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1 Effects of exergames and cognitive-motor dual-task training on cognitive, physical and dual-
2 task functions in cognitively healthy older adults: an overview

3

4 M. Gallou-Guyot¹, S. Mandigout¹, L. Bherer², A. Perrochon¹

5

6 ¹ Université de Limoges, HAVAE, EA 6310, Limoges, France.

7 ² Department of Medicine, Université de Montréal, Montreal, Canada;

8 Research Centre, Montreal Heart Institute, Montreal, Canada;

9 Research Centre, Institut Universitaire de Gériatrie de Montréal, Montreal, Canada.

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12 **Corresponding author:**

13 Anaïck Perrochon, PhD

14 Faculté des Sciences et Techniques, Laboratoire Handicap, Activités Vieillessement,

15 Autonomie, Environnement (HAVAE, EA 6310), Université de Limoges

16 123 avenue Albert Thomas, FR-87000 Limoges (France)

17 e-mail: anaick.perrochon@unilim.fr

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25 **Abstract**

26

27 This overview aims to summarize the effectiveness of cognitive-motor dual-task and
28 exergame interventions on cognitive, physical and dual-task functions in healthy older adults,
29 as well as the feasibility, safety, adherence, transfer and retention of benefits of these
30 interventions. We searched for systematic reviews or meta-analyses assessing the effects of
31 cognitive-motor dual-task and exergame interventions on cognitive, physical and dual-task
32 functions in cognitively healthy older adults through eight databases (CDSR (Cochrane),
33 MEDLINE (PubMed), Scopus, EMBASE, CINAHL, PsycINFO, ProQuest and SportDiscus).
34 Two reviewers performed the selection, data extraction and risk of bias evaluation
35 independently (PROSPERO ID: CRD42019143185). Eighteen reviews were included in this
36 overview. Overall, positive effects of cognitive-motor dual-task interventions on cognitive,
37 physical and dual-task functions, as well as exergames on cognitive functions only, were
38 observed in cognitively healthy older adults. In contrast, the effects of exergames on physical
39 functions are more controversial, and their effects on dual-task functions have not been
40 studied. The feasibility, safety, adherence, transfer and retention of benefits for both
41 intervention types are still unclear. Future studies should follow more rigorous
42 methodological standards in order to improve the quality of evidence and provide guidelines
43 for the use of cognitive-motor dual-task and exergame interventions in older adults.

44

45 **Keywords**

46

47 Dual-task training; Exergame; Healthy older adults; Cognitive functions; Physical functions.

48 **1. Introduction**

49

50 Aging is associated with a high risk of physical and cognitive impairment, which contributes
51 to disability and possible loss of independence (Anton et al., 2015). A cognitive-motor dual-
52 task (CMDT) is defined as the simultaneous completion of a cognitive and a motor task
53 (Montero-Odasso et al., 2012; Yogev-Seligmann et al., 2008). Cognitive-motor interference is
54 defined as the overwhelming of attention abilities, resulting in a decrease in one or both tasks'
55 performances. Aging is associated with increased risk of falling with the decrease in motor
56 and cognitive functions, or the increase of cognitive-motor interference (Montero-Odasso et
57 al., 2012; Yogev-Seligmann et al., 2008). Thus, the maintenance of cognitive, physical and
58 CMDT capabilities seems to be an important way of preserving autonomy through aging.

59

60 Many recent studies have used interventions requiring the realization of a motor and a
61 cognitive task, performed sequentially or simultaneously to improve CMDT functions (Tait et
62 al., 2017). Exergames (EGs) are increasingly being developed and are often studied together
63 with other CMDT modalities (Schoene et al., 2014; Wollesen & Voelcker-Rehage, 2014).
64 EGs are videogames played on a digital device, including a wide range of interfaces
65 (Baranowski et al., 2008) that require physical activity (Vázquez et al., 2018) as well as
66 cognitive tasks when played (e.g. considering the continuous feedback and making quick
67 decisions) (Larsen et al., 2013). EGs are characterized by their potential ability to motivate
68 older participants to practice through an attractive, interactive way (Skjæret et al., 2016).

69

70 Many reviews have tried to synthesize the results of CMDT and EG interventions (Agmon et
71 al., 2014; Stojan & Voelcker-Rehage, 2019), but those reviews show great heterogeneity
72 related to intervention (content, duration and modality), comparison (active or inactive control

73 groups) and outcome (cognitive, physical or dual-task functions). Moreover, the results are
74 controversial as interventions were found to be effective (Agmon et al., 2014), ineffective
75 (Donath et al., 2016) and unclear (Stojan & Voelcker-Rehage, 2019) across different studies.
76 A recent overview has summarized the positive effects of EGs on physical functions in
77 cognitively healthy older adults (Reis et al., 2019), but the effectiveness of EG interventions
78 on cognitive and dual-task functions in older adults is still to be determined.

79

80 At the same time, most intervention studies assess feasibility, long term effects, safety and
81 adherence, but this information seems unclear for CMDT and EG interventions in older adults
82 (Ghai et al., 2017; Kappen et al., 2019).

83

84 This overview is aimed at 1) summarizing the effects of CMDT and EG interventions on
85 cognitive, physical and dual-task functions in cognitively healthy older adults, and 2)
86 determining the feasibility, safety, adherence, transfer and retention of improvements in these
87 interventions.

88

89 **2. Methods**

90

91 *2.1. Design and protocol*

92

93 We used the definition of “systematic review” from a Cochrane guide (Chandler et al., 2017).
94 In order to perform this overview, we used a protocol established prior to the conduct of the
95 review that was registered on PROSPERO (registration ID: CRD42019143185). The design
96 and the protocol of this overview were established following authors’ recommendations
97 (Pollock et al., 2016), checklist (Bougioukas et al., 2018), Cochrane guidelines (Pollock et al.,

98 2018) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses
99 (PRISMA) (Moher et al., 2009).

100

101 *2.2. Search strategy*

102

103 In order to gather the maximum amount of literature, and not to miss any reviews, we
104 conducted our overview through different online databases: the Cochrane Database of
105 Systematic Reviews, MEDLINE (PubMed search engine), Scopus, EMBASE, CINAHL,
106 PsycINFO, ProQuest and SportDiscus. We also searched for grey literature through the
107 reference list of included reviews, and consulted content experts (Louis Bherer and Bradford
108 J. McFadyen). We performed the entire search from June to August 30, 2019. We searched
109 the titles, keywords and abstracts of database entries by using a keyword search: older adults
110 AND cognitive-motor dual-task training OR exergame AND physical OR cognitive OR dual-
111 task functions (see details in **Appendix A**).

112

113 *2.3. Eligibility criteria and selection*

114

115 Two authors (MGG and AP) conducted the eligibility analysis and selection of reviews for
116 inclusion in this overview independently; in case of disagreement or ambiguity, a third author
117 decided (SM). Concerning the study design, the inclusion criteria were systematic reviews or
118 meta-analyses, including randomized controlled trials (RCTs) or non-randomized studies of
119 interventions (NRSIs), and full scientific papers all written in English. To define the study
120 content's eligibility, we used the PICO framework (Population, Intervention, Comparison,
121 Outcome) (Schardt et al., 2007). The inclusion criteria were systematic reviews assessing as
122 primary outcome the CMDT's effect on cognitive, physical or dual-task functions and EG

123 interventions compared to cognitive or motor single-task trainings, fall prevention programs
124 or no interventions conducted on cognitively healthy older adults. Fall prevention programs
125 are trainings following recommendations for the prevention of falls in older adults (Nelson et
126 al., 2007). The physical outcomes encompass motor capacities (strength, gait, mobility,
127 postural control and balance), and falls. The cognitive outcomes encompass learning,
128 memory, executive functions, processing speed, visuospatial capabilities, attention, reaction
129 time and overall cognition. The dual-task functions encompass any combined cognitive and
130 physical functions performed simultaneously. The exclusion criteria were: i) non-systematic
131 reviews; ii) reviews integrating participants with neurological diseases (e.g. mild cognitive
132 impairment, dementia, stroke, Alzheimer's or Parkinson's disease) or young participants
133 (below 60 years old); iii) reviews that only included motor dual-tasks, sequential cognitive-
134 motor training or passive video games. After removing duplicates and scanning titles and
135 abstracts, eligible studies were screened for inclusion by thorough reading.

