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COMPREHENSIVE REVIEW

Cognitive and physical impact of cognitive-motor dual-task training in cognitively impaired
older adults: an overview

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Running title: Dual-task training in cognitively impaired older adults

Abstract

Ageing is associated with cognitive decline, ranging from normal to mild cognitive impairment or dementia. This leads to physical and cognitive impairments, which are risk factors for loss of autonomy. Therefore, cognitive and physical training are important for cognitively impaired older adults. The combination of both may represent an efficiency advantage. This overview aims to summarize the effectiveness of cognitive-motor dual-task (CMDT) interventions on cognitive, physical and dual-task functions in cognitively impaired older adults, as well as the safety, adherence, and retention of benefits of these interventions. We searched for systematic reviews or meta-analyses assessing the effects of CMDT interventions on cognitive or physical functions in older adults with mild cognitive impairment or dementia through eight databases (CDSR (Cochrane), MEDLINE, Scopus, EMBASE, CINAHL, PsycINFO, ProQuest and SportDiscus). Two reviewers independently performed the selection, data extraction and risk of bias evaluation. Nine reviews were included in this overview. CMDT interventions were found to be more effective than active control groups on cognitive and physical functions in older adults with cognitive impairment, irrespective of intervention dose and modalities; no information on dual-task functions was available. Retention of benefits, adherence, need for supervision and safety are still unclear. These results should be interpreted with caution, considering the low average methodological quality of included reviews. Future intervention research should follow more rigorous methodological standards and focus on other forms of CMDT.

Keywords

Cognition; Cognitive impairment; Dementia; Dual-task training; Motor.

Introduction

Ageing is associated with cognitive decline, ranging from normal to pathological. This broad spectrum includes mild cognitive impairment (MCI), defined as a transient state between normal cognition and major neurocognitive disorders [46]. At the other end of this spectrum is dementia, the most common of which is Alzheimer's disease (AD) [4].

Older adults with MCI present cognitive impairment [39] and sometimes additional physical impairment [10, 33]. These cognitive and physical impairments are risk factors for falls, loss of autonomy [49], and progression to AD and other dementias [22, 45]. This is particularly true for older adults with motoric cognitive risk syndrome (MCR), characterized by dual-decline of both motor (slowed walking speed) [36, 57] and cognitive functions (similar to MCI) [57].

Thus, many various programs have been developed to increase cognitive [6, 29] and motor [12] functions in older adults with MCI or dementias. These interventions consist of cognitive [29] or physical [6, 12] exercises. It has been assumed that the combination of cognitive and physical exercises (i.e., specifically designed simultaneous cognitive-motor dual-task (CMDT)) could maximize the effects [40] and present greater benefits on cognitive [28] and physical [40] functions than cognitive or motor single task trainings in MCI.

Many recent systematic reviews have investigated the effects of CMDT with varied modalities on numerous cognitive or motor outcomes, reaching different conclusions [38, 61]. Some reported positive effects on physical outcomes [61] while others reported CMDT as being ineffective on cognitive functions [38]. Furthermore, most intervention studies assessed feasibility, long-term effects and adherence, but this information seems unclear for CMDT in cognitively impaired older adults [20, 23]. Data for CMDT have been summarized in a recent overview [19], but only in cognitively healthy older adults. Inconsistent findings on CMDT in cognitively impaired older adults indicate the need for further studies. The present study

aimed at 1) summarizing the effects of CMDT training on cognitive, physical and dual-task functions in cognitively impaired older adults, and 2) determining the feasibility (setting, need for supervision, safety), retention of benefits and adherence of these interventions.

Methods

Design and protocol

We used the definition of “systematic review” from a Cochrane guide [13]. In order to perform this overview, we used a protocol established prior to carrying out this review. The design and the protocol of this overview were established following authors’ recommendations [44], checklist [9], Cochrane guidelines [43] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [35].

Search strategy

In order to gather the maximum amount of literature, and so as not to miss any reviews, we conducted our overview through different online databases: the Cochrane Database of Systematic Reviews, MEDLINE (PubMed search engine), Scopus, EMBASE, CINAHL, PsycINFO, ProQuest and SportDiscus. We also searched for grey literature through the reference list of included reviews. We performed the entire search to from February 1, 2020 to March 30, 2020. We searched the titles, keywords and abstracts of database entries by using a keyword search: cognitively impaired older adults AND cognitive-motor dual-task training AND physical OR cognitive OR dual-task functions (see details in **Appendix A**).

