Proceeding

Supplementary Issue: Winter Conferences of Sports Science. Costa Blanca Sports Science Events, 22-23 March 2021. Alicante, Spain.

Physical, cognitive and emotional outcomes in older adults exercisers: A systematic review

MIGUEL ÁNGEL ARAQUE-MARTÍNEZ[1], EVA MARÍA ARTÉS-RODRÍGUEZ[2], PEDRO JESÚS RUIZ-MONTERO[3] ✉, ANTONIO JESÚS CASIMIRO-ANDÚJAR[1]

[1]*Department of Education, Faculty of Education Sciences, University of Almería, Almería, Spain*

[2]*Department of Mathematics, Faculty of Economics and Business Sciences, University of Almería, Almería, Spain*

[3]*Department of Physical Education and Sport, Faculty of Education and Sport Sciences, University of Granada, Melilla, Spain*

ABSTRACT

Background: This systematic review provides an overview about those papers with a specific physical exercise intervention aimed to improve physical, cognitive and/or emotional outcomes in healthy older people aged 60 or over. Studies with no intervention whose sample were active healthy older adults were also included. Methodology: An exhaustive literature search was done through two databases, including studies from January 2000 to December 2020. The present systematic review was registered in an international database of prospectively systematic reviews in health and social care named PROSPERO with the registry number CRD42020223081. Results: Of the 2148 identified records, 69 met the inclusion criteria and were selected. Results from the review showed a wide variety of older adults and lengths of the interventions, from five weeks (the shortest one) to five years. Aerobic exercise, either isolated or combined with strength performance, was also the most common type of exercise recognized in this systematic review. Conclusions: Findings also suggest that the number of studies with all, physical, cognitive and emotional outcomes have been increasing during recent years in healthy older adults.

Keywords: Physical activity; Ageing; Review process; Cognition; Emotion.

Cite this article as:
Araque-Martínez, M.A., Artés-Rodríguez, E.M., Ruiz-Montero, P.J., & Casimiro-Andújar, A.J. (2021). Physical, cognitive and emotional outcomes in older adults exercisers: A systematic review. *Journal of Human Sport and Exercise, 16*(3proc), S1075-S1093. https://doi.org/10.14198/jhse.2021.16.Proc3.25

✉ **Corresponding author.** *Facultad de Ciencias de la Educación y del Deporte, Campus de Melilla, Calle Santander, nº1. 52006, Melilla, España. https://orcid.org/0000-0001-9349-2478*
E-mail: pedrorumo@ugr.es
Abstract submitted to: Winter Conferences of Sports Science. Costa Blanca Sports Science Events, 22-23 March 2021. Alicante, Spain.
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2021.16.Proc3.25

INTRODUCTION

The number of people aged 65 or over in 2050 will be doubled in comparison to the current one, from 703 million people at the moment to a future figure of 1.5 billion. In fact, life expectancy is also increasing, from 72.6 years in 2019 to a probable figure of 77.1 years in 2050 (United Nations, 2020).

According to the American College of Sport Medicine –ACSM- (Chodzko-Zajko et al., 2009), ageing is associated with some physiologic changes that modify physical and mental health among other factors. In addition, becoming older has some effects on individuals, such as an acceleration in the decline of aerobic capacity and strength (Fleg et al., 2005), memory deterioration (Peters, 2006), decline of motivation and increase of negative emotions (Carstensen and Mikels, 2005) or an increment on the prevalence of cognitive impairment and dementia (Yuan et al., 2016).

The role of physical activity (PA) is gaining attention in this group of people because of the evidence that shows the positive effects of it on healthy older adults, such as the prevention of some diseases including type 2 diabetes, strokes, hypertension and some types of cancer (Vogel et al., 2009). Furthermore, there are also beneficial effects of PA on unhealthy elders with dementia (Blankevoort et al., 2010), depression (Lavretsky et al., 2011), mild cognitive impairment –MCI- (Karssemeijer et al., 2017), and Alzheimer's (Salazar et al., 2017) or Parkinson's disease (Rios-Romenets et al., 2015).

Physiologically, regular physical exercise increases maximal oxygen consumption (VO_2max) (Malbut et al., 2002), physical function (Geirsdottir et al., 2015), strength and cardiorespiratory fitness (Ruiz-Montero et al., 2020). Because of that, physical performance is improved in healthy elderly practitioners of PA (Vaughan et al., 2014).

It is necessary to highlight brain health as an important factor related to regular PA (Powell et al., 2019) due to its effects on cognition, such as an enhancement of executive function and information processing speed (Coetsee and Terblanche, 2017) or beneficial effect on peripheral blood concentrations of brain-derived neurotrophic factor (BDNF) (Karssemeijer et al., 2017). Regular PA increases the function of neurotransmitters, such as serotonin, noradrenaline or dopamine; therefore, the motivation, happiness and satisfaction are going to be increased in practitioners (Secher et al., 2008).

Consequently, there is research focused on the relation between PA and cognitive function, which confirms that PA in healthy older adults enhances existing cognitive function and prevents or delays progression of cognitive diseases, such as Alzheimer's dementia (Carvalho et al., 2014), in both older adults with and without cognitive impairment (Gomes-Osman et al., 2018). In fact, combined physical and cognitive interventions have been proven as an effective tool for improving cognition in healthy older adults (Zhu et al., 2016).