136

137 *2.4. Data extraction*

138

139 Two authors (MGG and AP) independently extracted data from the reviews included: number
140 of primary studies included, objectives, populations, interventions, comparisons, outcomes,
141 conclusion, risk of bias, feasibility (centre or home based, grouped or individual interventions,
142 supervision), safety, adherence, transfer and retention of benefits. In case of disagreement or
143 ambiguity, a third author decided (SM).

144

145 *2.5. Study quality assessment*

146

147 Two authors (MGG and AP) independently rated the methodology quality of the reviews
148 included using the AMSTAR-2 critical appraisal tool (Shea et al., 2017). Any disagreements
149 were recorded to assess the agreement rate and then resolved by a third author (SM).

150

151 *2.6. Overlap*

152

153 The different systematic reviews included in this overview may have used the same primary
154 studies, at least partially; this is called overlap. It is necessary to calculate the corrected
155 covered area (CCA) (Pieper et al., 2014) to avoid the risk of interpretation and conclusion
156 errors, giving disproportionate power to multiple primary studies.

157

158 **3. Results**

159

160 *3.1. Characteristics of the reviews included*

161

162 The initial database search revealed 4243 potentially relevant reviews. After duplicate reviews
163 were removed, 2815 titles and abstract were screened. A total of 62 reviews were assessed as
164 full text, and 18 were included in this overview (**Figure A**). The list of excluded reviews and
165 reasons for exclusion are available in **Appendix B**. The eighteen reviews (Agmon et al.,
166 2014; Bleakley et al., 2015; Choi et al., 2017; Donath et al., 2016; Joubert & Chainay, 2018;
167 Larsen et al., 2013; Laufer et al., 2014; Levin et al., 2017; Molina et al., 2014; Neri et al.,
168 2017; Plummer et al., 2015; Rodrigues et al., 2014; Schoene et al., 2014; Stojan & Voelcker-
169 Rehage, 2019; Taylor et al., 2018; Wang et al., 2015; Wollesen & Voelcker-Rehage, 2014;
170 Zhu et al., 2016) were published in the last six years, including eight reviews with additional
171 meta-analyses (Donath et al., 2016; Neri et al., 2017; Plummer et al., 2015; Rodrigues et al.,

172 2014; Taylor et al., 2018; Wang et al., 2015; Zhu et al., 2016). The CCA value was 0.05, so
173 the overlap can be considered as slight (see the details of overlap in **Appendix C**).The
174 eighteen reviews included 203 singular primary articles (i.e. which did not overlap).

175

176 Figure A: flow chart

177

178 *3.1.1. Participants and interventions*

179

180 The characteristics of the 18 systematic reviews included are summarized in **Table A**. These
181 reviews included cognitively healthy older adults (Joubert & Chainay, 2018; Larsen et al.,
182 2013; Laufer et al., 2014; Levin et al., 2017; Molina et al., 2014; Rodrigues et al., 2014;
183 Stojan & Voelcker-Rehage, 2019; Wang et al., 2015; Zhu et al., 2016), or with balance
184 impairment or history of falls (Agmon et al., 2014; Bleakley et al., 2015; Choi et al., 2017;
185 Donath et al., 2016; Neri et al., 2017; Plummer et al., 2015; Schoene et al., 2014; Taylor et al.,
186 2018; Wollesen & Voelcker-Rehage, 2014). Participants were 60 years old or older, with
187 average ages in primary studies ranging from 60 (Stojan & Voelcker-Rehage, 2019) to 91
188 years old (Plummer et al., 2015). Eight reviews did not report the mean age of participants
189 within the studies they included (Joubert & Chainay, 2018; Molina et al., 2014; Neri et al.,
190 2017; Rodrigues et al., 2014; Schoene et al., 2014; Taylor et al., 2018; Wang et al., 2015;
191 Wollesen & Voelcker-Rehage, 2014). After examination of the overlap, so by considering
192 each study included in the reviews only once, the actual number of participants included was
193 28446.

194

195 Table A: Characteristics of the reviews included

196

197 Seven of the reviews included assessed the efficacy of CMDTs (Agmon et al., 2014; Joubert
198 & Chainay, 2018; Levin et al., 2017; Plummer et al., 2015; Wang et al., 2015; Wollesen &
199 Voelcker-Rehage, 2014; Zhu et al., 2016), and eleven assessed EG interventions (Bleakley et
200 al., 2015; Choi et al., 2017; Donath et al., 2016; Larsen et al., 2013; Laufer et al., 2014;
201 Molina et al., 2014; Neri et al., 2017; Rodrigues et al., 2014; Schoene et al., 2014; Stojan &
202 Voelcker-Rehage, 2019; Taylor et al., 2018). Reviews were classified according to their
203 actual interventions, not their titles (e.g. Schoene et al., 2014). CMDT interventions
204 systematically included a cognitive (attention, memory, executive functions, processing
205 speed, visuospatial capabilities or overall cognition) and a physical task (strength, gait,
206 mobility, postural control or balance training). EG interventions used mostly commercial
207 video games (Wii ®, Kinect ®, Dance Dance Revolution ® and virtual reality equipment).
208 Studies amongst reviews sometimes used non-commercial, specially designed games, such as
209 cybercycle (Larsen et al., 2013; Stojan & Voelcker-Rehage, 2019), cyberstep (Neri et al.,
210 2017; Stojan & Voelcker-Rehage, 2019) or computerized balance training (Bleakley et al.,
211 2015; Schoene et al., 2014; Taylor et al., 2018).

212

213 The characteristics of the interventions are summarized in **Table A**. Program characteristics
214 were heterogeneous within and between each review included, with respect to frequency (1 to
215 3 times a week), length (15 to 90 minutes) and duration (once to 96 weeks). The cognitive and
216 physical tasks were either asked simultaneously only (i.e., dual-task training) (Bleakley et al.,
217 2015; Choi et al., 2017; Donath et al., 2016; Larsen et al., 2013; Laufer et al., 2014; Molina et
218 al., 2014; Neri et al., 2017; Rodrigues et al., 2014; Stojan & Voelcker-Rehage, 2019; Taylor
219 et al., 2018) or both simultaneously and sequentially (i.e., sequential cognitive-motor training)
220 (Joubert & Chainay, 2018; Levin et al., 2017; Plummer et al., 2015; Zhu et al., 2016) within
221 reviews; some did not specify this modality (Agmon et al., 2014; Schoene et al., 2014; Wang

222 et al., 2015; Wollesen & Voelcker-Rehage, 2014). Sequential cognitive-motor trainings
223 combined physical and cognitive separately (e.g., Oswald et al., 2006, cited in Zhu et al.,
224 2016). The mode of release was reported in six reviews: CMDT interventions were mostly
225 distributed in groups (Agmon et al., 2014; Plummer et al., 2015; Zhu et al., 2016), and EGs
226 were mostly distributed individually (Laufer et al., 2014; Molina et al., 2014; Taylor et al.,
227 2018). The setting was only reported in three EG reviews (Choi et al., 2017; Schoene et al.,
228 2014; Taylor et al., 2018) and interventions were mostly not home-based (gymnasium,
229 clinical or research centre).

