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Cognitive stimulation and dementia: traditional interventions vs. computer-based methodologies

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ABSTRACT

We aim to examine the role of cognitive stimulation interventions applied to healthy older adults or older adults with mild-to-moderate dementia. The most important benefits and differences between using these programs without computerized tasks compared to computer-based assistive technologies are also addressed. We conducted a literature review which includes empirical studies in the cognitive stimulation field, applied to healthy older adults or in participants with some type of dementia. All studies include cognitive stimulation intervention using traditional methods or computer-based assistive technology. We included a total of 35 studies in our review. In general, our findings provide support for applying cognitive stimulation programs, using traditional methods or computer-based assistive technology, specifically for older people with dementia. However, we found heterogeneity regarding methods, design of intervention, and procedures in both types of methodology. This review adds value towards a systematisation of heterogeneous data existing in this field. However, it remains difficult to perform unbiased comparisons. Future studies should provide a comparative assessment of the effectiveness of cognitive stimulation programs using computer-based assistive technology involving older adults at various stages of dementia, as well as the efficacy and reliability of this type of intervention, practical effects and the potential to delay or prevent dementia.

KEYWORDS: computer-based assistive technology; cognitive stimulation; dementia; healthy older adults; older adults.

INTRODUCTION

Dementia is one of the leading causes of disability and incapacity among the elderly throughout the world (World Health Organization, 2017). According to the Alzheimer's Disease International (2019), approximately 50 million people worldwide are affected by dementia. This number is expected to increase to more than 152 million by 2050. Moreover, the Alzheimer Portugal Association (2020) estimates that by 2050, the number of Portuguese citizens with dementia will gradually increase from 1.88% (in 2018) to 3.82% of the population.

A significant and rapid evolution of neurodegenerative dementias has been seen as a consequence of the substantial increase in average life expectancy in the last century (Murman, 2015). In fact, this issue has been increasingly considered an international health priority and has a significant impact on global healthcare services and governmental systems (Alzheimer's Disease International, 2019). Additionally, the deterioration of cognitive abilities affects individuals directly and their carers, posing new challenges related to the progression of dementia (Hedden & Gabrieli, 2004), such as impaired functions and changes in neuropsychological measures, functionality, independence, and quality of life.

Dementia must be distinguished from normal ageing (normal cognitive decline). There are several degrees of dementia, including pre-dementia (associated with mild cognitive deficit) (Petersen et al., 2001) and different types of dementia (implying severe cognitive deficits) (Alves et al., 2013), namely Alzheimer's disease (AD). When compared with

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mild cognitive impairment (MCI), dementia significantly affects the person's functioning (US Preventive Services Task Force et al., 2020).

In our view, early intervention must be a priority, and prevention should be assumed as important in the field of study of cognitive decline, namely because dementia is significantly responsible for the decline of several human cognitive functions and is considered the principal neurocognitive disorder (US Preventive Services Task Force et al., 2020).

The present review summarises the significant literature on the role of cognitive stimulation interventions applied to older adults with dementia and without cognitive decline and evaluates its effects and outcomes.

Cognitive stimulation

Cognitive stimulation has been extensively applied as an intervention to people with mild to moderate dementia and has been evidenced as a privileged methodology in this area (Aguirre et al., 2014; Capotosto et al., 2017; Piras et al., 2017). In general, the literature defines cognitive stimulation as a non-pharmacological technique that precludes cognitive decline and comprises computer-based cognitive stimulation systems (e.g. computers and tablets) and other traditional approaches that do not include computerized training, with multiple group activities, including engaging in non-specific activities (Mendes et al., 2022; Woods et al., 2012) such as mentally challenging exercises, museum visits, puzzles, and daily life activities.