Overall, considering how important and useful it is to be updated about different physical exercise interventions in an older adult population, the present systematic review pretends to highlight them, taking the recent literature into consideration.

The rationale for conducting the present systematic review was to summarize those supervised physical exercise interventions aimed to improve physical, emotional and/or cognitive performance in healthy older adults aged 60 or over. Studies without interventions in non-sedentary older adults with an active lifestyle have also been included. They are specified in the intervention characteristics column of the Table 1.

Broadly, this review is organized following different aspects, including original source of information, sample characteristics, study design, duration and characteristics of the intervention in case it exists, and the main outcomes under investigation.

MATERIAL AND METHODS

Survey methodology
This systematic review has followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Urrútia and Bonfill, 2010). A PRISMA flow diagram (Figure 1) summarizes the information on the phases of the systematic review process.

Search strategies
A systematic search for relevant studies was conducted on two of the most respected databases in the field of social sciences and education, ISI Web of Knowledge and Scopus-Elsevier. From these, we contemplated all peer-reviewed publications from the current century, between January of 2000 and December of 2020. We consider two decades as an appropriate period of time, which includes literature from recent years and allows us to observe the gradual process of change and development in this area. In order to be as accurate as possible, we decided which terms should be taken into account. Consequently, all the publications had to contain at least one of the following terms: 'older adults' (older adults, elderly, seniors, elders); 'cognition' (cognition, cognitive function, cognitive flexible, memory); 'physical activity' (physical activity, physical exercise, exercise); 'mood' (mood, state of mood); and 'emotions' (depression, sadness, anxiety, happiness, self-esteem, optimism, anger, hostility).

The search included those articles where the terms were found in titles and abstracts.

Apart from that, all the references from the retrieved articles were reviewed looking for possible additional publications related to physical exercise interventions in healthy older adults, as well as those where samples were active older adults.

Selection criteria
Studies were included according to the following criteria: (1) complete original study; (2) written in English; (3) involving healthy or active people aged 60 years and over; and (4) related to PA and the physical exercise field.

According to these criteria, healthy people were considered as those who did not suffer any kind of mental (e.g., Alzheimer's or Parkinson's disease), emotional (e.g., depression) or physical (e.g., arthritis) diagnosed impairment, while active older adults were those who exercised regularly (e.g., marathon runners) (Batmyagmar et al., 2019).

Studies were excluded if they were (1) not written in English; (2) a review, theoretical or protocol article; (3) book or chapter in a book; (4) related to other areas, such as medicine (Ates-Bulut et al., 2019) or genetics (Szentes et al., 2019); or (5) involving unhealthy older adults 60 years old and over.

Two independent expert reviewers screened the titles and abstracts; secondly, they evaluated full-text articles independently. In case of disagreement, a third reviewer was required to solve it. The way to agree on difference in evaluated manuscripts were to share own perspectives about them between the three reviewers. Those reviewers, who are members of different universities with much experience working with older adults and research in physical exercise in the area of health and sport sciences, followed the considerations previously described.

The present systematic review was registered in an international database of prospectively systematic reviews in health and social care named PROSPERO with the registry number CRD42020223081.

RESULTS

Study selection

A total of 2148 studies were identified using the databases as described in the Search Strategies section. After the removal of 45 duplicated papers, 1888 papers were also excluded based on titles and abstracts. The remaining 215 articles were screened, and from these, 146 were excluded after a full-text evaluation due to the exclusion criteria previously described, leaving 69 studies that were eligible for this review (Figure 1). These 69 papers were classified according to different aspects, including original source of information, sample characteristics, study design, duration and characteristics of the intervention in case it exists, and the main outcomes under investigation.