230

231 CMDTs and EGs were compared to inactive and active control groups (single-task training or
232 fall prevention programs) (Agmon et al., 2014; Bleakley et al., 2015; Choi et al., 2017;
233 Donath et al., 2016; Joubert & Chainay, 2018; Larsen et al., 2013; Laufer et al., 2014; Molina
234 et al., 2014; Neri et al., 2017; Plummer et al., 2015; Rodrigues et al., 2014; Schoene et al.,
235 2014; Stojan & Voelcker-Rehage, 2019; Taylor et al., 2018; Wang et al., 2015; Zhu et al.,
236 2016), with or without placebo (Laufer et al., 2014; Molina et al., 2014; Taylor et al., 2018) or
237 education (Agmon et al., 2014; Bleakley et al., 2015; Plummer et al., 2015; Zhu et al., 2016). .
238 The content of active control groups is similar, involving one or more functions training in the
239 same domain (cognitive or motor) carried out sequentially and separately (e.g., "fall
240 prevention programs" include muscle strength, mobility, balance and reaction time exercises)

241

242 *3.2. Results of individual studies*

243

244 The efficacy of CMDT and EG interventions on cognitive, physical and dual-task functions,
245 and their comparison with active or inactive control groups, are summarized in **Table A** and
246 illustrated in **Figure B**.

247

248 Figure B: Summary of findings

249

250 *3.2.1. Effectiveness of CMDT interventions on cognitive, physical and dual-task*
251 *functions*

252

253 Compared to fall prevention programs, single-task training, active and inactive control, two
254 reviews found CMDT interventions superior (Joubert & Chainay, 2018; Levin et al., 2017),
255 and one was found equivalent (Zhu et al., 2016) in improving cognitive functions. Cognitive
256 outcomes varied, including attention, memory, executive functions, processing speed,
257 visuospatial capabilities and overall cognition (Table A).

258 Compared to fall prevention programs, single-task training, motor-motor dual-task training,
259 active and inactive control, one review found CMDT interventions superior (Wang et al.,
260 2015), and one was found equivalent (Levin et al., 2017) in improving physical functions.
261 Physical outcomes varied, including motor capacities (strength, gait, mobility, postural
262 control and balance), and falls (rates, risk factors, fear) (Table A).

263 Three reviews assessed the effectiveness of CMDT interventions on dual-task capabilities in
264 healthy older adults (Agmon et al., 2014; Plummer et al., 2015; Wollesen & Voelcker-
265 Rehage, 2014), and found superior effects compared to single-task training in improving
266 postural control, balance, mobility and gait during dual-task conditions (Table A).

267 It is worth noting that, for all the functions studied, CMDT interventions' effects were greater
268 than for the inactive control group, and greater than or equal to the active control group.

269

270 *3.2.2. Feasibility, safety, adherence, transfer and retention of CMDT interventions*

271

272 One review reported the supervision in CMDT interventions, and the result was unclear
273 (Agmon et al., 2014). The assessment of the safety of interventions was conducted through
274 the occurrence of adverse events. The only review evaluating CMDT intervention safety
275 reported no serious adverse events (Wang et al., 2015). Adherence has rarely been studied in
276 CMDT interventions, but presented acceptable compliance and drop-out rates (Wollesen &
277 Voelcker-Rehage, 2014). The assessment of the transfer of benefits encompasses several
278 factors, and was only reported in four CMDT intervention reviews (Agmon et al., 2014;
279 Joubert & Chainay, 2018; Wollesen & Voelcker-Rehage, 2014; Zhu et al., 2016). CMDT
280 interventions induced positive (Joubert & Chainay, 2018) or unclear (Zhu et al., 2016) effects
281 on daily living activities and mixed effects on tasks other than those trained for (Agmon et al.,
282 2014; Wollesen & Voelcker-Rehage, 2014). Long-term benefits were only reported in three
283 CMDT intervention reviews (Agmon et al., 2014; Joubert & Chainay, 2018; Zhu et al., 2016).
284 Benefits persisted from two weeks (Agmon et al., 2014) to five years (Joubert & Chainay,
285 2018).

286

287 *3.2.3. Effectiveness of EG interventions on cognitive and physical functions*

288

289 One review found EG interventions effective on cognitive functions (Bleakley et al., 2015).
290 Two reviews found that EG interventions were equivalent compared to fall prevention
291 programs, single-task training and active and inactive controls (Schoene et al., 2014; Stojan &
292 Voelcker-Rehage, 2019). Cognitive outcomes varied, including attention, memory, executive
293 functions, processing speed, visuospatial capabilities and overall cognition (Table A).
294 The effectiveness of EG interventions on physical functions was unclear (Bleakley et al.,
295 2015; Molina et al., 2014; Rodrigues et al., 2014). Compared to fall prevention programs,
296 single-task training, motor-motor dual-task training and active and inactive controls, two

297 reviews found EG interventions superior (Neri et al., 2017; Taylor et al., 2018), and four were
298 found equivalent (Choi et al., 2017; Larsen et al., 2013; Laufer et al., 2014; Schoene et al.,
299 2014) in improving physical functions. One review found higher benefits for single-task
300 training compared to EGs in cognitively healthy older adults (Donath et al., 2016). Physical
301 outcomes varied, including motor capacities (strength, gait, mobility, postural control and
302 balance), and falls (rates, risk factors, fear) (Table A).

303 No review assessed the effectiveness of EG interventions on dual-task functions.

304 It is worth noting that for all the functions studied, the effects of EG interventions were
305 greater than for the inactive control group, and greater than or equal to the active control
306 group.

307

308 *3.2.4. Feasibility, safety, adherence, transfer and retention of EG interventions*

309

310 EG interventions were mostly supervised (Donath et al., 2016; Laufer et al., 2014; Molina et
311 al., 2014; Schoene et al., 2014; Stojan & Voelcker-Rehage, 2019; Taylor et al., 2018), or the
312 use of supervision was unclear (Bleakley et al., 2015). Concerning safety, EG interventions
313 induced no (Bleakley et al., 2015; Laufer et al., 2014; Molina et al., 2014) or rare adverse
314 events (Taylor et al., 2018). The assessment of adherence to EG interventions encompassed
315 several factors, such as appeal, enjoyment or completion. Thus, appeal and enjoyment
316 (Bleakley et al., 2015; Molina et al., 2014; Taylor et al., 2018) were good. Completion and
317 compliance were high (Bleakley et al., 2015; Laufer et al., 2014; Taylor et al., 2018; Stojan &
318 Voelcker-Rehage, 2019), while the drop-out rate was very low (Larsen et al., 2013). No
319 reviews reported transfers or retention of benefits for EG interventions.

320

321 *3.2.5. Methodological quality, risk of bias, quality of evidence and funding*

322

323 The reviews included used different tools to assess the methodological quality of the primary
324 studies included: the Cochrane collaboration risk of bias tool (Bleakley et al., 2015; Larsen et
325 al., 2013; Neri et al., 2017; Stojan & Voelcker-Rehage, 2019; Taylor et al., 2018), the
326 Physiotherapy Evidence Database scale (Donath et al., 2016; Joubert & Chainay, 2018;
327 Laufer et al., 2014; Molina et al., 2014; Wang et al., 2015), the Jadad scale (Levin et al.,
328 2017; Rodrigues et al., 2014), the Downs and Black scale (Plummer et al., 2015), the Portney
329 and Watkins score (Agmon et al., 2014), and personal or modified scales (Schoene et al.,
330 2014; Wollesen & Voelcker-Rehage, 2014; Zhu et al., 2016). The quality of the primary
331 studies included was low to high (see details in **Table A**).

332

333 Details of the AMSTAR-2 assessment of methodological quality are presented in **Table B**.
334 Two overview authors (MGG and AP) agreed at 87% in their rating across the 18 systematic
335 reviews included. The overall quality of the systematic reviews included was “critically low”,
336 with a 6/16 mean score.

337

338 Six reviews reported a source of funding (Choi et al., 2017; Larsen et al., 2013; Rodrigues et
339 al., 2014; Stojan & Voelcker-Rehage, 2019; Wang et al., 2015; Zhu et al., 2016), and all
340 authors declared no conflicts of interests (**Appendix D**).

341

342 Table B: methodological quality of the reviews included

343

344 **4. Discussion**

345

346 The present overview aimed to summarize the effects of CMDT and EG interventions on
347 cognitive, physical and dual-task functions in healthy older adults, as well as the feasibility,
348 safety, adherence, transfer and retention of benefits of these interventions. Overall, the
349 eighteen reviews included in this overview highlighted positive effects of CMDT
350 interventions on cognitive, physical and dual-task functions, and EGs on cognitive outcomes.
351 However, this overview also highlighted controversial elements, such as the effects of EG
352 interventions on physical functions. Lastly, the effects of EG interventions on dual-task
353 outcomes, as well as safety, adherence, transfer and retention of benefits, remain understudied
354 for both types of intervention.