Eligibility criteria and selection

Two authors (MGG and AP) independently conducted the eligibility analysis and selection of reviews for inclusion in this overview. Concerning the study design, the inclusion criteria

were systematic reviews or meta-analyses, including randomized controlled trials (RCTs) or non-randomized studies of interventions (NRSIs), and full scientific papers all written in English. To define the eligibility of a study's content, we used the PICO framework (Population, Intervention, Comparison, Outcome) [48]. The inclusion criteria were systematic reviews assessing as primary outcome the CMDT's effects on cognitive, physical or dual-task functions compared to active control groups or no intervention in cognitively impaired older adults. This included adults with MCI, MCR, dementia and AD. Active control groups were cognitive or motor trainings, or traditional interventions, i.e. supervised training programs following recommendations for the prevention of falls in older adults [12]. The physical outcomes encompassed motor capacities (strength, gait, mobility and balance) and falls. The cognitive outcomes encompassed attention, memory and executive functions. The dual-task functions encompassed any combined cognitive and physical functions, performed simultaneously. The non-inclusion criteria were: i) non-systematic reviews; ii) reviews integrating participants with neurological disease other than dementia or MCI (e.g., stroke, Parkinson's disease, multiple sclerosis), young participants (below 60 years old), or healthy participants only; iii) reviews that only included motor dual-tasks, or sequential cognitive-motor training. After removing duplicates and scanning titles and abstracts, eligible studies were screened for inclusion by thorough reading.

Data extraction

Two authors (MGG and AP) independently extracted data from the reviews, including: number of primary studies included, objectives, populations, interventions, comparisons, outcomes, conclusion, and risk of bias. In case of disagreement or ambiguity, a third author decided (SM).

Study quality assessment

Two authors (MGG and AP) independently rated the methodology quality of the reviews included using the AMSTAR-2 critical appraisal tool [50], and any disagreements were resolved by consensus.

Overlap

The different systematic reviews included in this overview may have used the same primary studies, at least partially; this is called overlap. It is necessary to calculate the corrected covered area (CCA) [41] to avoid the risk of interpretation and conclusion errors, giving disproportionate power to multiple primary studies.

Results

The initial database search revealed 4225 potentially relevant reviews. After duplicates were removed, 2544 titles and abstract were screened. A total of 95 reviews were assessed as full text, and 9 were included in this overview (**Figure 1**). The list of excluded reviews and reasons for exclusion are available in **Appendix B**. The nine reviews were published in the last six years [7, 11, 20, 23, 28, 31, 38, 56, 61], including 5 reviews with additional meta-analysis [7, 11, 20, 23, 56]. The CCA value was 0.04, so the overlap can be considered as slight (see the details of overlap in **Appendix C**).

Figure 1: flow chart

Participants and interventions

The characteristics of the nine included systematic reviews are summarized in **Table 1**. Interventions within reviews assessed cognitively impaired older adults only (i.e., with MCI,

dementia or AD) [7, 23, 31, 38, 61], or compared with cognitively healthy older adults [11, 20, 28, 56], ranging from 62 to 87 years old. No review integrated older adults with MCR. Eight reviews assessed cognitive outcomes, including global cognition, memory, attention, executive functions, processing speed, verbal fluency, reaction time, motivation, and orientation [11, 20, 23, 28, 31, 38, 56, 61]. Brain cortex structure changes were reported in four studies within one review [61], reporting no effects of CMDT on grey matter volume [5, 55], or better results for CMDT than control groups [26, 51]. Four reviews assessed physical outcomes, including gait, balance, strength, mobility, flexibility, falls occurrence and rate, cardiorespiratory fitness, and physical health and activity [7, 11, 31, 61]. No review investigated dual-task functions as outcomes.

Table 1: Characteristics of the reviews included

Program characteristics were very heterogeneous with respect to frequency (1-6 times a week), length (30-180 minutes) and duration (4-52 weeks long). CMDT interventions' support varied: gymnastic group-based sessions [28, 38, 61], mind-body exercises such as tai-chi, dance, music or martial arts [7, 11, 20], sometimes computer-assisted activities [23, 31, 56]. The cognitive and motor tasks were either to be performed simultaneously [7, 56], or simultaneously and sequentially [11, 20, 23, 28, 31, 38, 61]. Interventions were mostly distributed in groups rather than individually [7, 11, 23, 61], and mixed between home and center-based [11, 28, 38, 61]. Studies that did not take place at home were qualified as center-based (e.g. in a center, a laboratory, a hospital, a clinic, or in a community association).

CMDT were compared to active control groups (cognitive or motor single-task training or activities, usual care or traditional intervention) or no intervention [7, 11, 20, 23, 28, 31, 38, 56, 61], including placebo [31, 38, 56] or education [28, 31, 38, 56].

Effectiveness of CMDT interventions

On cognitive functions

CMDT interventions presented mixed effects on cognitive functions in cognitively impaired older adults: they were found effective in three reviews [28, 31, 56], and ineffective in one other [38]. The benefits of CMDT interventions on cognitive functions were clearer when compared with active control groups: CMDT intervention presented superior benefits on cognition than physical [11, 20, 23, 61] and cognitive [11, 61] training (**Figure 2**). CMDT interventions seem to be effective on global cognition [11, 23, 28, 31, 61], executive functions [23, 28, 61] and memory [11, 23, 28, 31, 61].