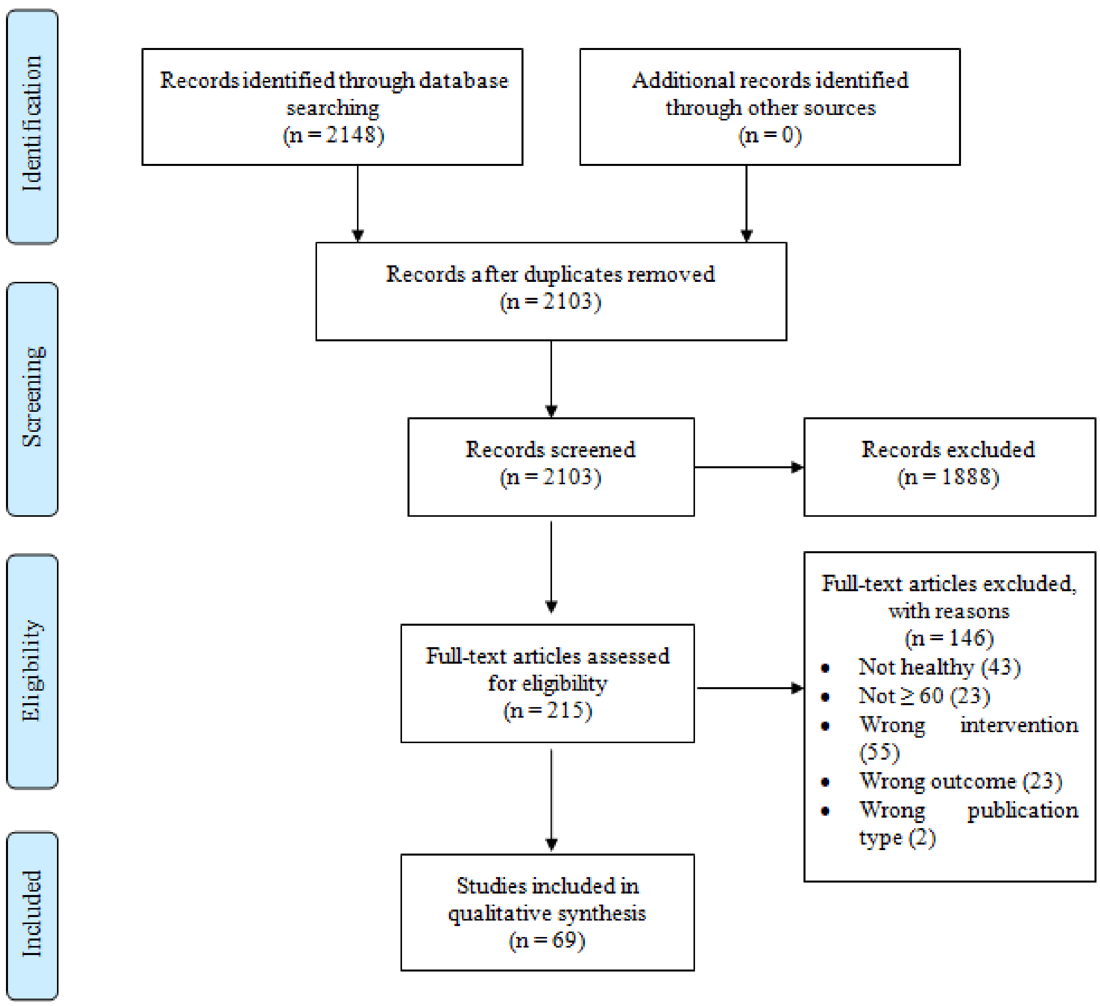

Figure 1: Flowchart of the study selection process using the PRISMA framework.

Participant characteristics
The sample size varied from eight participants (Lindahl et al., 2016) to 1193 (Brady et al., 2020) participants. The ages of the participants ranged from 60, which was the minimum accepted in this paper, to 99 years old (Anderson-Hanley et al., 2011).

In terms of gender, most of the papers (74%) had mixed samples, although there was a minority with men exclusively (6%) and a bigger percentage of studies (20%) comprised mainly of women. Three papers included in this systematic review (Dupuy et al., 2018; Joung and Lee, 2019; Pereira et al., 2014) did not distinguish between men or women in their samples.

According to a PA profile, we found more articles (32%) with a sample composed of sedentary older adults in comparison with those with an active sample (24%). Those active practitioners took part in different studies doing regular activities, such as yoga (Afonso et al., 2017), athletics (Batmyagmar et al., 2019) and dancing (Serra et al., 2016).

However, there were also studies (41%) that did not specify the PA profile of their samples, as well as those whose samples were comprised of both active and sedentary people (Stone et al., 2018). In those papers in which there was no physical exercise intervention, we only included the physically active sample.

Type of intervention
One of the peculiarities of this systematic review is the inclusion of those papers in which there was no physical exercise intervention, but the articles were related to physical exercise in older adult practitioners. In this way, there were 15 studies (22%) out of the 69 included where there was not a physical exercise intervention. The rest of studies included physical exercise interventions with differences in the length of those, from five weeks (the shortest one) (Lee et al., 2017) to five years (Pandya, 2020). In relation to the weekly frequency of physical exercise sessions, most of the interventions had two (28%) or three (51%) sessions per week in comparison to those with four (Vaccaro et al., 2019), five (Tada, 2018) or seven (Hardman et al., 2020) weekly sessions. Moreover, we found papers where the number of weekly sessions varied depending on the intervention group (Anderson-Hanley et al., 2011; Hunter et al., 2013; Matsouka et al., 2005).

According to the type of physical exercise during the intervention, aerobic training was the most common one whether isolated (45%) or combined with strength training (16%). The combination of different types of activities, such as cognitive and physical training; outdoor leisure activities and callisthenic exercises; or aerobic, strength and balance exercises was also interesting. These types of exercise combinations have been defined in Table 1 of this study as concurrent interventions.

Research methodology
In terms of methodology, almost all studies (97%) followed a quantitative methodology, whereas only two (Fox et al., 2007; Zafar et al., 2017) used a mixed model. Therefore, none of the articles included in this systematic review followed a qualitative methodology. However, there was less of a difference between the design of studies. Almost half of the number of articles (n = 34; 49%) had a quasi-experimental (QE) study design in contrast to those with a randomized controlled trial (RCT) study design.

Main outcomes investigated
This systematic review is focused on summarizing different types of studies where the main outcomes investigated are related to physical, cognitive and/or emotional performance. Those outcomes investigated

from studies included in this systematic review that were not related to physical, cognitive and/or emotional performance were not included in Table 1.

Table 1: Overview on main characteristics of included studies.