355

356 *4.1. Cognitive-Motor Dual-Task (CMDT) interventions*

357

358 Compared to single-task, fall prevention programs or no intervention, CMDT intervention
359 effects were found: i) superior (Joubert & Chainay, 2018; Levin et al., 2017) or equivalent
360 (Zhu et al., 2016) on cognitive function; ii) superior (Wang et al., 2015) or equivalent (Levin
361 et al., 2017) on physical functions and iii) superior on dual-task functions (Agmon et al.,
362 2014; Plummer et al., 2015; Wollesen & Voelcker-Rehage, 2014). CMDTs can be
363 recommended to improve cognitive, physical and dual-task functions in cognitively healthy
364 older adults. CMDT interventions were mostly distributed in groups (Agmon et al., 2014;
365 Plummer et al., 2015; Zhu et al., 2016), which would be as effective as individual sessions
366 (Agmon et al., 2014) and less time-consuming.

367

368 The transfer of benefits of CMDT interventions on tasks other than those trained for or daily
369 living activities was varied, with positive (Joubert & Chainay, 2018), mixed (Agmon et al.,
370 2014; Wollesen & Voelcker-Rehage, 2014) or unclear results (Zhu et al., 2016). This may be

371 due to the lack of measurement tools to assess early changes in daily living activities or
372 functional tests (Bruderer-Hofstetter et al., 2018).

373 The long-term benefits of CMDT interventions is understudied, even though it looks
374 promising. (Agmon et al., 2014; Joubert & Chainay, 2018; Zhu et al., 2016). Through these
375 reviews, nine articles included a follow-up period and reported a good retention of benefits.
376 This retention varied from two weeks (Agmon et al., 2014) to five years (Joubert & Chainay,
377 2018); even though it could be discussed whether a persistence of effect of two weeks is
378 "long-term".

379

380 The need for supervision, safety, home-based feasibility and adherence to CMDT
381 interventions were almost never reported in reviews, while we know from the literature that
382 the major obstacle to exercise interventions in older adults is often weak participation and
383 adherence (Nyman & Victor, 2012).

384

385 *4.2. Exergame (EG) interventions*

386

387 EG interventions were found effective on cognitive functions (Bleakley et al., 2015) and
388 equivalent to single-task, fall prevention programs or no intervention (Schoene et al., 2014;
389 Stojan & Voelcker-Rehage, 2019).

390 Conversely, the effectiveness of EG interventions on physical functions in older adults is
391 unclear (Bleakley et al., 2015; Molina et al., 2014; Rodrigues et al., 2014). Moreover,
392 compared to single-task, fall prevention programs or no intervention, reviews found EG
393 interventions superior (Neri et al., 2017; Taylor et al., 2018), equivalent (Choi et al., 2017;
394 Larsen et al., 2013; Laufer et al., 2014; Schoene et al., 2014) or less effective (Donath et al.,
395 2016). Thus, EGs cannot be considered as an alternative intervention for improving physical

396 functions in cognitively healthy older adults. This might be due to the lack of control of the
397 difficulty or intensity of the physical task (Lauenroth et al., 2016; Wollesen & Voelcker-
398 Rehage, 2014).

399 It seems that authors have so far assessed the impact of EG interventions on physical
400 functions more than on cognitive functions, with the induced cognitive task being considered
401 as “secondary” (Larsen et al., 2013). This could be reconsidered in view of recent results
402 showing an effect of EGs on cortical activity (Anders et al., 2018). When interventions were
403 directly compared, however, EGs were found more effective than CMDTs on cognitive
404 functions in healthy older adults (Bruderer-Hofstetter et al., 2018; Lord & Close, 2018).

405 The effects of EG interventions on dual-task functions have never been reported in reviews. It
406 is surprising that interventions including dual-tasks did not systematically have dual-task
407 functions as their outcome. This may be due to the lack of standardized functional
408 assessments for cognitive-motor dual-tasks (Agmon et al., 2014; Plummer et al., 2015;
409 Wollesen & Voelcker-Rehage, 2014).

410

411 EG interventions were mostly distributed individually (Laufer et al., 2014; Molina et al.,
412 2014; Taylor et al., 2018). This may be due to the experimental need for supervision and the
413 game support used.

414 Most reviews reported supervised EG interventions (Donath et al., 2016; Laufer et al., 2014;
415 Molina et al., 2014; Schoene et al., 2014; Stojan & Voelcker-Rehage, 2019; Taylor et al.,
416 2018), and this does not provide sufficient information to establish whether EG interventions
417 can be recommended for unsupervised home use (Howes et al., 2017). However, systematic
418 reviews reported satisfactory effectiveness and feasibility for exercise-based games
419 interventions in home settings for healthy (Miller et al., 2014) or neurologically impaired
420 (Perrochon et al., 2019) older adults.

421 The safety (Bleakley et al., 2015; Laufer et al., 2014; Molina et al., 2014; Taylor et al., 2018)
422 and adherence (Bleakley et al., 2015; Larsen et al., 2013; Laufer et al., 2014; Molina et al.,
423 2014; Stojan & Voelcker-Rehage, 2019; Taylor et al., 2018; Wollesen & Voelcker-Rehage,
424 2014) during EG interventions were good when assessed, but only reported in a few studies in
425 this reviews. This is promising, EG being considered even more enjoyable than traditional
426 interventions (Choi et al., 2017).

427 The transfer and long-term effects of EGs were mostly not reported, whereas they are needed
428 to propose the best possible interventions. It is worth noting that many authors highlighted the
429 lack of long-term assessment (Larsen et al., 2013; Laufer et al., 2014; Molina et al., 2014;
430 Plummer et al., 2015; Wang et al., 2015).

431 Lastly, an unclear parameter is the use of commercial or non-commercial games. Commercial
432 videogames such as Nintendo Wii ® or Xbox Kinect ® have already been introduced as
433 alternatives in rehabilitation (Bonnechère et al., 2016) and balance training (Pietrzak et al.,
434 2014). Commercial videogames are relatively inexpensive when compared with custom-
435 developed rehabilitation tools, but less adapted (Laufer et al., 2014). They are not developed
436 to specifically improve clinical outcomes and present a lack of task-specificity and
437 progressive overload (Schoene et al., 2014). It has been reported that some dropouts were due
438 to task complexity (Bleakley et al., 2015).

439

440 *4.3. Common to CMDT and EG interventions*

441

442 The positive results for CMDT and EG interventions should be interpreted carefully, because
443 all included reviews with low or critically low methodological quality (**Table B**).

444 The purpose of this overview was not to assess the most prolific intervention conditions.

445 However, "recommendations" emerge from the literature included. For the most effective

446 interventions on cognitive outcomes, one should focus on general rather than specific dual-
447 task training (Lipardo et al., 2017; Wollesen & Voelcker-Rehage, 2014), individual or group-
448 based (Agmon et al., 2014; Bruderer-Hofstetter et al., 2018) with increasing difficulty
449 (Wollesen & Voelcker-Rehage, 2014) of demanding tasks (Lauenroth et al., 2016),
450 integrating feedback (Lauenroth et al., 2016; Wollesen & Voelcker-Rehage, 2014) and step
451 training (Lord & Close, 2018; Schoene et al., 2014). For the most effective interventions on
452 physical outcomes, one should focus on general rather than specific dual-task training
453 (Lipardo et al., 2017; Wollesen & Voelcker-Rehage, 2014), demanding tasks (Lauenroth et
454 al., 2016; Wollesen & Voelcker-Rehage, 2014) with increasing difficulty (Wollesen &
455 Voelcker-Rehage, 2014) and variable rather than fixed priority tasks (Agmon et al., 2014;
456 Wollesen & Voelcker-Rehage, 2014) including step training (Lord & Close, 2018; Schoene et
457 al., 2014). In order to maximize the transfer effect, one should focus on variable (Lussier et
458 al., 2017; Wollesen & Voelcker-Rehage, 2014) and simultaneous task training (Wollesen &
459 Voelcker-Rehage, 2014), including functional exercises (Bruderer-Hofstetter et al., 2018).
460 The optimal dose of the interventions (length, frequency and duration) could not be
461 established because every intervention seemed effective despite the great variability in
462 modalities and outcomes both within and between reviews. While the dose was not a
463 moderator according to one review (Vázquez et al., 2018), other authors indicated an efficacy
464 for short programs (i.e. 40 minutes per week) (Agmon et al., 2014) or superior to 150 minutes
465 per week (Howes et al., 2017). Also, it seems that the interventions should not be too frequent
466 (i.e. less than five times per week), so as not to cause fatigue (Zhu et al., 2016).