Cognitive stimulation intervention is aimed at improving general cognition and social functioning (Bahar-Fuchs et al., 2013; Clare & Woods, 2004; Eckroth-Bucher & Siberski, 2009; Gates & Sachdev, 2014; Kim & Kim, 2014; Kueider et al., 2014; Melguizo Herrera et al., 2017; Miranda-Castillo et al., 2012; Mowszowski et al., 2010; Steinerman, 2010) based on the social environment and multisensory stimulation (e.g., attention, language, problem-solving, memory, information processing speed), for example by increasing attention to improving orientation or engaging in activities to improve memory. This approach combines fun, learning, improving performance and skills, and enhancing social contacts (Piras et al., 2017). Also, the literature highlights that cognitive stimulation may preserve or improve cognitive abilities besides reducing the decline caused by normal ageing.

Various studies reported cognitively stimulating activities or tasks (computerized and non-computerized) to reduce cognitive decline (Newson & Kemps, 2006) and improve the cognitive functioning, health, quality of life, and well-being of healthy older adults (e.g. Castel et al., 2017; Fernández-Prado et al., 2012; Tranter & Koutstaal, 2008) or older adults with dementia (Toh et al., 2016; Woods et al., 2012; Yuill & Hollis, 2011). Research also suggests that cognitive stimulation intervention increases global cognitive functioning within a period of 6 to 12 months among people with cognitive impairment of distinct causes (mild cognitive deficit and other statuses of dementia) (Lin et al., 2013).

Cognitive stimulation without computerized tasks: a traditional intervention

Most studies (see Table 1) that do not include technology showed gains after cognitive stimulation in older adults with mild to moderate dementia (Capotosto et al., 2017; Spector et al., 2003; Woods et al., 2006; Yamanaka et al., 2013; Young et al., 2019), older adults diagnosed with mild to moderate vascular dementia (VaD) (Piras et al., 2017), and individuals with AD (Miranda-Castillo et al., 2012; Vidovich et al., 2011).

The study by Spector et al. (2003) conducted a program consisting of 45-minute sessions twice a week over 7 weeks. The study included a prominent reality orientation approach and focused on cognitive stimulation of 201 older adults with dementia (including multisensory stimulation). Results indicated improvements in the individuals' cognitive functioning and quality of life, namely in emotional symptoms. Along the same line, Woods et al. (2006) demonstrated that cognition-based interventions directly impacted the quality of life in older adults diagnosed with dementia.

Another study by Spector et al. (2010), using the same theoretical concepts and a methodological approach similar to their previous study (Spector et al., 2003), demonstrated improvements in conversation and communication and a positive impact on the well-being of 201 older adults with dementia. Despite their promising results, no significant changes in memory and orientation or praxis were found. Yamanaka et al. (2013) reached similar findings in a study with 56 older adults with dementia (26 in the treatment group and 30 in the control group) designed based on principles of the cognitive stimulation program (Spector et al., 2003) adapted to the Japanese culture. Their results demonstrated significant benefits in improving the cognitive function, quality of life, and mood of participants with dementia. Capotosto et al. (2017) showed similar results, namely, decreased emotional loneliness, in 39 older adults with mild to moderate dementia.

Piras et al. (2017) applied a cognitive stimulation intervention in a specific population of 35 older adults with mild to moderate vascular dementia (VaD) divided into two groups: the intervention group, composed of 21 individuals

Table 1. Type of cognitive intervention (cognitive stimulation) for older adults.