On physical functions

CMDT interventions have been found effective in improving physical function in older adults with MCI or dementias [31]. This was confirmed when compared to active control groups: CMDT intervention presented superior benefits on physical function than physical [7, 11, 61] and cognitive [11, 61] training alone (**Figure 2**). More specifically, CMDT interventions seem to be effective on balance [7, 11, 31, 61], mobility [7, 61], gait [7, 61], strength [11], physical activity [61] and cardiorespiratory fitness [11, 61].

Figure 2: Summary of findings

Supervision, safety, adherence, and retention of benefits

Degree of supervision was reported in three reviews [11, 28, 61]; CMDT interventions in older adults with MCI or dementias were mostly supervised [28, 61] or unsupervised [11]. One review assessed interventions' safety [38] and reported no difference in the occurrence of adverse events between intervention and control groups. One other review assessed adherence and reported a low average drop-out rate [61]. Finally, only one study [37] included in one

review [28] reported 5-year retention of benefits. Across reviews, authors agree on the need for investigation of long-term effects [20, 23, 38, 56].

Methodological quality, risk of bias, quality of evidence and funding

Details of the AMSTAR-2 assessment of methodological quality are presented in **Table 2**. Two authors (MGG and AP) agreed at 90% in their rating across the nine systematic reviews included. The overall quality was critically low in seven reviews [11, 20, 23, 28, 38, 56, 61], and low in two [7, 31], with a 7/16 mean score.

Table 2: Methodological quality of the reviews included

Discussion

Effects of CMDT trainings

This overview aimed at summarizing the effects of CMDT training on cognitive, physical and dual-task functions in cognitively impaired older adults. Overall, this type of intervention seems to be effective on both cognitive and physical functions in adults with MCI or dementias, with superior effects compared to active and inactive control groups. However, this overview also highlighted understudied elements, such as effects on dual-task functions, modalities, optimal dose and retention of benefits of interventions.

Cognitive functions

CMDT interventions showed positive effects in older adults with MCI or dementias in different domains: global cognition [11, 23, 28, 31, 61], executive functions [23, 28, 61] and memory [11, 23, 28, 31, 61]. There appears to be no effect of cognitive domain on efficacy [23]. It is worth noting that one review found no effects of CMDT on global cognition or memory [38]. However, it is difficult to know what cognitive and physical components of

interventions are included in this review. Furthermore, this review from Özbe et al. found positive effects of CMDT on dual-task performance, even though it is not part of the described outcomes. We therefore preferred to retain the conclusion common to all of the other authors.

Motor functions

CMDT interventions showed positive effects in cognitively impaired older adults specifically on balance [8, 11, 31, 61], mobility [8, 61], gait [8, 61], strength [11], physical activity [61] and cardiorespiratory fitness [11, 61]. Even though the loss in balance, mobility, gait and strength are known to be risk factors for falls, the effects of CMDT interventions on falls occurrence in cognitively impaired adults remains unclear [8].

Moderator parameters

Participants' status

Two meta-analyses evaluated the effects of CMDT interventions according to participants' cognitive status [20, 23]. The effects were found to be equivalent between healthy and MCI older adults [20], but differences between older adults with MCI or dementia was unclear [23]. It seems logical that severity of participants' cognitive impairment would have an impact on the intervention benefits, but this does not yet seem to be confirmed. In addition, no review assessed the impact of participants' physical status.

Intervention modalities

The optimal dose is difficult to define: meta-analysis showed that CMDT intervention length, duration or frequency had no impact on their efficiency [11, 20]. In addition, these interventions were effective in improving cognitive and physical functions even at short doses

of four weeks [11]. A previous meta-analysis even found a negative association between the intervention length and the effects on cognition in adults with MCI [30]. This might be explained by a cognitive fatigue [27] or excessive stress [18] due to combined mental and physical exertion.

CMDT interventions were mostly group-based, which seems to be recommended for better benefits on cognitive and physical functions [11], although it seems that an individualized approach could have greater effects on fall rates in older adults with cognitive impairment compared with a group exercise [7]. In order to maximize the transfer effect, functional exercises should be the main focus [11]. Although the majority of interventions consisted of simultaneous CMDT, it is unclear whether the two tasks should be performed simultaneously or sequentially. Some authors found simultaneous CMDT more effective than sequential cognitive-motor trainings for adults with MCI [20], while others found the opposite [11]. This has already been explored in cognitively healthy adults, and the advantage on cognitive improvement for simultaneous CMDT [54] may be due to the increased brain-delivered neurotrophic factor (BDNF) after physical activity [25].