467
468 The reviews included suggest that plasma brain-delivered neurotrophic factor (BDNF) and
469 structural brain plasticity variations induced by CMTD and EG interventions need to be
470 explored (Levin et al., 2017; Stojan & Voelcker-Rehage, 2019). Indeed, the effects of

471 physical activity on neuroplasticity facilitation (i.e. increasing BDNF) are limited in time and
472 return to baseline 10-60 minutes after the physical activity (Knaepen et al., 2010). This might
473 explain why simultaneous CMDT interventions were found more effective than sequential
474 interventions for cognitively healthy older adults (Tait et al., 2017), inducing synergistic
475 cognitive effects (Fissler et al., 2013) and affecting neuroplasticity additively (Bamidis et al.,
476 2014; Bherer, 2015).

477

478 *4.4. Limits*

479

480 The first limit of this overview is the low methodological quality and high risk of bias of the
481 reviews included and the primary literature within these reviews. The evaluation tools for risk
482 of bias and rates for the primary literature differed through the different studies included. The
483 AMSTAR-2 we used showed an overall critically low confidence in the results of the reviews
484 included, even though seven of them followed PRISMA or Cochrane Guidelines (Donath et
485 al., 2016; Larsen et al., 2013; Laufer et al., 2014; Neri et al., 2017; Plummer et al., 2015;
486 Stojan & Voelcker-Rehage, 2019; Zhu et al., 2016). A possible explanation is how the grid
487 was read and interpreted. AMSTAR-2 integrates a new system with critical domains. For
488 instance, the 7th item (“providing the list of excluded studies”) was reported as “No” in 83%
489 of the reviews included, dropping their assessment to at least "low" (see Table B). We have
490 realised a simulation of this evaluation without the 7th and the 13th items. The overall
491 confidence in the results of the reviews would then be mostly "moderate" or "low".

492

493 In addition, the classification of reviews was sometime difficult. For example, the review
494 from Schoene et al. indicates “cognitive-motor training” in the title, but actually deals with
495 EGs; we therefore chose to classify it as EG interventions. On the other hand, the review from

496 Joubert et al. contains a single study using EG. In order not to provide conclusions on the
497 effectiveness of EGs using a review of which one study out of fifty-two used Wii for its
498 intervention, we therefore chose to classify it among CMDT interventions.

499

500 Lastly, as the interventions were multicomponent, it is difficult to fully identify which of the
501 cognitive or physical tasks were the “active ingredients”, or whether it was a combination that
502 provided the effects (Booth et al., 2016). Furthermore, the clinical scales used only provided
503 an overall assessment, and not information on specific aspects or underlying mechanisms
504 (Choi et al., 2017). Moreover, one cannot reach the same intensity levels during a dual-task
505 training as during separate tasks (single-task or sequential training) (Joubert & Chainay,
506 2018). It is even possible that older people prioritize physical over cognitive tasks, which
507 might be explained by wanting to protect oneself from falls (Schaefer & Schumacher, 2011).
508 It thus seems important to propose interventions with suitable physical and cognitive loads,
509 ensuring that neither task takes precedence over the other.

510

511 *4.5. Futures studies*

512

513 Since the effectiveness of CMDT interventions on cognitive, physical and dual-task functions,
514 and EGs on cognitive functions in cognitively healthy older adults were demonstrated, it is
515 necessary to focus on that which is unclear, specifically the effectiveness of EG interventions
516 on physical and dual-task functions, as well as the transfer and retention of benefits and the
517 feasibility of both interventions (i.e. the optimum dose, the need for supervision, the need for
518 group or individual sessions, safety and adherence). Further research should also focus on the
519 need for task prioritization (Kelly et al., 2013; Yogev-Seligmann et al., 2010) in order to
520 counterbalance avoidance strategies (Schaefer & Schumacher, 2011). Moreover, further

521 research should focus on comparing the use of patient-oriented EGs with the use of
522 commercial games. Lastly, CMDTs and EGs seem to be promising interventions with
523 cognitively-impaired older adults (Bruderer-Hofstetter et al., 2018; Gheysen et al., 2018), but
524 it would be relevant to explore this. Similarly, other types of CMDTs should be studied, such
525 as mind-body exercises (i.e. tai-chi, dance, martial arts) (Booth et al., 2016; Bruderer-
526 Hofstetter et al., 2018; Gheysen et al., 2018).

527

528 **5. Conclusion**

529

530 This present overview found positive effects of CMDT interventions on cognitive, physical
531 and dual-task functions, and positive effects of EG interventions on cognitive functions in
532 cognitively healthy older adults. These results should be interpreted carefully, considering
533 their critically low average methodological quality. Future research should focus on the
534 effects of EG interventions on physical and dual-task functions. Home-based feasibility,
535 adherence, optimal dose, retention and transfer of benefits of these interventions, and the
536 possible need for custom made EGs, are also still to be determined. Further individual studies
537 should follow recommendations and more rigorous methodological standards in order to
538 improve the quality of the evidence and provide guidelines for the use of CMDT and EG
539 interventions in older adults.

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544

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546

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776

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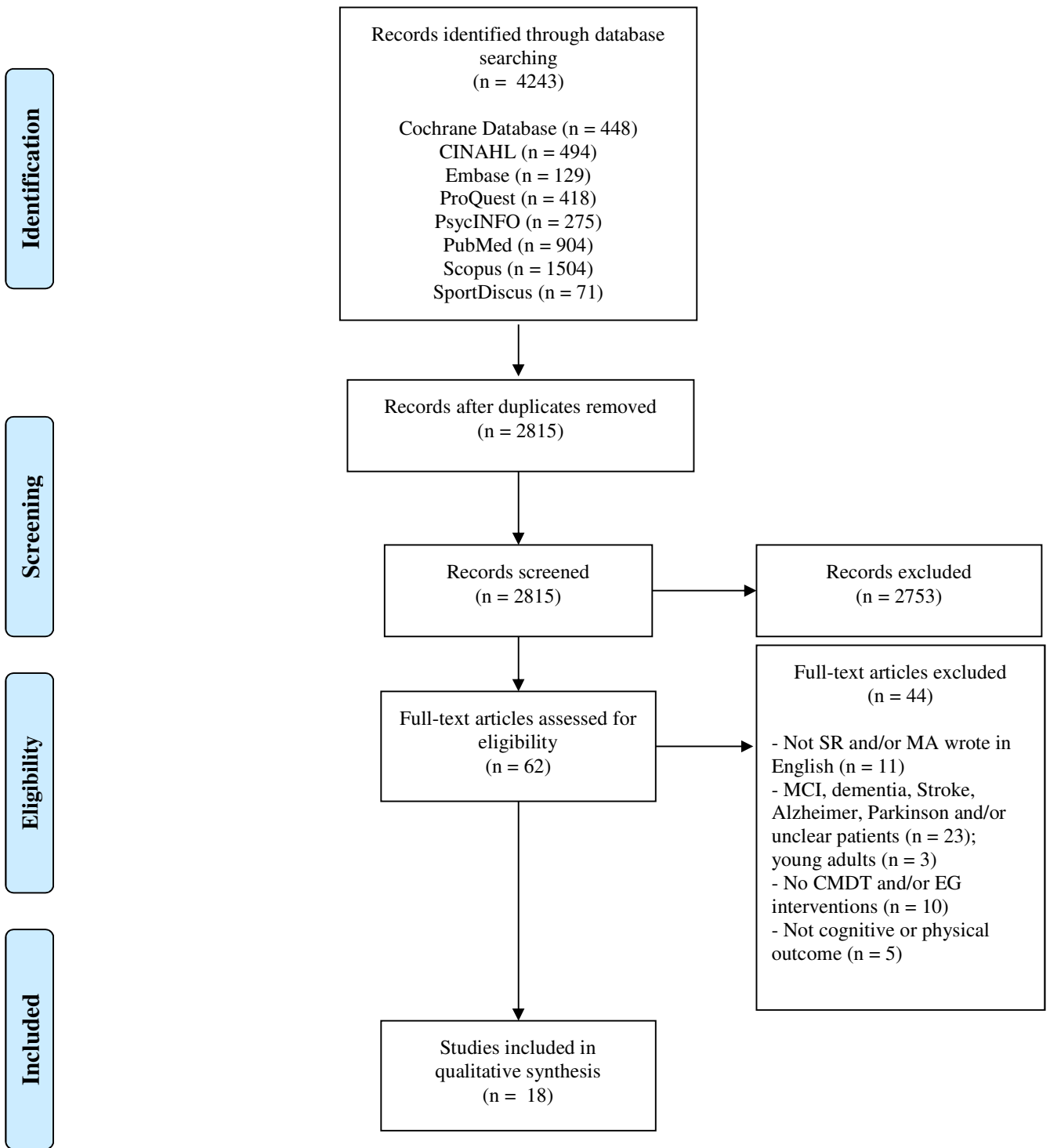