Author(s), Year	Subjects | Research design	Main intervention	Main results
Spector et al., 2003.	201 older adults with dementia (115 intervention group and 86 control group) | RCT	Benefit cognition and QoL (do not include computerized tasks).	⇑ Cognitive functioning. ⇑ QoL.
Woods et al., 2006.	201 older adults with dementia | RCT	QoL, cognition, dementia, mood, dependency, and communication (do not include computerized tasks).	Cognition-based interventions have a direct impact on QoL.
Tranter & Koutstaal, 2008.	44 healthy older adults (intervention and control group) | RCT	Fluid intelligence performance (do not include computerized tasks).	⇑ Problem solving and flexible thinking.
Niu et al., 2010.	32 older adults with AD (intervention and control group) | RCT	Executive functions and working memory (do not include computerized tasks).	⇓ Apathy and depression symptomatology.
Spector et al., 2010.	201 older adults with dementia (115 treatment and 86 control groups) | RCT	Memory, praxis and language (do not include computerized tasks).	⇑ Conversation and communication. No significant changes in memory and orientation or praxis.
Vidovich et al., 2011.	128 patients with AD | RCT; follow-up of participants for 6 months post-intervention.	Reducing score on the Alzheimer Disease Assessment Scale-Cognitive Subscale; QoL, mood, memory, language, executive functions, independent living abilities, and psychiatric symptoms (do not include computerized tasks).	⇑ QoL. ⇓ Cognitive decline.
Fernández-Prado et al., 2012.	104 older adults (53 intervention group and 51 control group) | RCT	QoL and cognitive changes (do not include computerized tasks).	⇑ Cognitive performance and QoL.
Miranda-Castillo et al., 2012.	22 older adults with AD (intervention and control group) | RCT; follow-up of participants for 7 weeks post-intervention.	Cognition, QoL, functional ability (do not include computerized tasks).	⇑ Cognitive function and QoL in the intervention group. No differences in functional ability in both groups.
Moro et al., 2012.	30 older adults with MCI (2 groups) | Pre and post-test design.	Attention, memory, and executive functions (do not include computerized tasks).	⇑ Memory abilities on short-term and working memory in group A and long-term memory in group B.
Thiel et al., 2012.	159 older adults (114 intervention group and 45 control group) | RCT; follow-up of participants for 6 months post-intervention.	Combined physical and cognitive intervention in older adults (do not include computerized tasks).	Cognitive stimulation and physical activity may prevent age-related cognitive decline.
Yamanaka et al., 2013.	56 older adults with dementia (26 treatment group and 30 control group) | RCT	QoL, cognition and mood (do not include computerized tasks).	⇑ Cognition, QoL, and mood.
Alves et al., 2014.	20 older adults with cognitive impairment | RCT	Changes in neuropsychological, functionality, QoL, and caregiver outcomes (do not include computerized tasks).	Excellent adherence and completion rates, reasonable costs, high values of experiential relevance to participants.
Dannhauser et al., 2014.	67 older adults with MCI | RCT	No computerized tasks - ThinkingFit program (physical activity, group-based and individual cognitive stimulation - attention, processing speed, working memory, problem-solving, and reasoning).	⇑ Physical health and fitness. ⇑ Working memory.
De Oliveira et al., 2014.	42 healthy older adults (25 institutionalized and 17 noninstitutionalized) | Pre and post-test design.	Memory and language (do not include computerized tasks).	⇑ Language and cognitive performance institutionalized group.
Suzuki et al., 2014.	58 older adults (intervention and control group) | RCT	Memory, executive functions and attention (do not include computerized tasks).	⇑ Executive function, memory, and attention.
Zimmermann et al., 2014.	14 healthy older adults | Pre and post-test design.	Differences between direct and indirect stimulation of WM (do not include computerized tasks).	Both approaches showed benefits (executive functions and linguistic abilities).
Moro et al., 2015.	30 older adults with MCI (2 groups) | Pre and post-test design	General functions, executive functions, memory, and language (do not include computerized tasks).	⇑ Performance, memory, and general functions in both groups.

Continue...

Table 1. Continuation.

