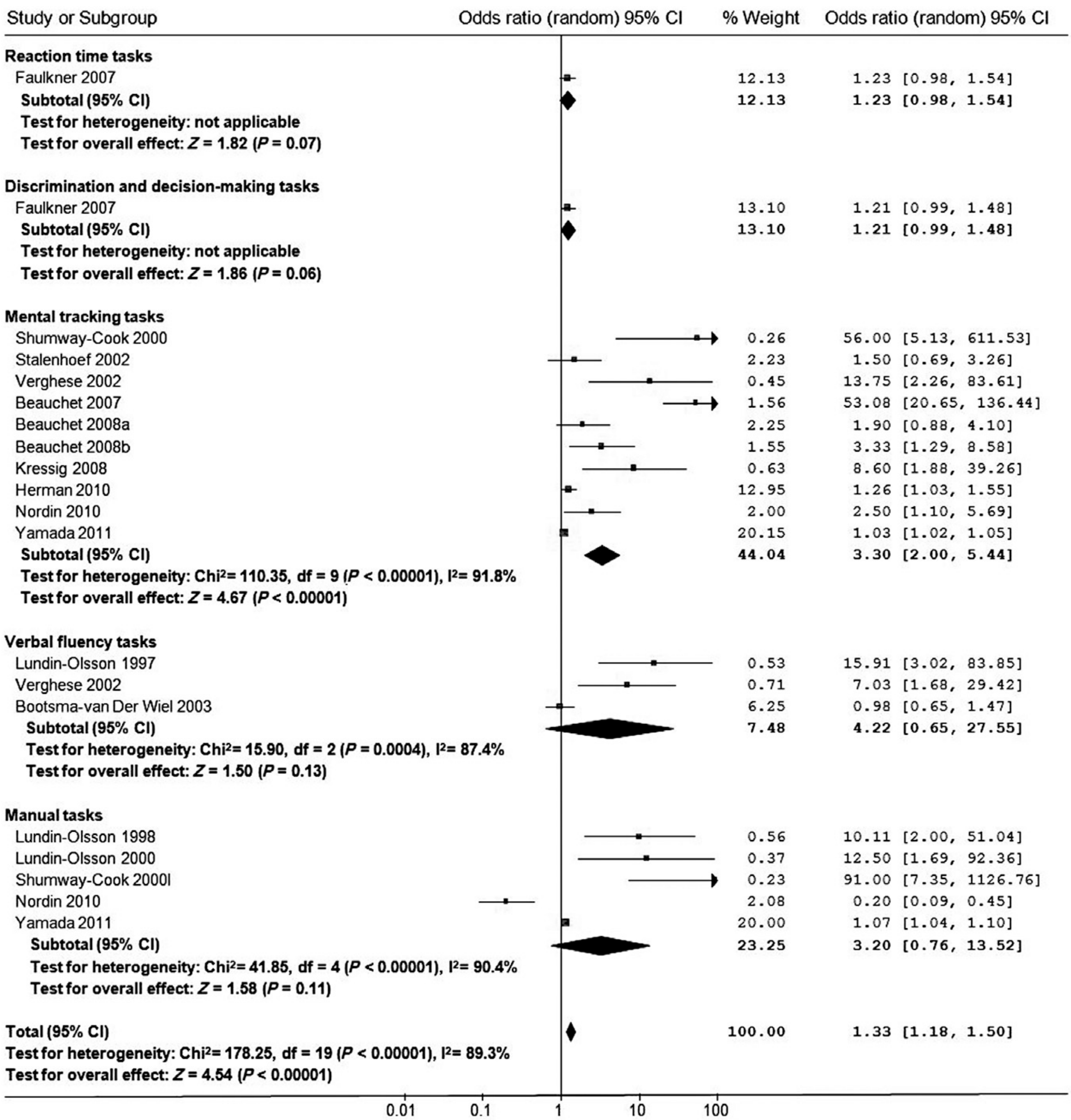

Figure 2 Forest plot of the pooled estimated odds ratio (OR) associated with the risk of falls according to the dual-task-related performance computed from the natural logarithm transformation of the OR and 95% confidence interval (CI).

methodological heterogeneity of the included studies. The study of Yamada *et al.*, with rather small OR (1.03 for the mental tracking task and 1.07 for the manual task), was the greatest contributor to the pooled OR (in the direction of reducing it).[23] Carrying out meta-analyses increased the sample size (i.e. power), still resulting in a significant pooled OR of 1.33 with 95% CI of 1.18–1.50. The finding that changes in performance while dual-tasking were significantly associated with an increased risk of falling in older adults is in accordance with the review by Beauchet *et al.*[3]

Direct comparisons were not possible for different secondary task domains, and the evidence in this regard is limited. However, forest plots suggest that the evidence regarding fall prediction is robust for mental tracking tasks, but is lacking for reaction time, and