Figure A : selection of systematic reviews

SR : systematic review; MA : meta-analysis ; CMTD : cognitive-motor dual-task; EG : exergame; MCI : mild cognitive impairment

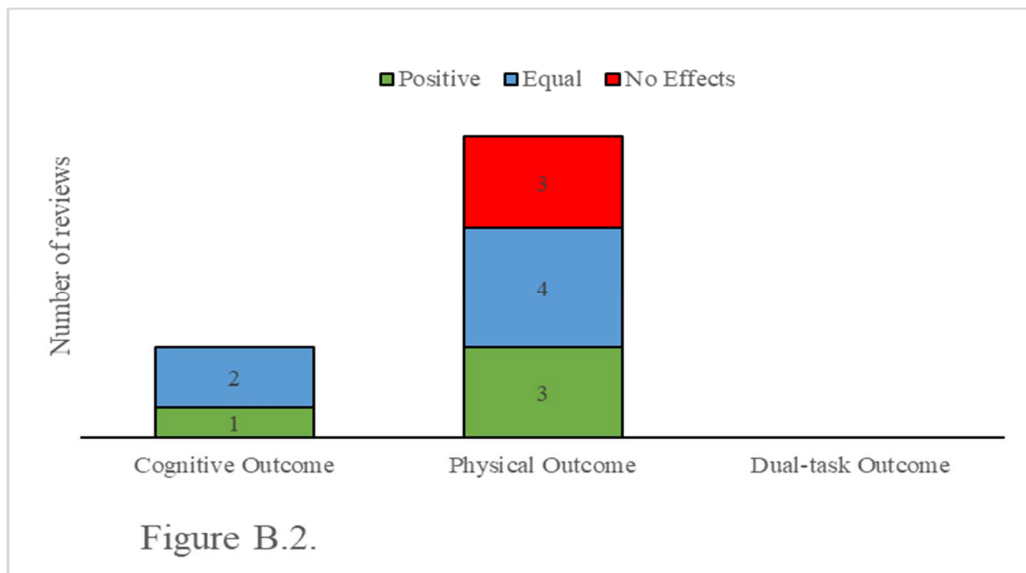
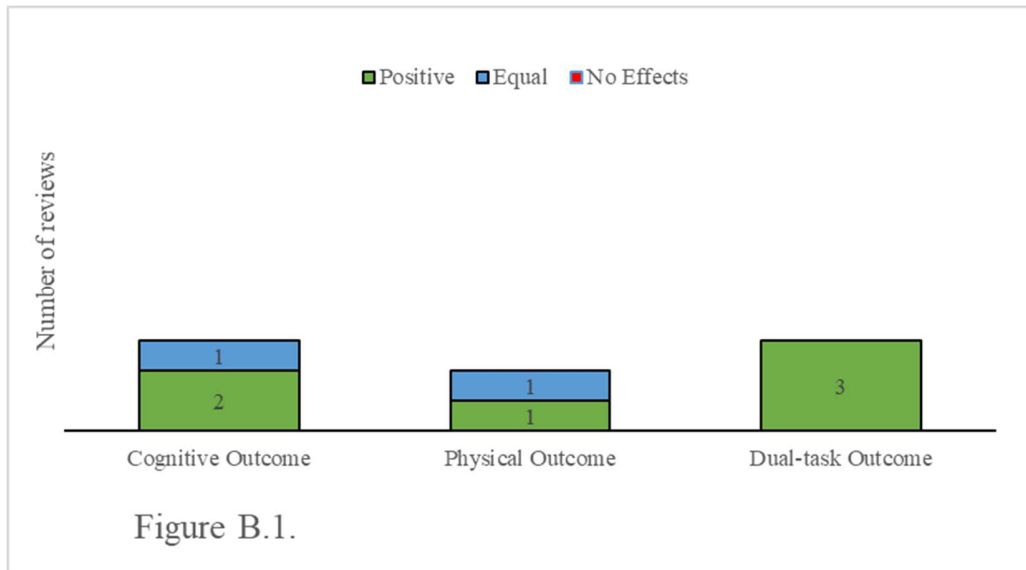


Figure B : effects of cognitive-motor dual-task (CMDT) (1) and exergame (EG) (2) interventions on cognitive, physical or dual-task outcomes.

Review	Objectives	Included literature :	Population :	Interventions	Modalities :	Outcomes	Conclusions	RoB
First author, year Country	1) Primary 2) Secondary	Review design (N) Primary studies design (N)	N (Exp / Ctrl) Age (range or mean) Characteristics (N)	Experimental or control group, content (N)	Seq / Sim Grp / Ind Center / home Duration min Duration max	Type, functions assessed	1) Primary objective 2) Secondary objective	Scale , score or criteria (mean ± SD) or [range] Appreciation

COGNITIVE-MOTOR DUAL-TASK TRAINING

Cognitive outcome

Joubert, 2018 France	1) Effects of CMDT compared with cognitive or physical STT on cognition 2) Assess retention and transfer	SR (52) RCT (36), NRSI (16)	20512 (n.r.) n.r. HE (52)	Exp : CMDT (Wii, Kinect, eybereycling, treadmill, combined cognitive & physical training) (7), EG (Wii) (1) Ctrl : NI (n.r.) and/or active : physical STT (resistance, aerobic, stretching, balance) (10), cognitive STT (speed processing, attention, memory, visuospatial abilities, task switching) (31)	Sim (2), Seq (6) n.r. n.r. 60 min, 1x 90min, 1x/w, 30w	Cognitive : attention, PS, memory, EF, visuospatial performance	1) Improving cognition, CMDT are superior to cognitive and physical STT 2) Retention (4) and transfer (1) were unclear	PEDro (/10) [4-10], for DT training [5-11] n.r.
Zhu, 2016 China	1) Effects of CMDT compared with cognitive or physical STT on cognition	SR (20) - MA (20) RCT (14), NRSI (6)	2667 (1667 - 1000) [65 - 82] HE (20)	Exp : EG (3), CMDT (20), combining a cognitive task (multidomain (11), single domain (4)) with a physical task (multicomponent exercises (12), aerobic (6), strength and balance (1)) Ctrl : education (3), NI (11), and/or STT (3)	Sim (6), Seq (14) Grp (10), Ind (3), mixed (4) n.r. 30 min, 3x/w, 6w 10-60min, 3-11x/w, 96 w	Cognitive : global cognition, memory, EF, attention, PS, visuospatial performance	1) Improving cognition, CMDT are superior to NI, TI and physical STT; equivalent to cognitive STT	Modified PEDro (/9) 6,3 ± 1,3 [2-9] 7 low, 13 high risk