Author(s), Year	Subjects | Research design	Main intervention	Main results
Malvy, 2016.	11 older adults with MCI| Descriptive study.	Attention, memory, language, praxis, visuo-spatial skills, and executive function training. Computerized cognitive stimulation KODRO software.	⇑ Attention, memory, language, and praxis.
Yasini & Marchand, 2016.	15 older adults | Pre and post-test design.	WM, attention, concentration, visual-spatial memory. Tablet application Stim'Art.	No significant difference in improving the well-being between male and female users.
van Zon et al., 2016.	53 older adults (37 experimental and 16 control group) | Pre and post-test design.	Reasoning, attention and memory (do not include computerized tasks).	⇑ Cognitive abilities in long-term care. ⇑ Memory and verbal fluency.
Castel et al., 2017.	176 older adults (123 intervention group and 53 control group) | Pre and post-test design.	No computerized tasks (orientation, memory, language, gnosis, praxis, reminiscences, numerical calculation, attention, and concentration).	⇑ Psychological well-being in cognitive stimulation group.
Capotosto et al., 2017.	39 older adults with mild to moderate dementia | RCT	Cognitive functioning, QoL, mood, functional activities in daily living, and behavior (do not include computerized tasks).	⇑ Cognitive functioning. ⇑ QoL and mood.
Dethlefs et al., 2017.	23 older adults (13 healthy and 10 with dementia) | Pilot nonrandomized.	Memory and communication. Computer-based assistive - Wizard-of-Oz.	⇑ Spoken natural language.
Djabelkhir et al., 2017.	19 older adults with MCI (9 CCS and 10 CCE) | RCT	Computerized cognitive stimulation (KODRO). Global cognitive function, executive functions, working memory, episodic memory, and psychosocial functioning.	⇑ Processing speed, episodic memory, and self-esteem in CCE group. ⇑ Self-esteem in CCS group.
Grimaud et al., 2017.	67 older adults | Pre and post-test design.	Processing speed, working memory, executive functions, memory span, and self-esteem (do not include computerized tasks).	⇑ Memory span, updating and memory self-perception; processing speed. ⇑ Self-esteem.
Melguizo Herrera et al., 2017.	37 older adults (23 experimental group and 14 control group) | Pre and post-test design.	Memory, orientation, information about daily events, and arithmetic (do not include computerized tasks).	⇑ Cognitive functioning.
Ordonez et al., 2017.	124 older adults (102 experimental group and 22 control group) | Pre and post-test design.	Global cognition, depressive and anxiety symptoms, memory complaints, and learning satisfaction. Electronic games equipment Actively Station.	⇑ Language and memory. ⇓ Anxiety symptoms and memory complaints.
Piras et al., 2017.	35 older adults with mild to moderate VaD | RCT	Working memory, language, QoL, mood, behavior and everyday life functioning (do not include computerized tasks).	⇑ General cognitive functioning.
Stewart et al., 2017.	40 older adults with dementia | Pre and post-test design.	Cognition, QoL and depression (do not include computerized tasks).	⇑ Cognitive status. ⇓ Depression. No differences in QoL.
Djabelkhir-Jemmi et al., 2018.	51 older adults with MCI | Pre and post-test design; - follow-up of participants for 3 months post-intervention	Executive functions, attention, and processing speed. Computerized cognitive stimulation KODRO software.	⇑ Executive functioning, processing speed, and memory – patients with MCI-WMH.
Martínez-Alcalá et al., 2018.	22 older adults | Pilot nonrandomized.	Attention, memory, comprehension, perception, and visualspatial processes. Mobile app iBenni.	⇑ Attention, comprehension, and short-term memory.
Karssemeijer et al., 2019.	115 older adults with dementia | RCT; follow-up of participants for 6 months post-intervention.	Executive function, episodic memory, working memory, and psychomotor speed. Interactive virtual bike tours: Bike Labyrinth.	No effects were found on executive function, episodic and working memory.
Valdés et al., 2019.	49 older adults with MCI (24 treatment group and 25 control group) | RCT	Processing speed. Road Sign Test computer training.	⇑ Speed of processing training.
Young et al., 2019.	101 older adults with dementia (51 treatment group and 50 control group) | RCT	Cognitive functioning (do not include computerized tasks).	⇑ Cognitive functioning in the treatment group.
Young, 2020.	80 older adults with mild-stage dementia (41 treatment group and 39 control group) | RCT	Cognitive ability and QoL (do not include computerized tasks).	⇑ General cognitive functioning.

RCT: Randomized controlled trial; AD: Alzheimer's disease; QoL: Quality of life; MCI: Mild cognitive impairment; WM: Working memory; CCS: Computerized cognitive stimulation; CCE: Computerized cognitive engagement; VaD: Vascular dementia; WMH: White matter hyperintensities.

who attended the 14 sessions of the cognitive stimulation program, and the other group, which took part in alternative educational activities. They analysed the cognitive functioning, quality of life, mood, behaviour, and functional activities of daily living and detected improvements in general cognitive functioning and a trend toward increased short-term/working memory in the intervention group.