Source	Sex, N, age	Duration	Intervention characteristics/ Study design	Main outcomes investigated
(Afonso et al., 2017)	F, 21, ≥ 60	-	- /QE	Instrumental activities of daily living, depression, cognitive function, anthropometrics measurements
(Alghadir et al., 2016)	F/M, 35/65, 65–95	24 weeks	Moderate aerobic exercise, three times a week/ RCT	Leisure time of PA, cognitive abilities
(Alghadir and Gabr, 2020)	F/M, 10/20, 65-95	12 weeks	Aerobic training program with moderate intensity, 45-60 min session three times a week/ RCT	Mood state, leisure-time physical activity
(Anderson-Hanley et al., 2011)	F/M, 13/1, 60–99	12 weeks	Virtual reality-enhanced stationary bike exercise, two-five times a week/ RCT	Anthropometrics measurements, heart rate, exercise effort
(Antunes et al., 2015)	F, 51, 60–70	24 weeks	Concurrent intervention: aerobic exercise, stretching and joint flexibility, 1 h session three times a week/ RCT	Physical assessment, depression, attention, memory, spatial/visual orientation, global cognitive and executive functioning, mental control, non-verbal and general intelligence, verbal fluency
(Azizan and Justine, 2016)	F/M, 35/28, ≥ 60	12 weeks	Concurrent intervention: cardiorespiratory endurance, strength, balance and flexibility training, 1 h session three times a week/ QE	Depression, health-related quality of life
(Batmyagmar et al., 2019)	F/M, 4/46, ≥ 60	-	-/ QE	Cognitive function, self-reported physical, mental and emotional health
(Bouaziz et al., 2019)	F/M, 44/16, ≥ 70	9.5 weeks	Cycling, 30 min session twice a week/ RCT	Verbal fluency, cognitive impairment, attention, anxiety, depression, health-related quality of life, functional performance, aerobic capacity, gait and balance
(Brady et al., 2020)	F/M, 569/624, 65–89	-	-/ QE	PA frequency, social isolation, loneliness, health-related quality of life
(Brown et al., 2009)	F/M, 135/19, 62–95	24 weeks	Concurrent intervention: resistance and balance training; flexibility exercise and relaxation technique, 1 h session twice a week/ RCT	Fluid intelligence, visual, verbal and working memory, executive function, depression, mood
(Carrasco et al., 2020)	F/M, 26/12, ≥ 65	6 weeks	Nintendo Wii Sports (tennis, baseball, bowling and boxing), 1 h session twice a week/ QE	PA frequency, health-related quality of life, cognitive performance

(Cassilhas et al., 2007)	M, 62, 65–75	24 weeks	High resistance training; moderate resistance training, 1 h session three times a week/ RCT	Body composition, muscle strength, digit span, short and long-term memory, attention, quality of life, depression, mood
(Cassilhas et al., 2010)	M, 43, 65–75	24 weeks	High resistance training, 1 h session three times a week/ RCT	Muscle strength, mood, anxiety
(Čekanauskaitė et al., 2020)	F/M, 30/3, ≥ 60	10 weeks	Yoga, 90 min session twice a week/ RCT	Heart rate variability, mood, anxiety, depression, perceived stress, mental flexibility, working memory, response inhibition, visuospatial processing, motor learning, balance
(Chutimakul et al., 2018)	F/M, 37/7, 60–65	12 weeks	Khon exercise, 1 h session three times a week/ QE	Functional fitness
(Coubard et al., 2011)	F/M, 104/6, 60–89	23 weeks	Contemporary dance; fall prevention programme; Tai Chi Chuan, 1 h session once a week/ QE	Neuropsychological assessment
(Cruz-Ferreira et al., 2015)	F, 57, 65–80	24 weeks	Creative dance, 50 min session three times a week/ RCT	Physical fitness, life satisfaction
(de Oliveira et al., 2019)	F/M, 77/23, ≥ 60	-	-/ QE	PA frequency, health-related quality of life, anxiety, depression
(Douka et al., 2019)	F/M, 107/23, ≥ 60	32 weeks	Greek traditional dance, 75 min session twice a week/ QE	Physical fitness
(Dupuy et al., 2018)	F/M, 19, 60–70	-	-/ QE	Aerobic fitness, heart rate variability, cognitive assessment
(Eckardt et al., 2020)	F/M, 41/27, 65–79	10 weeks	Instability resistance training; stable machine-based resistance training; stable machine-based adductor/abductor training, 1 h session twice a week/ RCT	Working memory, response and processing speed, attention, conflict resolution, set shifting
(Ericson et al., 2018)	F, 32, 65–70	24 weeks	Resistance training, twice a week/ RCT	Health-related quality of life, hope, affect
(Filar-Mierzwa et al., 2017)	F, 24, 61–74	12 weeks	Dance sessions, 45 min session three times a week/ QE	Postural stability, limits of stability, risk of falls
(Flegal et al., 2007)	F/M, 101/34, 65–85	24 weeks	Iyengar/Hatha yoga, 90 min session once a week; Aerobic walking, 1 h session once a week/ RCT	Cognitive function, mood, fatigue, anxiety, health-related quality of life, physical measures
(Flodin et al., 2017)	F/M, 27/20, 64–78	24 weeks	Aerobic exercise, 30–60 min session three times a week/ RCT	VO2peak, episodic and working memory, executive function, processing speed
(Fox et al., 2007)	F/M, 74/58, ≥ 70	48 weeks	Concurrent intervention: aerobic exercise, strength, Tai Chi and flexibility exercises, 60–90 min session three times a week/ QE	Quality of life, global life satisfaction, general well-being, physical self-perception profile, PA