Feasibility

Although supervision does not appear to be essential [11], and safety [38], adherence [61] and retention [28] were good when reported, these data were almost never reported in reviews, and were overall understudied in included studies within reviews. However, this is very important information, because presence of MCI or dementia requires long-term adhesion to the training program and the ability to practice this alone safely. It is also important to discuss what adequate “retention” is implied in this population. Indeed, the evolutionary aspect of cognitive impairment such as MCI or dementias implies that maintaining performance is an ideal objective, and that slowing down the degradation would in itself be beneficial.

Quality and risk of bias

This overview presents an average low methodological quality and high risk of bias of the included reviews. The AMSTAR-2 tool we used showed an overall critically low confidence in the results of the included reviews, even though seven of them followed PRISMA or Cochrane Guidelines [7, 11, 20, 23, 28, 56, 61]. A possible explanation is the critical domains system of the AMSTAR-2 tool. For instance, the 7th item (“providing the list of excluded studies”) was reported as “No” in 7 reviews, dropping their assessment to at least "low" (see Table 2).

A second limit of this study is inherent to overviews and is due to the great heterogeneity of included reviews. We included here studies of various cognitive impairments (MCI, dementias, AD), program content and modalities, and outcomes (motor and cognitive). All of this can represent a potential source of misinterpretation when generalizing and extrapolating the results. For instance, we observed an overall superior efficiency for CMDT interventions than control groups, mixing comparison to active or inactive groups. It would be interesting to determine whether CMDT interventions are more effective than placebo, an education program, or a single-task training program. Also, a distinction between three kinds of "multicomponent interventions" would thus be relevant for better readability [5]. Therefore, we could use “combined intervention” for sequential cognitive-motor training, “dual-task intervention” for simultaneous yet distinct tasks (e.g., not functional), and “interactive intervention” in which the actions in one realm affect the other, such as exergames. At last, it is yet unclear if physical and cognitive activities used as control groups in several studies are single task trainings, because they may be multicomponent and include motor-motor or cognitive-cognitive dual-tasks.

Future studies

The positive effects of CMDT interventions on cognitive and physical functions in adults with MCI or dementia no longer require to be proven, and the great heterogeneity in the intervention methodology does not seem to have an impact on efficiency. Conversely, certain elements need to be clarified.

No review included older adults with MCR, who typically show a dual-decline profile of both motor and cognitive functions [57]. To our knowledge, there are not yet any trials including adults with MCR, only incidence or prevalence studies. Future studies should assess the effectiveness of CMDT in this population on cognitive, motor and dual-task functions, depending on the subtype and cognitive profile [2]. This is particularly relevant given the increased risk of conversion to dementia in dual-decliners [36], and because older adults with MCR are close to MCI with slower gait speed [57]. The need to differentiate older adults with MCI according to physical status and functional impairment has already been highlighted [16]. Future studies should assess the differences between fallers and non-fallers, or between participants with and without gait disorders; it is likely that the consequences of CMDT interventions will be different depending on the severity of motor impairment [16]. Finally, reviews including participants with dementia did not provide information about the types of dementia [7, 23, 28]. This information would be relevant, because the type of dementia implies different predominant cognitive impairment: disorientation in dementia with Lewy bodies, executive functions in frontotemporal dementia and coordination in AD. Thus, future studies should distinguish participants according to dementia type, because the training content and objective may differ.

Some of the included reviews integrated mind-body exercises [7, 11, 20] or exergames [11, 20, 23]. Future studies should focus on other forms of CMDT than the analytical combination of a motor and a cognitive task, such as music therapy or tai-chi, which may well be more

entertaining and encouraging for participants. Exergames, for instance, seem promising [21, 24, 53]. Although interventions have been found effective no matter their length, duration and frequency, future studies should evaluate the optimal dose response according to participant characteristics and intervention modalities.

It is surprising that interventions using CMDT as training did not assess the impact on dual-task functions. This was also observed for reviews in cognitively healthy elderly people [19]. We can even consider that measuring the impact of CMDT using single-task evaluations as outcomes does not assess their effectiveness, but the transfer of benefits to other functions. This may be due to the lack of standardized functional assessment for CMDT [1, 42, 60]. However, dual-tasks are already used as specific screening tools for the management of gait disorders and falls in older adults with MCI or dementia [3]. The development of such standardized tools is to be encouraged. Beyond efficiency, future studies should also assess retention of benefits, safety, need for supervision and adherence. The retention of benefits should be evaluated by considering the natural history of degradation of functions in MCI, MCR, dementias or AD, and by considering that a slowdown in this degradation would consist in a retention.

Previous studies in cognitively healthy older adults identified BDNF as a biomarker linking cognitive functions and healthy aging [17, 32]. Moreover, physical activity has been found effective at increasing BDNF secretion [14, 25, 32], and CMDT to be as effective as physical activity alone in healthy young subjects [34]. Thus, the impact of CMDT interventions on neuroplasticity facilitation (i.e., increasing BDNF) remains to be explored in cognitively impaired adults, who are known to have lower BDNF serum levels [52]. An increase in BDNF induces an increase in gray matter volume [15]; this may explain the increase in grey matter observed in few studies [26, 51]. These brain structural modifications are still under debate [5, 26, 51, 55], and should be explored in future studies because they represent a

potential means of action against the progressive loss of grey matter observed in older adults with MCI [47, 58] or AD [59].