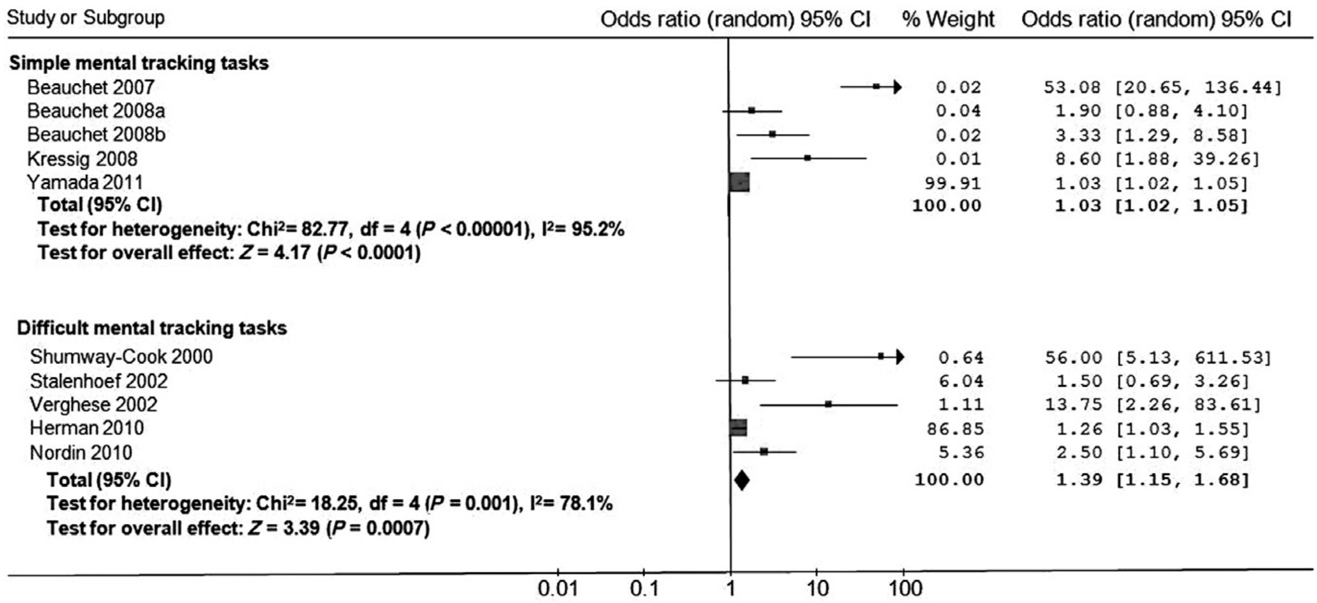

Figure 3 Forest plot of the pooled estimated odds ratio associated with the risk of falls according to the dual-task-related performance, as a function of task complexity of the mental tracking tasks. CI, confidence interval.

discrimination and decision-making tasks. This finding is in accordance with Al-Yahya *et al.*'s claim that cognitive tasks that involve internal interfering factors (e.g. mathematic tasks) seem to disturb gait performance more than those involving external interfering factors (e.g. reaction time tasks).[6] Furthermore, the evidence regarding fall prediction was marginal for verbal fluency tasks. This insignificance might be a result of the small number of studies involved, as Al-Yahya *et al.* reported no different effects of executing mental tracking tasks and verbal fluency tasks on gait speed and cadence.[6] However, mental tracking tasks might indeed have superior predictive ability for elderly falls compared with verbal fluency tasks. Verbal fluency tests are among the three classical tests of executive function;[28] however, the semantic fluency tests target semantic memory, which has no direct relationship to executive functions.[29] The mental tracking test, on the contrary, depends on working memory, which is a system for temporary storage and information processing that is directly related to executive functions.[29]

With regard to the evidence for manual task fall prediction, four of the five studies showed positive evidence. The pooled OR, however, was insignificant because of the very small OR value (i.e. 0.20, showing significant negative evidence) of the study by Nordin *et al.*[8] They used the absolute value of changes of gait performance rather than specifying the direction of gait changes during dual-tasking. Although a manual task alone does not require a specific cognitive demand, it requires divided attention during dual-tasking.[4] It is likely that further studies will show evidence of manual task fall prediction.

When applying the dual-task paradigm, the complexity level of the secondary task must be carefully considered. The current review seems to suggest that an appropriate level of complexity is specific to the population of interest and that with a properly chosen level of complexity, a positive finding is likely. For example, for the institutionalized population, it might be more appropriate to use a simple task level, such as counting backwards by ones or carrying a half-full cup of water. For the community-dwelling population, a more difficult level of secondary task might be more appropriate, such as counting backwards by threes, reciting the alphabet or carrying a full cup of water. In support of the aforementioned notion, the current meta-analyses on simple mental tracking tasks, which are typically used for institutionalized older adults, and difficult mental tracking tasks, which are typically used for community-dwelling older adults, showed similar levels of significant OR.

Whereas a previous review used a mix of adjusted and crude OR for meta-analysis,[3] we mainly opted for crude OR in the analyses because of its easier application in study comparisons and clinical interpretations. Generally speaking, we observed that the reported adjusted OR is smaller than the crude OR, suggesting that a deteriorated performance during dual-tasking is not the sole predictor of falls. The dual-task approach might be useful only for identifying fallers who have increased attention demands of postural control. Other subgroups of fallers may be identified by targeting other possible risk factors for falls. An assessment profile that consists of divergent assessments targeting different risk factors including a dual-task assessment, such as those developed by Lord *et al.*[30] or Lundin-Olsson *et al.*,[27] might be more predictive of falls than a single assessment.

The current results suggest that the mental tracking task, which is typically combined with the Timed Up & Go test in clinics,[7] yields significant dual-task-related changes for falls prediction, whereas the evidence for fall prediction of the manual tasks and the verbal fluency tasks requires further research to reach a consensus. The complexity of a specific task must also be carefully chosen and standardized to fit the capacity of a specific target population. Because just 15 articles were reviewed and the methodological variations considerably complicated data interpretation and challenged drawing definite conclusions about this literature, more research is warranted that directly compares the influence of different types and complexities of a secondary task during walking on the prediction of falls in the elderly.

Disclosure statement

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