(González-Palau et al., 2014)	F/M, 31/8, ≥ 60	12 weeks	Concurrent intervention: cognitive training, 40 min session three times a week and physical training in platform, 1 h session three times a week/ QE	Language, attention, working memory, sustained attention, executive functions, verbal learning, depression
(Gothe et al., 2019)	F/M, 169/78, 60–79	24 weeks	Aerobic dance; aerobic walking; aerobic walking + nutritional supplement; stretching exercise, 1 h session three times a week/ RCT	PA, physical, mental and social well-being, quality of life
(Haraldstad et al., 2017)	F, 49, 60–81	12 weeks	Strength training, three times a week/ QE	Health-related quality of life, maximal strength, physiological characteristics
(Hardman et al., 2020)	F/M, 26/12, 60-90	24 weeks	Aerobic exercise; Mediterranean diet; aerobic exercise + diet intervention 45-60 min session every day/ RCT	Aerobic fitness, simple and choice reactions times, different types of memory, mood, wellness, brain-derived neurotropic factor
(Hars et al., 2014)	F/M, 129/5, ≥ 65	24 weeks	Music-based multitask exercise classes, 1 h session once a week/ RCT	Cognitive impairment, executive functioning-related abilities, anxiety, depression
(Haslacher et al., 2012)	F/M, 6/50, ≥ 60	-	-/ QE	Executive functions, depression
(Haslacher et al., 2015a)	F/M, 5/50, ≥ 60	-	-/ QE	Physical performance, depression, cognitive abilities
(Haslacher et al., 2015b)	F/M, 5/50, ≥ 60	-	-/ QE	Depression, estimators of intelligence, quality of life, physical and psychical well-being
(Haslacher et al., 2016)	F/M, 4/43, ≥60	-	-/ QE	Physical performance
(Haslacher et al., 2017)	F/M, 4/43, ≥ 60	-	-/ QE	Physical performance
(Hunter et al., 2013)	F, 72, 60–74	16 weeks	Concurrent intervention: aerobic and resistance training, two, four or six 50 min sessions a week/ RCT	Maximal strength, physical performance, mood
(Imaoka et al., 2019)	F/M, 61/13, ≥ 60	12 weeks	Concurrent intervention: memory training and aerobic exercise; memory training, aerobic exercise and soy peptide supplementation, 1 h session once a week/ RCT	Cognitive impairment, attentiveness, body composition, muscle strength, gait speed, depression
(Joung and Lee, 2019)	F/M ,82, 65–80	8 weeks	Creative dance; stretching training, 90 min session twice a week/ RCT	Physical fitness, functional balance, functional mobility
(Kang et al., 2020)	F, 20, 68–80	16 weeks	Aquatic exercise, 1 h session three times per week/ QE	Cognitive function
(Khazaee-pool et al., 2015)	F/M, 37/83, 65-89	8 weeks	Concurrent intervention: aerobic exercise, stretching, kinetic movements and balance exercises, three times a week/ RCT	Well-being, happiness

(Kim et al., 2019)	F, 21, 67–81	24 weeks	Strength exercise, 50–80 min session three times a week/ RCT	Depression
(Laredo-Aguilera et al., 2018)	F/M, 32/6, ≥ 65	10 weeks	Concurrent intervention: aerobic exercise, muscular strengthening and balance training, 1 h session three times a week/ RCT	Anthropometrics, pain, mood, depression
(Lee et al., 2017)	M, 21, ≥ 65	5 weeks	Concurrent intervention: aerobic cycling and leg stretching, 50 min session twice a week/ RCT	Depression, balance
(Lindahl et al., 2016)	F/M, 2/6, ≥ 60	7 weeks	Hatha yoga, 1 h session twice a week/ QE	Balance, flexibility, functional mobility, health-related quality of life, exhaustion, stress
(Liu et al., 2019)	F/M, 21/10, ≥ 60	-	-/ QE	Depression, personality, attention
(Machacova et al., 2017)	F/M, 172/17, ≥ 60	12 weeks	Basic steps and combinations of ballroom dances, 1 h session once a week/ RCT	Mobility, basic activities of daily living, instrumental activities of daily living
(Martins et al., 2011)	F/M, 47/31, 65–95	16 weeks	Aerobic training; strength exercise, 45 min session three times a week/ RCT	Functional fitness, mood states
(Mason et al., 2020)	F/M, 15/16, 65-84	-	-/ QE	VO_2 peak, cognitive function
(Matsouka et al., 2005)	F, 55 60–75	12 weeks	Concurrent intervention: outdoor and indoor leisure activities and callisthenic exercises, 45 min session once/twice/three times a week/ QE	Positive engagement, revitalization, tranquillity, physical exhaustion
(Matsouka et al., 2010)	F, 45, 60–75	12 weeks	Concurrent intervention: outdoor leisure activities and callisthenic exercises, 45 min session twice a week/ QE	Positive engagement, revitalization, tranquillity, physical exhaustion
(Noopud et al., 2019)	F, 43, 60–80	12 weeks	Thai traditional dance, 30–60 min session three times a week/ RCT	Posture control, agility, functional balance, walking speed
(Oken et al., 2006)	F/M, 101/34, 65–85	24 weeks	Hatha yoga, 90 min session once a week; aerobic exercise, 1 h session once a week/ RCT	Attention, alertness, mood, fatigue, depression, health-related quality of life, anxiety, physical performance
(Pandya, 2020)	F/M, 394/398, ≥ 60,	5 years	Yoga, 40 min session once a week/ RCT	Cognitive impairment, memory
(Pereira et al., 2014)	F/M, 32 ≥ 60	16 weeks	Square-stepping exercise, 1 h session twice a week/ QE	Cognitive function, balance, functional mobility, depression
(Rosanti et al., 2014)	F, 17, 60–70	-	-/ QE	Neuropsychological assessment, self-efficacy
(Serra et al., 2016)	F, 55, 60–85	-	-/ QE	PA level, muscle strength, postural balance

