

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

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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
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25 Abstract

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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). Two reviewers performed the selection, data extraction and risk of bias evaluation 34 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

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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 with other CMDT modalities (Schoene et al., 2014; Wollesen & Voelcker-Rehage, 2014). 63 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

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

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

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

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

88

89 **2.** Methods

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91 2.1. Design and protocol

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We used the definition of "systematic review" from a Cochrane guide (Chandler et al., 2017).
In order to perform this overview, we used a protocol established prior to the conduct of the review that was registered on PROSPERO (registration ID: CRD42019143185). The design and the protocol of this overview were established following authors' recommendations
(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 conducted our overview through different online databases: the Cochrane Database of 104 105 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).

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113 2.3. Eligibility criteria and selection

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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

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

144

145 2.5. Study quality assessment

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).
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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
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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

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- 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 each study included in the reviews only once, the actual number of participants included was 192 193 28446.

194

195 Table A: Characteristics of the reviews included

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 reviews; some did not specify this modality (Agmon et al., 2014; Schoene et al., 2014; Wang 221

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.

248 Figure B: Summary of findings

249

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

252

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

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

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

It is worth noting that, for all the functions studied, CMDT interventions' effects were greaterthan 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*

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

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One review found EG interventions effective on cognitive functions (Bleakley et al., 2015). Two reviews found that EG interventions were equivalent compared to fall prevention programs, single-task training and active and inactive controls (Schoene et al., 2014; Stojan & Voelcker-Rehage, 2019). Cognitive outcomes varied, including attention, memory, executive functions, processing speed, visuospatial capabilities and overall cognition (Table A).

The effectiveness of EG interventions on physical functions was unclear (Bleakley et al., 2015; Molina et al., 2014; Rodrigues et al., 2014). Compared to fall prevention programs, single-task training, motor-motor dual-task training and active and inactive controls, two

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

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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

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

Details of the AMSTAR-2 assessment of methodological quality are presented in Table B.
Two overview authors (MGG and AP) agreed at 87% in their rating across the 18 systematic
reviews included. The overall quality of the systematic reviews included was "critically low",
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**

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 effects were found: i) superior (Joubert & Chainay, 2018; Levin et al., 2017) or equivalent 359 360 (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

The transfer of benefits of CMDT interventions on tasks other than those trained for or daily living activities was varied, with positive (Joubert & Chainay, 2018), mixed (Agmon et al., 2014; Wollesen & Voelcker-Rehage, 2014) or unclear results (Zhu et al., 2016). This may be due to the lack of measurement tools to assess early changes in daily living activities orfunctional tests (Bruderer-Hofstetter et al., 2018).

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

379

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

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

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

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

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

410

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

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

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

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

431 Lastly, an unclear parameter is the use of commercial or non-commercial games. Commercial videogames such as Nintendo Wii ® or Xbox Kinect ® have already been introduced as 432 433 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, because443 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

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

physical activity on neuroplasticity facilitation (i.e. increasing BDNF) are limited in time and
return to baseline 10-60 minutes after the physical activity (Knaepen et al., 2010). This might
explain why simultaneous CMDT interventions were found more effective than sequential
interventions for cognitively healthy older adults (Tait et al., 2017), inducing synergistic
cognitive effects (Fissler et al., 2013) and affecting neuroplasticity additively (Bamidis et al.,
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 instance, the 7th item ("providing the list of excluded studies") was reported as "No" in 83% 488 489 of the reviews included, dropping their assessment to at least "low" (see Table B). We have realised a simulation of this evaluation without the 7th and the 13th items. The overall 490 491 confidence in the results of the reviews would then be mostly "moderate" or "low".

492

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

Joubert et al. contains a single study using EG. In order not to provide conclusions on the
effectiveness of EGs using a review of which one study out of fifty-two used Wii for its
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 need for task prioritization (Kelly et al., 2013; Yogev-Seligmann et al., 2010) in order to 519 520 counterbalance avoidance strategies (Schaefer & Schumacher, 2011). Moreover, further research should focus on comparing the use of patient-oriented EGs with the use of commercial games. Lastly, CMDTs and EGs seem to be promising interventions with cognitively-impaired older adults (Bruderer-Hofstetter et al., 2018; Gheysen et al., 2018), but it would be relevant to explore this. Similarly, other types of CMDTs should be studied, such as mind-body exercises (i.e. tai-chi, dance, martial arts) (Booth et al., 2016; Bruderer-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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541

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544

545 **References**

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Figure A : selection of systematic reviews