Physical outcome

Wang, 2015 China	1) Effects of CMDT compared with STT or NI on falls	SR (30) - MA (30) RCT (10), NRSI (20)	1206 (n.r.) n.r. HE (30)	Exp : CMDT (n.r.) Ctrl : NI or STT (n.r.)	n.r. n.r. n.r. n.r.	Physical : gait, balance, falls, reaction time	1) Improving gait, balance and preventing falls, CMDT are superior to STT and NI 2) No serious adverse events	PEDro (/10) 5.4 ± 1.4 [3-8] 1 low, 21 moderate, 8 high risk
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Cognitive and Physical outcome

Levin, 2017 Israel	1) Effects of CMDT on cognitive and motor functions	SR (19) RCT (6), NRSI (13)	1226 (843 / 383) [66 - 82] HE (19)	Exp : STT (6), combined exercise training (aerobic, balance, resistance) (4), CMDT (10) (aerobic, balance, and resistance training with flexibility and memory tasks), Ctrl : NI and/or active STT (n.r.)	Sim (6), Seq (3) n.r. n.r. 7 sets, 8 rep, 2x/w, 6w 60min, 2x/w, 24w	Physical : mobility, gait, balance, strength, psychomotor tasks, aerobic fitness Cognitive : PS, EF, attention, DT cost	1) Improving physical functions, CMDT are equivalent to MMDTT; improving cognitive functions, CMDT are superior to MMDTT (psychomotor speed, processing speed, attention and DT cost)	Jadad (/5) [1-4] n.r.
<i>Dual-task outcome</i>								
Plummer, 2015 USA	1) Effects of CMDT compared with STT on DT gait performance	SR (21) - MA (14) RCT (15), NRSI (6)	911 (n.r.) [71 - 91] HE (13), BI, fall (5), frail (2)	Exp : MMDTT (4) and CMDT (9), combining a physical task (walking, balance, coordination, stretching, tai-chi, step, aerobic, strength) with a physical or a cognitive task (comprehension, arithmetic, verbal fluency, working memory) Ctrl : education (1), NI (11), or active : STT or FPP (9)	Sim (9), Seq (1) Grp (12), Ind (7), mixed (2) n.r. 45 min, 3x/w, 4w 60min, 1x/w, 25w	Physical : Gait under DT conditions	1) Improving gait speed, CMDT are superior to NI and TI, and equivalent to STT	Downs & Black (/25) 16,8 [12-21] 4 high, 13 good, 4 low quality
Wollesen, 2014 Germany	1) Effects of CMDT compared with STT on DT performances	SR (13) RCT (6), NRSI (7)	387 (n.r.) n.r. HE (11), fall (2)	Exp : CMDT (9), combining a physical (balance, strength, walking) and a cognitive task (memory, verbal, visuospatial, music), VR (2) Ctrl : STT (balance, walking) (5)	n.r. n.r. n.r. 60min, 3x 60min, 1x/w, 48w	Physical : postural control, mobility, gait Cognitive : PS, visuospatial performance, EF	1) Improving DT standing performance, CMDT are superior to STT; improving DT walking performance, CMDT are equivalent to STT	Modified Van Tulder (/12) [3-11] 5 High quality
Agmon, 2014 Israel	1) Effects of different interventions on DT postural control	SR (22) RCT (16), NRSI (6)	730 (387 / 343) ≥ 60 HE (6), fall (7)	Exp : CMDT (13), combining a physical (walking, balance, gait, agility) and a cognitive task (calculation, verbal and working memory), STT (postural) (9) Ctrl : education (4), NI (3) and/or STT (6)	n.r. Grp (14), Ind (8) n.r. 45min, 1x/w, 4w 60min, 1x/w, 25w	Physical : postural control, balance and gait under DT	1) Improving DT postural control, CMDT are superior to STT	Portney and Watkins (n.r.) [1-4] n.r.

EXERGAME

Cognitive outcome

Stojan, 2019 Germany	1) Effects of EG on cognitive domains (neurophysiological outcomes mostly)	SR (15) RCT (12), NRSI (3)	750 (n.r.) [60 - 85] HE (15)	Exp : Kinect (4), VR (3), dance videogame (5) including DDR (2), Cybercycle (2), Cyberstep (2), Wii (1) Ctrl : NI (n.r.) and/or active STT (n.r.)	Sim (15) n.r. n.r. 30min, 2x/w, 6w 60min, 2x/w, 26w	Cognitive : memory, EF, PS, visuospatial performance	1) Improving cognitive and brain functions, EG are effective (small and strongly varying positive effects); improving EF, EG are similar or slightly superior to TI	CCRT n.r. 3 High, 4 moderate, 6 low, 2 n.r.
<i>Physical outcome</i>								
Taylor, 2018 New Zealand	1) Effects of EG on physical functions 2) Assess the safety, game appeal, and usability	SR (18) - MA (10) RCT (18)	765 (n.r.) n.r. HE (13), BI or RoF (3), unclear (2)	Exp : Wii (11), pressure-sensitive systems (5), Kinect (1), VR (1) Ctrl : placebo (2), NI (9) and/or FPP (16)	Sim (18) Grp (2), Ind (16) Home (1), center (17) Mean : 40 min, 2-3x/w, 8w	Physical : mobility, balance	1) Improving balance and mobility, EG are superior to NI and TI 2) Safe when supervised, good adherence, enjoyed	CCRT n.r. 4 low, 14 high or unclear
Choi, 2017 South Korea	1) Effects of EG on fall	SR (25) RCT (6), NRSI (19)	752 (525 / 227) >60 HE (19), BI (6)	Exp : Wii (14), Kinect (5), SensBalance Fitness Board (2), DDR (1), others (3) Ctrl : NI (n.r.) and/or active : STT or FPP (n.r.)	Sim (25) n.r. Home (11), Center (14) 30min, 3x/w, 3w 45min, 3x/w, 15w	Physical : strength, RoF, balance, gait, mobility Cognitive : cognitive functions (not specified)	1) Improving balance, EG are superior to NI, and equivalent to TI	n.r. n.r. n.r.
Neri, 2017 Brazil	1) Effects of EG compared with NI or TI on fall	SR (28) - MA (6) RCT (28)	1121 (n.r.) n.r. HE (28), fall (2), prefrail (1)	Exp : Wii (15), VR (4), Cyberstep (3), dance videogame (2), Kinect (1), others (4) Ctrl : NI (12) or FPP (16)	Sim (28) n.r. n.r. 40 min, 3x/w, 2w 60 min, 1x/w, 20w	Physical : balance, strength, reaction time, mobility, RoF	1) Improving mobility and balance, EG are superior to NI; improving balance and RoF, EG are superior to TI	CCRT n.r. n.r.
Donath, 2016 Switzerland	1) Effects of EG compared with TI or NI on balance	SR (18) - MA (18) RCT (15), NRSI (3)	619 (n.r.) 76 ± 5 HE (15), fall (3)	Exp : Wii (12), VR (5), DDR (1) Ctrl : NI (13), and/or active : STT or FPP (9)	Sim (18) n.r. n.r. <45min, 2x/w, 3w 60min, 1x/w, 20w	Physical : balance, mobility, postural control	1) Improving mobility and balance, EG are superior to NI; improving standing balance and functional mobility, EG are inferior to TI	PE德罗 (/10) [4-8] n.r.
Molina, 2014 Brazil	1) Effects of EG on physical functions	SR (13) RCT (10), NRSI (3)	487 (n.r.) n.r. HE (4)	Exp : Wii (8), dance video game (2), balance or step training (1), computer games (2). EG only (7) or EG + physical activity (6) Ctrl : placebo (1), NI (6) and/or active : STT or FPP (9)	Sim (13) Grp (2), Ind (6), unclear (5) Additional home (1) 30min, 2x/w, 3w 30min, 2x/w, 12w	Physical : mobility, balance, RoF, strength, postural control, reaction time, gait	1) EG did not increase physical functions 2) Positive motivational aspect with EG	PE德罗 (/10) 5.6 ± 1.3 [4-8] n.r.