(Solberg et al., 2012)	F/M, 80/38, ≥ 70	16 weeks	Strength training; functional strength training; endurance training, 1 h session three times a week/ RCT	Vitality, psychological need satisfaction, perceived autonomy support
(Solberg et al., 2013a)	F/M, 80/38, ≥ 70	16 weeks	Strength training; functional strength training; endurance training, 1 h session three times a week/ RCT	Body composition, functional performance, maximal strength, life satisfaction, affect
(Solberg et al., 2013b)	F/M, 80/38, ≥ 70	16 weeks	Physical exercise, 1 h session three times a week/ RCT	Motivation, perceived competence, causality orientations, well-being
(Starkweather, 2007)	F/M, 14/6, 60–90	10 weeks	Aerobic exercise, 30 min session five times a week/ QE	Stress, mood, quality of life
(Stone et al., 2018)	F/M, 41/75, ≥ 60	-	-/ QE	Self-confidence on daily activities, fear of/concern for falling, expectations and experiences of ageing
(Tada, 2018)	F/M, 42/19, ≥ 60	24 weeks	Resistance exercise using Thera-Band, 20 min session twice a week/ QE	Mental health status
(Tsai et al., 2015)	M, 48, 65–79	48 weeks	Resistance exercise, 1 h session three times a week/ RCT	PA frequency, maximal strength, cognitive performance
(Vaccaro et al., 2019)	F/M, 17/8, ≥ 65	24 weeks	Dance classes and free dance, 2 h session three times a week and 1 h 30 min session once a week/ QE	Anthropometrics, physical fitness, cognitive impairment, memory, depression, anxiety
(Vrinceanu et al., 2019)	F/M, 30/10, 60–86	12 weeks	Dance/movement training; aerobic exercise training, 1 h session three times a week/ RCT	Maximal aerobic power, gait speed, cognitive impairment, depression, anxiety, quality of life, social engagement
(Zafar et al., 2017)	F/M, 49/14, ≥ 80	12 weeks	Adapted Tango dance intervention, 90 min session twice a week/ QE	Depression, physical function, cognitive impairment
(Zanuso et al., 2012)	F/M, 10/10, ≥ 65	12 weeks	Isotonic resistance training programme, 1 h session three times a week/ RCT	Anxiety, mood state profile
(Zheng et al., 2020)	F/M, 257/62, ≥ 65	6 weeks	Playing alone; playing with peers; playing with youths A set of exergames, each being played for 5–10 min twice a week/ RCT	Attitude toward exergames, sociability, positive and negative affect.

Note: N= Number of participants; QE= Quasi-experimental; RCT= Randomized controlled trial.

DISCUSSION

This systematic review aimed to summarize those studies of healthy older adults aged 60 and over with or without a physical exercise intervention programme where the main outcomes investigated have been related to physical, cognitive and/or emotional performance. We found 69 suitable studies fitting the pre-established inclusion criteria.

These outcomes were, mainly, related to physical performance (Chutimakul et al., 2018; Douka et al., 2019), although emotional and cognitive outcomes were also studied, isolated (Coubard et al., 2011; Kim et al., 2019) or combined (Pereira et al., 2014) with the physical ones. This combination of physical, cognitive and emotional outcomes was observed in 14 (20%) out of the 69 chosen studies, where six of those 14 papers were published in 2019 (Batmyagmar et al., 2019; Bouaziz et al., 2019; Gothe et al., 2019; Imaoka et al., 2019; Vaccaro et al., 2019; Vrinceanu et al., 2019). According to this, it is conceivable that there is a current tendency of studying these combinations of physical, cognitive and emotional outcomes together with older adults. It is also interesting how technology is used for improving those outcomes through exergames (Carrasco et al, 2020; Zheng et al., 2020).

Hogan et al. (2013) suggested important benefits in older adults for both affective and cognitive performance after a single bout of moderate exercise, whereas Tarazona-Santabalbina et al. (2016) published the physical, cognitive, emotional and social effects of a multicomponent exercise intervention in frail older adults. In reference to reviews and meta-analysis publications, there is considerable published research focused on the effects of physical exercise on cognition in healthy (Carvalho et al., 2014; Gomes-Osman et al., 2018; Zhu et al., 2016) and unhealthy (Karssemeijer et al., 2017, Öhman et al., 2014) older adults.