Conclusion

This overview found positive effects of CMDT interventions on cognitive and physical functions in adults with cognitive impairment, irrespective of intervention dose and modalities. These results should be interpreted carefully, considering their critically low average methodological quality. Future individual research should follow more rigorous methodological standards, and focus on different CMDT training modalities, assessing the optimal dose response. Long-term retention of benefits, need for supervision, and adherence to these interventions also remain to be determined.

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Conflict of interest

The authors declare no conflict of interest.

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Table 1 : characteristics of included reviews

Review First author, year Country	Objectives 1) Primary 2) Secondary	Included lit. Reviews design (N) Primary studies design (N)	Population N (Exp / Ctrl) Age (mean range) Cognitive status (N)	Interventions Experimental or control group, content (N)	Modalities Sim / seq Ind / grp Center / home Duration min- max	Outcome Types, functions assessed	Conclusions Effectiveness, comparison (primary objective)	Specific results Specific to CI (MCI, Dem or AD), or secondary objective	RoB Scale, score or criteria Mean, range or appreciation
<i>Cognitive Outcome</i>									
Gheysen, 2018 Belgium [20]	1) Effects of CMDT compared to PA and CA 2) Dose and modalities response (frequency, duration, total length, sim/seq) 3) Preventive effects of CMDT	SR (41) - MA (40) RCT (32), NRSI (9)	n.r. n.r. HE (30), MCI (11)	Exp : CMDT (12), EG (6), CMDT-EG (1), Tai-chi-Dance-Martial Arts (13), unclear (9) CG : NI (30), PA (21), CA (10)	Sim (29), seq (9), sim & seq (3) n.r. n.r. 12-24w	Cognitive : memory, attention, executive control, visuospatial performance	CMDT effective CMDT > PA CMDT = CA	Sim > seq (trend) Dose response, retention : unclear (no minimum length, duration and frequency) No difference in cognitive effects according to cognitive status (HE = CI)	EPHPP Weak (13), Moderate (18), Strong (10)
Karssemeijer, 2017 Switzerland [23]	1) Effects of CMDT on cognitive functions, ADL and mood	SR-MA (10) RCT (10)	742 (391 / 351) [71 - 86] MCI (3), Dem (5), MCI & dem (2)	Exp : CMDT (10), computer assisted (3); cognitive (oral, memory, verbal fluency, spatial learning, attention, executive functions, orientation) + physical (strength, balance, resistance, aerobic training, cycling, physical therapy, walking) CG : treatment /care as usual (5), education program (2), sham (2), psychological support (1)	Sim (3), seq (7) Ind (3), grp (7) n.r. 8-52w	Cognitive : global cognition, memory, attention/EF Others : ADL, mood	CMDT effective CMDT > CG	No difference in cognitive effects according to cognitive status (MCI = dem)	CCRT (Unclear - Low)
Law, 2014 Australia [28]	1) Effects of CMDT on cognitive functions	SR (8) RCT (4), NRSI (4)	802 (185 / 617) [62-82] HE (3), Dem (2), MCI (3)	Exp : cognitive (memory, processing speed, attention and memory training, calculation) + physical (aerobic, balance, flexibility, strength, walking) (8) CG : NI (4), PA (4), CA (4), education (3)	Sim (5), seq (3) n.r. Center (4), home (2), unclear (4) 8-52w	Cognitive : global cognition, memory, subjective measures of cognitive impairment, functional status, attention, processing speed, verbal fluency, EF, DT cost Others : ADL	CMDT effective -	HE: significant benefits on general cognitive functions compared to active control groups CI: significant benefits on general cognitive functions, lack of comparison	Personal list modified from Delphi list, PEDro scale and AHRQ (13) : [7-11] Medium (7) High (1)