Contrary to most studies, some did not evidence positive effects on the quality of life of older adults with dementia who integrated a cognitive stimulation program without technology. Namely, Young et al. (2019) and Young (2020) applied an expanded traditional cognitive stimulation model (without computerized tasks) with tai chi techniques to older adults with mild-stage dementia and found a trend toward improving general cognitive functioning but no overall increase in quality of life. Stewart et al. (2017), who applied a cognitive stimulation intervention to 40 older adults with dementia, also did not detect differences in quality of life, even though encouraging results were highlighted in cognitive functioning and reduced depression levels.

Regarding AD, in particular, three studies used traditional interventions. Niu et al. (2010) integrated 32 older adults with mild to moderate AD in a cognitive stimulation therapy group that included individual tasks using executive functioning and working memory, such as "The reality orientation task," "The fluency task," "The overlapping figure task," and "The photo-story learning task." The training consisted of 45-minute sessions twice a week for 10 weeks, and positive effects were found, with decreased apathy and depression symptomatology. Miranda-Castillo et al. (2012), who integrated 22 participants diagnosed with AD in a program of 14 sessions of cognitive stimulation therapy, found improvements in cognitive function and quality of life in the intervention group but no differences in functional ability in either group.

Vidovich et al. (2011) applied a 12-week cognitive activity program with a follow-up of 6 months post-intervention to 128 older adults with AD divided into two groups. In group 1, individuals with mild AD and their companions participated together in a 7-week intervention of one 90-minute session per week focused on cognitive abilities usually affected in AD (attention, processing speed, memory, language, and executive functions). The program had a supervision and practice component with strategy techniques and examples of home activities, with phone-call support. In turn, group 2 only included carers, who received information and materials in the same terms as Group 1 and were instructed to transmit all the knowledge to facilitate patients in their natural environment and everyday situations. The main results revealed an improvement in quality of life and decreased cognitive decline in older adults with mild AD. That study also suggests that the cognitive stimulation approach for individuals with AD is probably more reliable when caregivers are also included in therapy.

Cognitive stimulation intervention without computerized tasks has also been shown to be beneficial for people with MCI. In a two-stage study, Moro et al. (2012) applied cognitive stimulation to 30 older adults with MCI divided into two groups. Both groups were assessed at an early stage of the program, but only 15 individuals of group A took part in an immediate cognitive stimulation intervention for six months. Group B only attended the program in the second stage and received specific training for six months. Positive effects of cognitive stimulation were detected in memory, particularly in short-term and working memory for group A and long-term memory for group B. These results are encouraging and emphasise the significant role of specific training in reducing cognitive impairments in people with cognitive decline. Similar findings were found later by Moro et al. (2015) in a sample of 30 older adults with MCI participating in a program based on cognitive stimulation, whose main intervention focused on general cognitive functions, executive functions, memory, and language. In addition to improvements in memory, the authors found an increment in performance and general functions.

Dannhauser et al. (2014) conducted a study combining physical activity with cognitive stimulation to test a complex multimodal activity intervention (ThinkingFit program) in reducing the risk of dementia in 67 older adults with MCI. The intervention had three components: physical activity and group and individual cognitive stimulation training (in domains of attention, processing speed, working memory, problem-solving, and reasoning). The results showed positive outcomes for physical health and fitness and improved working memory. Previously, Thiel et al. (2012) had already concluded that physical activity, together with cognitive stimulation intervention, could prevent age-related cognitive decline in a large sample of seniors.

A study by Alves et al. (2014) with a sample of 20 older adults with cognitive impairment (cognitive decline ranging from MCI to mild-to-moderate dementia) used two distinct approaches – a standard cognitive stimulation program (17 sessions, six weeks) and a brief cognitive stimulation program (11 sessions, four weeks) — to assess changes in different domains: neuropsychological, functionality, quality of life, and caregiver outcomes. Findings pointed out outstanding adherence and completion rates, acceptable costs, and high values of experiential relevance to users. Despite these conclusions, the remaining results were not considered clinically significant.