Investigating cognitive or emotional outcomes, apart from physical outcomes, during physical exercise interventions may contribute to establish more connections between body, brain and emotions to the benefit of science and particularly to older adults. According to the 54 accepted papers in this systematic review in which there was a physical exercise intervention, in 26 of them (48%), the number of physical exercise min per week was 150 or more. If we compare these results and current guidelines of physical exercise for older adults (Chodzko-Zajko et al., 2009; Nelson et al., 2007; Powell et al., 2019), we could suggest that a considerable number of selected papers did not contribute to the minimum of weekly min, which these guidelines established to achieve benefits in physical health: 150 min of moderate intensity exercise or 75 min of vigorous exercise. According to this, an intervention that does not follow these recommendations could not be successful for practitioners. Thus, this result may insinuate that, in the future, physical exercise interventions should follow current recommendations for weekly min in order to obtain greater benefits to health. In the overall analysis, the results found in this systematic review may prove that physical exercise interventions in healthy older adults have been increasing during recent years. An update on these interventions could provide useful information, such as the length, type of exercise or the effects produced by itself, to those professionals who are in daily contact with older adults.

We considered it appropriate to focus this systematic review in healthy older adults in order to establish differences with the unhealthy older adults. However, there are also published reviews (Coelho et al., 2013; van Uffelen et al., 2008), which include both healthy and unhealthy older adults in the same paper. In that case, data or results from those papers should be carefully observed, taking into account possible differences and conclusions to come to.

The sample of studies included in this systematic review was located in two databases, ISI Web of Knowledge and Scopus-Elsevier. We acknowledge that by limiting the search to a couple of databases, we could not capture all possible information. It would be interesting to expand the search to other databases with the purpose of giving access to more information to interested populations. Moreover, of all the included papers, none followed a qualitative methodology, which could also contribute to providing more information in this area.

CONCLUSIONS

The results of the present paper suggest there were a remarkable number of research articles and systematic reviews about this topic, which has been increasing during recent years. This increment shows how current and important it is to investigate the way physical exercise is being practiced in healthy older adults and the connection it has with cognition and emotions. Moreover, the present systematic review is supported on previous systematic reviews where the impact of physical exercise on the cognitive functioning of healthy and symptomatic older adults is more than an undeniable fact. These studies show a large methodological heterogeneity in intervention characteristics (e.g., number of participants, length of the intervention or type of exercise). The current systematic review illustrates how physical, cognitive and emotional outcomes could be, or not be, simultaneously investigated following a specific physical exercise intervention or under no intervention but being focused on active older adults who regularly exercise. However, the results of these investigations are not included in this paper. Future research should also focus on results in order to provide useful information about the effects of these kinds of studies.

AUTHOR CONTRIBUTIONS

All authors were involved in the conception and design of the systematic review. Miguel Ángel Araque-Martínez generated and conducted the search. Eva María Artes-Rodríguez and Pedro Jesús Ruiz-Montero were involved in the data collection, extraction and synthesis. Antonio Jesús Casimiro-Andújar revised the manuscript critically for important intellectual content. All authors contributed to the writing of the paper, read and approved the final manuscript.

REFERENCES

Afonso, R. F., Balardin, J. B., Lazar, S., Sato, J. R., Igarashi, N., Santaella, D. F., … Kozasa, E. H. (2017). Greater cortical thickness in elderly female yoga practitioners-A cross-sectional study. Front Aging Neurosci, 9. https://doi.org/10.3389/fnagi.2017.00201

Alghadir, A.H., Gabr, S. A., & Al-Eisa, E. S. (2016). Effects of moderate aerobic exercise on cognitive abilities and redox state biomarkers in older adults. Oxid Med Cell Longev, 2016. https://doi.org/10.1155/2016/2545168

Alghadir, A. H., & Gabr, S. A. (2020). Hormonal function responses to moderate aerobic exercise in older adults with depression. Clin Interv Aging, 15, 1271-1283. https://doi.org/10.2147/CIA.S259422

Anderson-Hanley, C., Snyder, A. L., Nimon, J. P., & Arciero, P. J. (2011). Social facilitation in virtual reality-enhanced exercise: Competitiveness moderates exercise effort of older adults. Clin Interv Aging, 6(1), 275-280. https://doi.org/10.2147/cia.s25337

Antunes, H. K. M., Santos-Galduroz, R. F., De Aquino Lemos, V., Bueno, O. F. A., Rzezak, P., de Santana, M. G., & De Mello, M. T. (2015). The influence of physical exercise and leisure activity on neuropsychological functioning in older adults. Age, 37(4). https://doi.org/10.1007/s11357-015-9815-8

Ates Bulut, E., Soysal, P., Yavuz, I., Kocyigit, S. E., & Isik, A. T. (2019). Effect of Vitamin D on Cognitive Functions in Older Adults: 24-Week Follow-Up Study. Am J Alzheimers Dis, 34(2), 112-117. https://doi.org/10.1177/1533317518822274

Azizan, A., & Justine, M. (2016). Effects of a behavioral and exercise program on depression and quality of life in community-dwelling older adults. J Gerontol Nurs, 42(2), 45-54. https://doi.org/10.3928/00989134-20151124-01

Batmyagmar, D., Kundi, M., Ponocny-Seliger, E., Lukas, I., Lehrner, J., Haslacher, H., & Winker, R. (2019). High intensity endurance training is associated with better quality of life, but not with improved cognitive functions in elderly marathon runners. Sci Rep-UK, 9(1). https://doi.org/10.1038/s41598-019-41010-w

Blankevoort, C. G., Van Heuvelen, M. J. G., Boersma, F., Luning, H., De Jong, J., & Scherder, E. J. A. (2010). Review of effects of physical activity on strength, balance, mobility and ADL performance in elderly subjects with dementia. Dementia Geriatr Cogn, 30(5), 392-402. https://doi.org/10.1159/000321357