Özbe, 2019 Germany [38]	1) Effects of CMDT	SR (9) RCT (9)	513 (258 / 255) [70 - 85] AD (4), MCI (3), AD or MCI (2)	Exp: cognitive (n.r.) + physical (resistance, balance, strength, aerobic, psychomotor, ADL) CG: NI or usual care (6), education (1), placebo (1), cognitive STT (1)	Sim (2), seq (7) n.r. Center (n.r.), home (n.r.) 6-52w	Cognitive: global cognition, memory, flexibility, attention Other: depression, anxiety, apathy, agitation, ADL E-ADL, QoL	No effects on cognition -	CMDT seem to have no global effect on cognition or other outcomes, but they can improve DT performance. This effect only appeared in AD, not in MCI.	CCRT High - unclear
Untari, 2019 Indonesia [56]	1) Effects of CMDT on cognitive functions	SR-MA (11) RCT (11)	1145 (n.r.) [65-85] HE (3), MCI (6), AD (1), MCI and AD (1)	Exp: cognitive (computer-based training, memory, VF, visuospatial memory, social interaction, attention, EF) + physical (aerobic, psychomotor, strength, balance, walking, cycling) CG : education (3), usual care (4), cognitive or motor STT (2), psychosocial support (1), placebo (2)	Sim (11) n.r. n.r. 8-52w	Cognitive: global cognition, EF, logical memory, mental abilities, reaction time Other: ADL, E-ADL, cortical atrophy, self-esteem, QoL	CMDT effective -	n.r.	CCRT n.r.
<i>Physical Outcome</i>									
Booth, 2016 United Kingdom [7]	1) Effects of CMDT on risk of falls	SR-MA (8) RCT (8)	1041 (n.r.) [70-83] Dem (3), AD (1), MCI (1), CI (3)	Exp: multicomponent cognitive/physical exercise programs (6), Tai-Chi (1), Music (1) CG : PA (4), usual care or NI (4)	Sim (8) Ind (2), Grp (8) n.r. 4-52w	Physical: falls related risk factors (gait, balance, strength, mobility), falls occurrence	CMDT effective CMDT > physical STT	n.r.	JBIMAStARI (/10) 7,5 [5-10]
<i>Cognitive and Physical Outcome</i>									
Lipardo, 2017 China [31]	1) Effects of CMDT on falls and fall risk factors (balance, lower limb strength, gait, cognitive functions)	SR (17) RCT (17)	1679 (n.r.) [70 - 79] MCI (17)	Exp: physical STT (6), cognitive computerized STT (4), cognitive group-based STT (4), CMDT (3) CG : NI, placebo, education, ST or traditional intervention (not specified)	n.r. n.r. n.r. 5-52w	Cognitive: global cognitive function, memory, EF Physical : falls rate and incidence, balance, gait, lower limb muscle strength	CMDT effective on physical functions and memory, no effects on global cognition -	Physical STT improved fall-related factors such as walking speed and global cognitive function in MCI Cognitive STT did not improve cognitive outcomes in MCI CMDT improved balance in MCI; inconclusive on global cognition and EF	JBIMAStARI (/10) 7,8 [7-10]

Bruderer-Hofstetter, 2018 Switzerland [11]	1) Effects of CMDT on physical and/or cognitive function and transfer to I-ADL 2) provide a rating of the "best intervention" (physical, cognitive or I-ADL) 3) evaluate modalities (content, frequency, duration, intensity, sim/seq)	SR-MA (17) RCT (17)	1758 (n.r.) [66-82] HE (11), CI (2), MCI (4)	Exp: cognitive (memory, executive function, attention, processing speed, learning, planning, spatial) + physical (aerobic, interval, stretching, strength resistance, balance) (12), Tai-chi-Dance (3), EG (2) GC : NI (6) and/or activities (12), education (3)	Sim (9), seq (8) Ind (6), grp (12) Center (9), home (6), n.r. (3) 4-52w	Cognitive: global cognition, learning and memory, EF, attention, language, perceptual-motor function Physical : cardiorespiratory fitness, balance, muscle strength, flexibility	CMDT effective on physical and cognitive functions CMDT > physical STT and cognitive STT improving physical and cognitive functions	CMDT are more effective on global cognition, learning & memory, complex attention, language, and realized seq in MCI CMDT are more effective on cognitive functions, and realized sim and seq in HE	CCRT high - low GRADE very low (17)
Yang, 2019 USA [61]	1) Effects of CMDT compared with STT or NI on functional outcomes	SR (10) RCT (10)	1418 (526 / 892) [67-87] MCI (6), aMCI (4), naMCI (1)	Exp: cognitive (i.g., memory skills) + physical (e.g., aerobic exercise), or cognitive and physical + other (e.g., omega 3) CG: NI or usual care (5), cognitive or motor STT (5)	Sim (4), seq (6) Grp (10) Center (10) 6-52w	Cognitive: global cognition, EF, working memory, mood, emotion, motivation, orientation, changes in brain cortex Physical: physical health and activity, mobility, gait, balance, cardiorespiratory fitness	CMDT effective on physical and cognitive functions CMDT > physical STT and cognitive STT improving physical and cognitive functions	n.r.	CCRT n.r.

AD: Alzheimer’s disease; ADL: activity of daily living; aMCI: amnesic MCI; CA: cognitive activity; CCRT: Cochrane collaboration RoB tool; CI: cognitive impairment; CMDT: cognitive-motor dual-task; Dem: dementia; EF: executive functions; EG: exergame; EPHPP: Effective Public Health Practice Project assessment tool; Grp: group; HE: cognitively healthy elderly; I-ADL: instrumental activities of daily living; Ind: independently; MA : meta-analysis; MCI: mild cognitive impairment; naMCI: non amnesic MCI; NI: no intervention; NRSI: non randomized study of intervention; PA: physical activity; QoL: quality of life; RCT: randomized controlled trial; RoB: risk of bias; Seq: sequential CMDT; Sim: simultaneous CMDT; SR : systematic review; STT: single task training; w: week; "n.r.": not reported.