Many studies have confirmed the benefits of cognitive stimulation intervention in healthy older adults. In the study by Castel et al. (2017), 176 older adults were divided into two groups: 123 participated in a cognitive stimulation program, while 53 formed a control group, using a pre-and post-test design. Participants engaged in various tasks related to orientation, memory, language, gnosis, praxis, reminiscences, numerical calculation, attention, and concentration, without the use of computerised methods. Results showed an improvement in psychological well-being in the cognitive stimulation group. Tranter and Koutstaal (2008) observed gains in cognitive functions, such as problem-solving and flexible thinking, in n study that encouraged engagement in mentally stimulating activities. Zimmermann et al. (2014) applied two different approaches for direct and indirect stimulation of working memory: the first group attended a structured working memory training program with 2-hour sessions for 6 weeks, while the second integrated a poetry-based stimulation program of twelve 2-hour sessions for 6 weeks. Both interventions showed benefits in executive functions (direct stimulation) and linguistic abilities (indirect stimulation). De Oliveira et al. (2014) also demonstrated positive effects on executive functions and linguistic abilities in a population of healthy older adults, applying a multisensory and cognitive stimulation method.

Other studies with healthy older adults have found similar benefits when applying traditional cognitive stimulation interventions, including positive results in executive function, memory, and attention (Suzuki et al., 2014), general cognitive functionality (Fernández-Prado et al., 2012; Melguizo Herrera et al., 2017; van Zon et al., 2016); memory and verbal fluency (van Zon et al., 2016); and memory span, updating and memory self-perception and processing speed (Grimaud et al., 2017).

Cognitive stimulation using computer-based assistive technology

Studies on cognitive stimulation based on computerized tasks and supported by technological methodologies have shown strong evidence suggesting that cognitive stimulation intervention in a particular domain improves performance in that specific domain for individuals with mild to moderate cognitive impairment.

Djabelkhir et al. (2017) applied computerized cognitive exercises and social interaction activities in a sample of 19 patients with MCI divided into two groups of intervention: computerized cognitive stimulation (first group, 9 participants) and computerized cognitive engagement (second group, 10 participants). The first group was involved in computerized cognitive exercises (KODRO software) and social interactions, and results confirmed improvement of inhibitory control, mental flexibility, and self-esteem, as well as a higher performance in free recall. The second group conducted tasks previously defined (e.g., exploring applications about a specific theme) in an informal context. Although the main results showed positive effects in processing speed, episodic memory, and self-esteem, no significant differences were detected in quality of life, memory complaints, anxiety, and depression between computerized cognitive stimulation and computerized cognitive engagement. These results are corroborated by another study that confirms this software enables the improvement of executive functioning, processing speed, and memory (Djabelkhir-Jemmi et al., 2018). The study by Malvy (2016) also documented the positive effects of the KODRO cognitive stimulation program applied to 11 individuals diagnosed with MCI, particularly in four domains of six cognitive functions tested: memory, attention, language, and praxis. Participants used a touch tablet in a weekly session for 12 months.

A recent study by Valdés et al. (2019) focused on cognitive processing speed training in 49 older adults with MCI, with three different tasks: i) the Road Sign Test, which tests the reaction time of participants in response to a set of stimuli presented by a computer; ii) The Timed IADL Test, which uses stimuli of instrumental activities of daily living (e.g., reading the directions on a medicine bottle label) presented by a computer; and iii) the UFOV Test, which is a computerized test of cognitive processing speed for visual attention tasks. Conclusions indicated that computer training improved the processing speed in people with MCI.

Dethlefs et al. (2017) conducted a study on 23 participants involved in cognitively stimulating activities (memory and communication tasks) based on processing information, such as sorting, name recall, quiz, and proverbs, for 20 minutes, using the electronic game Wizard-of-Woz (WoZ interface). They showed that this game could improve the spoken natural language of adults with dementia and healthy older people. In turn, Martínez-Alcalá et al. (2018) used the mobile app iBenni to train attention, memory, comprehension, perception, and visual-spatial processes in a more general sample of 22 older adults and detected gains in attention, comprehension, and short-term memory. Ordonez et al. (2017) used a cognitive stimulation tool, the electronic games equipment Actively Station, in 124 older adults and confirmed the improvement of language and memory functions and the reduction of anxiety symptoms and memory complaints.