SR : systematic review; MA : meta-analysis ; CMDT : 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 First author, year Country	Objectives 1) Primary 2) Secondary	Included literature : Review design (N) Primary studies design (N)	re: Population: Interventions) N (Exp / Ctrl) Experimental or control group, Age (range or content (N) mean) Characteristics (N)		Modalities : Seq / Sim Grp / Ind Center / home Duration min Duration max	Outcomes Type, functions assessed	Conclusions 1) Primary objective 2) Secondary objective	RoB Scale , score or criteria (mean ± SD) or [range] Appreciation
COGNITIVE-	MOTOR DUAL-TA	SK TRAINING						
Cognitive outcome	e							
Joubert, 2018 France	 Effects of CMDT compared with cognitive or physical STT on cognition Assess retention and transfer 	SR (52) RCT (36), NRSI (16)	20512 (n.r.) n.r. HE (52)	Exp : CMDT (Wii, Kineet, eybercycling, 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 (<u>6</u>) n.r. n.r. 60 min, 1x 90min, 1x/w, 30w	Cognitive : attention, PS, memory, EF, visuospatial performance	 Improving cognition, CMDT are superior to cognitive and physical STT Retention (4) and transfer (1) were unclear 	PEDro (/10) [4-10], for DT training [5-11] n.r.
Zhu, 2016 1) Effects of China CMDT compa with cognitive physical STT of 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	 Improving gait, balance and preventing falls, CMDT are superior to STT and NI No serious adverse events 	PEDro (/10) 5.4 ± 1.4 [3-8] 1 low, 21 moderate, 8 high risk
Cognitive and Phy	vsical 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 fitnessCognitive : 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.				
Dual-task outcome												
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)	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.				
				and/or STT (6)								
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.
Physical outcome	2							
Taylor, 2018 New Zealand	 Effects of EG on physical functions 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 <u>FPP</u> (16)	Sim (18) Grp (2), Ind (16) Home (1), center (17) Mean : 40 min, 2- 3x/w, 8w	Physical : mobility, balance	 Improving balance and mobility, EG are superior to NI and TI 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, mobilityCognitive : 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 <u>FPP</u> (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	PEDro (/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	 EG did not increase physical functions Positive motivational aspect with EG 	PEDro (/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 : <u>FPP</u> (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	en, 2013 1) Effects of EG on SR (7) 311 (n.r.) nark physical outcomes RCT (7) [73 - 86] HE (7)		311 (n.r.) [73 - 86] HE (7)	Exp : Wii (4), DDR (1), Cybercycle (1), other (1) Ctrl : NI (4) and/or active : <u>FPP</u> (5), tai-chi (1)	Sim (7) n.r. n.r. 3w 20w	Sim (7) Physical : balance, n.r. mobility, strength n.r. 3w 20w		CCRT n.r. n.r.
Cognitive and P	Physical outcome							
Bleakley, 2015 United Kingdom	 Effects of EG on physical and cognitive functions 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	 Improving physical and cognitive functions, EG are effective 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)	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; <u>FPP: fall prevention programs</u>; 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.

									AMSTAI	R-2 Criter	ia									
Systematic Review	- Use PICO	* Method	5 Inclusion	* Search strategy	G Selection x2	9 Extraction x2	* Exclusions	∞ Description	8-1*	8-5* 8-5*	Bunding 10	HI Mathod	MA : Method 11-5*	MA : RoB	*RoB discuted	Heterogeneity	808 : MA : RoB	10 COI / funding	Rating (/16)	Overall confidence in the results of the review
Larsen, 2013	Y	Р	N	N	Y	N	N	Р	Y	n.a.	N	n.a.	n.a.	n.a.	N	Y	n.a.	Y	5	Critically low
Laufer, 2014	Y	Ν	Ν	Y	Y	Y	N	Р	Р	n.a.	N	n.a.	n.a.	n.a.	Ν	Ν	n.a.	Y	5	Critically low
Rodrigues, 2014	Y	Р	Ν	Р	Y	Y	Ν	Ν	Р	Ν	N	Y	Ν	Ν	Y	Y	Ν	Y	7	Critically low
Agmon, 2014	Ν	Р	Ν	Р	Y	Y	Ν	Y	N	N	N	n.a.	n.a.	n.a.	N	N	n.a.	Y	4	Critically low
Wollesen, 2014	Y	Р	Y	Р	Ν	Ν	Y	Y	Р	Y	Ν	n.a.	n.a.	n.a.	Ν	Y	n.a.	Y	7	Low
Molina, 2014	Y	Ν	Ν	Р	Y	Ν	Ν	Р	Р	n.a.	Ν	n.a.	n.a.	n.a.	Y	Y	n.a.	Y	5	Critically low
Schoene, 2014	Y	Ν	Ν	Р	Y	Ν	Ν	Ν	Р	Y	Ν	n.a.	n.a.	n.a.	Y	Y	n.a.	Y	5	Critically low
Plummer, 2015	Y	Y	Ν	Ν	Y	Y	Y	Р	Y	Y	Ν	Y	n.a.	Y	Ν	Y	Y	Y	12	Low
Wang, 2015	Y	Y	Ν	Р	Y	Y	Ν	Ν	Р	n.a.	Ν	Y	n.a.	Ν	Ν	Y	Y	Ν	9	Critically low
Bleakley, 2015	Ν	Р	Ν	Ν	Y	Y	Ν	Р	Ν	Ν	Ν	n.a.	n.a.	n.a.	Ν	Y	n.a.	Y	4	Critically low
Donath, 2016	Y	Р	Ν	Р	Y	Y	Ν	Р	Р	n.a.	Ν	Ν	Ν	Y	Y	Y	Y	Y	8	Critically low
Zhu, 2016	Y	Y	Ν	Р	Y	Y	Ν	Р	Р	Р	Ν	Y	Ν	Ν	Ν	Ν	Y	Y	8	Critically low
Neri, 2017	Y	Y	Ν	Р	Y	Y	Ν	Y	Y	n.a.	Ν	Y	n.a.	Y	Y	Y	Ν	Y	11	Critically low
Choi, 2017	Y	Ν	Ν	Р	Y	Ν	Ν	Р	Ν	Ν	Ν	n.a.	n.a.	n.a.	Ν	Ν	n.a.	Ν	2	Critically low
Levin, 2017	Y	Р	Ν	Ν	Y	Ν	Y	Ν	Р	Ν	Ν	n.a.	n.a.	n.a.	Ν	Ν	n.a.	Y	8	Critically low
Taylor, 2016	Y	Р	Ν	Ν	Y	Ν	Ν	Р	Y	n.a.	Ν	Y	n.a.	Ν	Ν	Y	Ν	Y	6	Critically low
Joubert, 2018	Y	Р	Ν	Ν	Ν	Ν	Ν	Р	Y	Y	Ν	n.a.	n.a.	n.a.	Ν	Y	n.a.	Y	5	Critically low
Stojan, 2019	Y	N	N	Р	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	Mea	n 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