Table 2: methodological quality assessment.

	AMSTAR-2 Criterion																		Rating (/16)	Overall confidence in the results of the review
	Use PICO	Method	Inclusion	Search strategy	Selection x2	Extraction x2	Exclusions	Description	RoB - RCT	RoB - N-RCT	Funding	MA : Method	MA : RoB	MA : RoB	RoB discuted	Heterogeneity	MA : RoB	COI / funding		
Systematic Review	1	2*	3	4*	5	6	7*	8	9-1*	9-2*	10	11-1*	11-2*	12	13*	14	15*	16		
Law, 2014 [28]	Y	P	N	P	Y	N	Y	P	P	N	N	n.a.	n.a.	n.a.	N	N	n.a.	Y	4	Critically low
Booth, 2016 [7]	Y	Y	N	P	N	N	Y	P	Y	n.a.	N	Y	n.a.	Y	Y	Y	N	Y	9	Low
Lipardo, 2017 [31]	Y	P	Y	P	Y	Y	N	P	Y	n.a.	N	n.a.	n.a.	n.a.	Y	Y	n.a.	Y	8	Low
Karssemeijer, 2017 [23]	Y	Y	N	P	Y	N	N	P	Y	n.a.	N	Y	n.a.	Y	N	Y	Y	Y	9	Critically low
Bruderer-Hofstetter, 2018 [11]	Y	Y	N	P	Y	Y	N	P	Y	n.a.	N	Y	n.a.	Y	Y	Y	N	Y	10	Critically low
Gheysen, 2018 [20]	Y	N	N	P	Y	Y	N	N	P	Y	N	N	N	Y	N	Y	Y	Y	8	Critically low
Özbe, 2019 [38]	N	P	Y	P	Y	Y	N	P	Y	n.a.	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	6	Critically low
Untari, 2019 [56]	Y	P	N	P	Y	N	N	P	N	n.a.	N	N	N	N	N	Y	N	N	3	Critically low
Yang, 2019 [61]	Y	P	N	P	Y	Y	N	n.r.	Y	n.a.	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	6	Critically low
% of "No"	11	11	78	0	11	33	78	11	11	0	100	22	22	11	56	11	33	11	Mean score = 7	

*: AMSTAR 2 critical domains; Y: Yes; P: Partially yes; N: No; n.a.: not applicable; n.r.: not reported.

Rating overall confidence in the results of the review:

High: no or one non-critical weakness. The systematic review provides an accurate and comprehensive summary of the results of the available studies that address the question of interest

Moderate: more than one non-critical weakness*. The systematic review has more than one weakness but no critical flaws. It may provide an accurate summary of the results of the available studies that were included in the review

Low: one critical flaw with or without non-critical weaknesses. The review has a critical flaw and may not provide an accurate and comprehensive summary of the available studies that address the question of interest

Critically low: more than one critical flaw with or without non-critical weaknesses. The review has more than one critical flaw and should not be relied on to provide an accurate and comprehensive summary of the available studies