However, not all studies showed positive effects of cognitive stimulation using computer-based assistive technology, especially in studies including older adults with dementia or MCI. Namely, Karssemeijer et al. (2019), who used the interactive virtual bike tours Bike Labyrinth in 115 older adults with dementia to train executive function, episodic memory, working memory, and psychomotor speed, confirmed improvements in psychomotor speed but no effects on executive function and episodic and working memory. Yasini and Marchand (2016) found no significant differences in the trained cognitive functions when increasing the difficulty levels and the time older adults spend using the tablet application Stim'Art. However, although the results showed no gains in the well-being of users, the participants' self-evaluations reflected an improvement in the well-being score.

CONCLUSION

The current study presents a review of the recent state of cognitive stimulation intervention in older adults with mild to moderate dementia. In general, the studies evidence the psychological and cognitive benefits of applying cognitive stimulation, both traditionally and using computer-based assistive technology. Regarding quality of life, the results reported in some of the studies considered indicate a positive trend of this intervention's traditional use compared to using technology, especially in people with dementia and AD (Miranda-Castillo et al., 2012; Spector et al., 2003; Spector et al., 2010; Vidovich et al., 2011; Woods et al., 2006; Yamanaka et al., 2013) and in improvement of general cognitive functioning (Capotosto et al., 2017; Young et al., 2019; Young, 2020). Positive results have also been verified in several cognitive functions, especially in healthy older adults reported in some of the studies that do not include technology, namely general cognitive functioning (Fernández-Prado et al., 2012; Melguizo Herrera et al., 2017; van Zon et al., 2016), executive function, memory, attention (Suzuki et al., 2014), verbal fluency (van Zon et al., 2016), and processing speed (Grimaud et al., 2017). On the other hand, some authors confirm improvements in attention, memory, language, praxis (Malvy, 2016), processing speed (Djabelkhir et al., 2017; Valdés et al., 2019) and executive functioning (Djabelkhir-Jemmi et al., 2018) in older adults with MCI after computerized cognitive stimulation.

Despite the significant increase in research on ageing and dementia, it appears that the cognitive stimulation intervention is still at an early stage. Although most studies confirm the effectiveness of a traditional intervention (compared to studies of computer-based assistive technology), further studies are needed to compare the true benefits of this intervention at the various stages of dementia. The analysed studies also confirm the benefits of multimodal interventions (physical activity and cognitive stimulation). Thus, we propose further studies in this area to facilitate the effective verification of this intervention methodology. Future investigations should also study whether or not the cognitive stimulation intervention can delay or prevent dementia. This assessment is relevant because it can facilitate the adoption and implementation of this type of intervention by diverse healthcare entities, reducing the consequences of this disease for society.

We found heterogeneity in the design of intervention studies, namely, study design, sample size and characteristics (the samples of studies that use computer-based assistive technology are considerably smaller compared to studies without computerized tasks or a traditional intervention), control condition, the number of sessions, the program duration, costs and benefits to the user, the ideal level of intensity/difficulty, the standardisation of neuropsychological assessment protocols, and treatment procedures. In this regard, it might be important to consider the standardisation of research methods based on evaluation by specialists in the cognition field and related areas. In terms of brain structures and the effects of cognitive stimulation, it is important to include neuroimaging measures and other neuropsychological assessment measures (depression, fatigue, quality of life, motivation, interpersonal relationships, and others) in the different research stages of dementia and protocols, in order to assess the global and specific effects of this intervention on the user's life, but also its immediate and long-term effects and the possible preventive role.

In conclusion, we argue that there is a need for standardised procedures in the cognitive stimulation intervention field in order to maximise the practical evidence of this type of intervention and its different roles at the various stages and types of dementia. These advances might benefit older adults, specifically their cognitive, psychological and social functioning, directly impacting their quality of life, including healthy older adults or impaired individuals (e.g., MCI, demented patients).

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