Rodrigues, 2014 Brazil	1) Effects of EG on musculoskeletal functions	SR (16) - MA (4) RCT (14), NRSI (2)	532 (268 / 264) n.r. HE (16)	Exp : Wii (10), Dance video game (2), VR (1), others (3) Ctrl : NI (10), and/or physical activity (7)	Sim (16) n.r. n.r. 15min, 2x/w, 3w ? min, 1x/w, 20w	Physical : balance, mobility, strength, falls efficacy scale, gait, fear of falling	1) EG did not increase functional mobility nor the fear of falls	Jadad (/5): [1-3] 9 low, 7 high
Laufer, 2014 Israel	1) Effects of EG (Wii) compared with TI or NI on balance control	SR (7) RCT (7)	285 (126 / 159) [61 - 86] HE (7)	Exp : Wii Mote (1), Wii Balance Board (7) Ctrl : placebo (1), NI (3) and/or active : FPP (5)	Sim (7) Grp (1), Ind (6) n.r. 40min, 2x/w, 6w 60 min, 1x/w, 20w	Physical : standing/walking balance, postural sway, fitness, strength, falls	1) Improving balance, EG are superior to NI and equivalent to TI; and feasible	PEDro (/10) 5.6 ± 0.8 [5-7] n.r.
Larsen, 2013 Denmark	1) Effects of EG on physical outcomes	SR (7) RCT (7)	311 (n.r.) [73 - 86] HE (7)	Exp : Wii (4), DDR (1), Cybercycle (1), other (1) Ctrl : NI (4) and/or active : FPP (5), tai-chi (1)	Sim (7) n.r. n.r. 3w 20w	Physical : balance, mobility, strength	1) Improving physical functions, EG are superior to NI, and equivalent to TI 2) Additional cognitive effect of EG (assessed in 1 study)	CCRT n.r. n.r.
<i>Cognitive and Physical outcome</i>								
Bleakley, 2015 United Kingdom	1) Effects of EG on physical and cognitive functions 2) Assess the compliance, enjoyment and adverse events	SR (12) RCT (5), NRSI (7)	455 (n.r.) >65 HE (9), fall (1), BI (1)	Exp : VR (4), Wii (4), computerized balance training (3), dance mat (1) Ctrl : education (1), NI (2) and/or active : STT or FPP (5)	Sim (12) n.r. n.r. 20 min, 2x/w, 4w 90 min, 2x/w, 12w	Physical : postural control, balance strength, falls Cognitive : global cognition, EF, memory, attention, PS	1) Improving physical and cognitive functions, EG are effective 2) EG are safe; the optimal dose, enjoyment and adherence remains unclear	CCRT n.r. n.r.
Schoene, 2014 Netherlands	1) Effects of EG [#] compared with TI on falls and RoF	SR (37) n.r.	1066 (n.r.) n.r. HE (21), functional impairment (16), fall or BI (6)	Exp : Wii Balance Board (16), WiiMote (10), pressure-sensitive platforms (7), force plates with VR (3), tillable platforms (2), Kinect (1), EyeToy (1), Fovea (1), walks film projected onto a screen (1), others (2) Ctrl : NI (9) and/or active (9)	n.r. n.r. Center (34), home (2), mixed (1) 30min, 3x/w, 3w 60min, 2x/w, 12w	Physical : step, balance, mobility, falls, balance, postural control, strength Cognitive : attention, EF, global cognition	1) Improving physical and cognitive fall risk factors, EG [#] are equivalent to TI; effects on falls remains unclear	Modified Downs and Black (/27) 16.8 ± 4.5 [5, 24] n.r.

Table A : characteristics of included systematic reviews

BI : balance impairment; CCRT : Cochrane Collaborations RoB Tool; CMDT : cognitive-motor dual-task; Ctrl : control group; DDR : dance-dance revolution; DT : dual-task; EF : executive functions; EG : exergame ; Exp : experimental group; **FPP**: fall prevention programs; Grp : group; HE : healthy elderly; Ind : individual; MA : meta-analysis; min : minutes; MMDTT: motor-motor dual-task training; NI : no intervention; NRSI : non-randomized studie of interventions ; n.r. : not reported; PEDro : Physiotherapy Evidence Database; PS : processing speed; QOL : quality of life; RCT : randomized controlled trial; RoB : risk of bias; RoF : risk of fall; SR : systematic review; Seq : sequential; Sim : simultaneous; STT : single-task training; VR : virtual reality; w : week; # CMDT, requalified as EG.

Systematic Review	AMSTAR-2 Criteria																			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 : Method	MA : RoB	RoB discuted	Heterogeneity	MA : RoB	COI / funding			
	1	2*	3	4*	5	6	7*	8	9-1*	9-2*	10	11-1*	11-2*	12	13*	14	15*	16			
Larsen, 2013	Y	P	N	N	Y	N	N	P	Y	n.a.	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	5	Critically low	
Laufer, 2014	Y	N	N	Y	Y	Y	N	P	P	n.a.	N	n.a.	n.a.	n.a.	N	N	n.a.	Y	5	Critically low	
Rodrigues, 2014	Y	P	N	P	Y	Y	N	N	P	N	N	Y	N	N	Y	Y	N	Y	7	Critically low	
Agmon, 2014	N	P	N	P	Y	Y	N	Y	N	N	N	n.a.	n.a.	n.a.	N	N	n.a.	Y	4	Critically low	
Wollesen, 2014	Y	P	Y	P	N	N	Y	Y	P	Y	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	7	Low	
Molina, 2014	Y	N	N	P	Y	N	N	P	P	n.a.	N	n.a.	n.a.	n.a.	Y	Y	n.a.	Y	5	Critically low	
Schoene, 2014	Y	N	N	P	Y	N	N	N	P	Y	N	n.a.	n.a.	n.a.	Y	Y	n.a.	Y	5	Critically low	
Plummer, 2015	Y	Y	N	N	Y	Y	Y	P	Y	Y	N	Y	n.a.	Y	N	Y	Y	Y	12	Low	
Wang, 2015	Y	Y	N	P	Y	Y	N	N	P	n.a.	N	Y	n.a.	N	N	Y	Y	N	9	Critically low	
Bleakley, 2015	N	P	N	N	Y	Y	N	P	N	N	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	4	Critically low	
Donath, 2016	Y	P	N	P	Y	Y	N	P	P	n.a.	N	N	N	Y	Y	Y	Y	Y	8	Critically low	
Zhu, 2016	Y	Y	N	P	Y	Y	N	P	P	P	N	Y	N	N	N	N	Y	Y	8	Critically low	
Neri, 2017	Y	Y	N	P	Y	Y	N	Y	Y	n.a.	N	Y	n.a.	Y	Y	Y	N	Y	11	Critically low	
Choi, 2017	Y	N	N	P	Y	N	N	P	N	N	N	n.a.	n.a.	n.a.	N	N	n.a.	N	2	Critically low	
Levin, 2017	Y	P	N	N	Y	N	Y	N	P	N	N	n.a.	n.a.	n.a.	N	N	n.a.	Y	8	Critically low	
Taylor, 2016	Y	P	N	N	Y	N	N	P	Y	n.a.	N	Y	n.a.	N	N	Y	N	Y	6	Critically low	
Joubert, 2018	Y	P	N	N	N	N	N	P	Y	Y	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	5	Critically low	
Stojan, 2019	Y	N	N	P	Y	Y	N	P	Y	n.a.	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	6	Critically low	
% of "No"	11	28	94	33	11	44	83	22	17	22	100	6	17	22	72	28	17	11	Mean score = 5,8		

Table B : methodological quality of systematic reviews

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

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