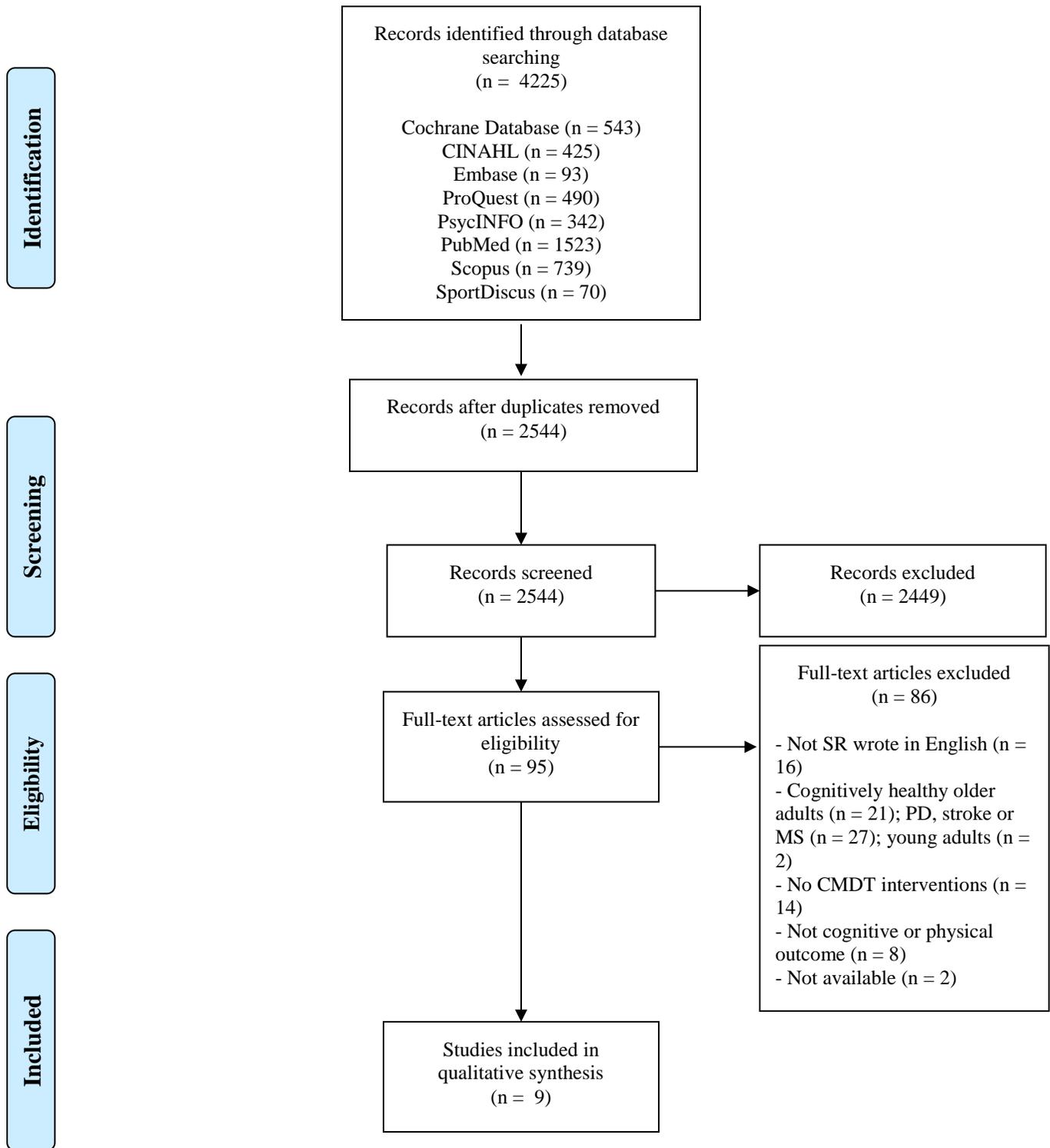


Figure 1: selection of systematic reviews

SR : systematic review; CMDT : cognitive-motor dual-task; PD: Parkinson’s disease; MS: multiple sclerosis

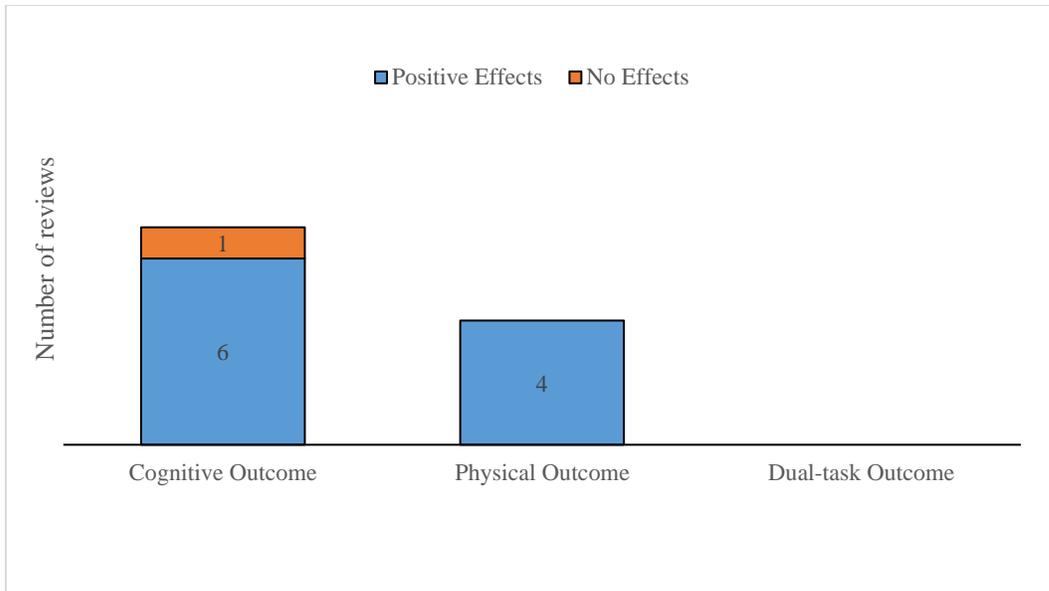


Figure 2: Summary of findings - effects of CMTD interventions on cognitive, physical and dual-task outcomes in older adults with MCI or dementia.