Bouaziz, W., Schmitt, E., Vogel, T., Lefebvre, F., Leprêtre, P.-M., Kaltenbach, G., … Lang, P.-O. (2019). Effects of a short-term Interval Aerobic Training Programme with active Recovery bouts (IATP-R) on cognitive and mental health, functional performance and quality of life: A randomised controlled trial in sedentary seniors. Int J Clin Pract, 73(1). https://doi.org/10.1111/ijcp.13219

Brady, S., D'Ambrosio, L. A., Felts, A., Rula, E. Y., Kell, K. P., & Coughlin, J. F. (2020). Reducing Isolation and Loneliness Through Membership in a Fitness Program for Older Adults: Implications for Health. J Appl Gerontol, 39(3), 301-310. https://doi.org/10.1177/0733464818807820

Brown, A. K., Liu-Ambrose, T., Tate, R., & Lord, S. R. (2009). The effect of group-based exercise on cognitive performance and mood in seniors residing in intermediate care and self-care retirement facilities: a randomised controlled trial. Brit J Sport Med, 43(8), 608-614. https://doi.org/10.1136/bjsm.2008.04988

Carrasco, M., Ortiz-Maqués, N., & Martínez-Rodríguez, S. (2020). Playing with Nintendo Wii Sports: Impact on Physical Activity, Perceived Health and Cognitive Functioning of a Group of Community-Dwelling Older Adults. Activities, Adaptation and Aging, 44(2), 119-131. https://doi.org/10.1080/01924788.2019.1595261

Carstensen, L. L., & Mikels, J. A. (2005). At the intersection of emotion and cognition - Aging and the positivity effect. Curr Dir Psychol Sci, 14(3), 117-121. https://doi.org/10.1111/j.0963-7214.2005.00348.x

Carvalho, A., Rea, I. M., Parimon, T., & Cusack, B. J. (2014). Physical activity and cognitive function in individuals over 60 years of age: A systematic review. Clin Interv Aging, 9, 661-682. https://doi.org/10.2147/CIA.S55520

Cassilhas, R. C., Antunes, H. K. M., Tufik, S., & de Mello, M. T. (2010). Mood, anxiety, and serum IGF-1 in elderly men given 24 weeks of high resistance exercise. Percept Motor Skill, 110(1), 265-276. https://doi.org/10.2466/PMS.110.1.265-276

Cassilhas, R. C., Viana, V. A. R., Grassmann, V., Santos, R. T., Santos, R. F., Tufik, S., & Mello, M. T. (2007). The impact of resistance exercise on the cognitive function of the elderly. Med Sci Sport Exer, 39(8), 1401-1407. https://doi.org/10.1249/mss.0b013e318060111f

Čekanauskaitė, A., Skurvydas, A., Žlibinaitė, L., Mickevičienė, D., Kilikevičienė, S., & Solianik, R. (2020). A 10-week yoga practice has no effect on cognition, but improves balance and motor learning by attenuating brain-derived neurotrophic factor levels in older adults. Exp Gerontol, 138. https://doi.org/10.1016/j.exger.2020.110998

Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. A., Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S. (2009). Exercise and physical activity for older adults. Med Sci Sport Exer. https://doi.org/10.1249/MSS.0b013e3181a0c95c

Chutimakul, L., Sukonthasab, S., Kritpet, T., & Vannalee, C. (2018). Effect of modified Khon dance performance on functional fitness in older Thai persons. Journal of Health Research, 32(6), 432-439. https://doi.org/10.1108/JHR-05-2018-0009

Coelho, F. G. D. M., Gobbi, S., Andreatto, C. A. A., Corazza, D. I., Pedroso, R. V., & Santos-Galduróz, R. F. (2013). Physical exercise modulates peripheral levels of brain-derived neurotrophic factor

(BDNF): A systematic review of experimental studies in the elderly. Arch Gerontol Geriat, 56(1), 10-15. https://doi.org/10.1016/j.archger.2012.06.003

Coetsee, C., & Terblanche, E. (2017). The effect of three different exercise training modalities on cognitive and physical function in a healthy older population. Eur Rev Aging Phys A, 14. https://doi.org/10.1186/s11556-017-0183-5

Coubard, O. A., Duretz, S., Lefebvre, V., Lapalus, P., & Ferrufino, L. (2011). Practice of contemporary dance improves cognitive flexibility in aging. Front Aging Neurosci, 3, 1-12. https://doi.org/10.3389/fnagi.2011.00013

Cruz-Ferreira, A., Marmeleira, J., Formigo, A., Gomes, D., & Fernandes, J. (2015). Creative dance improves physical fitness and life satisfaction in older women. Res Aging, 37(8), 837-855. https://doi.org/10.1177/0164027514568103

de Oliveira, L. S. S. C. B., Souza, E. C., Rodrigues, R. A. S., Fett, C. A., & Piva, A. B. (2019). The effects of physical activity on anxiety, depression, and quality of life in elderly people living in the community. Trends in Psychiatry and Psychotherapy, 41(1), 36-42. https://doi.org/10.1590/2237-6089-2017-0129

Douka, S., Zilidou, V. I., Lilou, O., & Manou, V. (2019). Traditional dance improves the physical fitness and well-being of the elderly. Front Aging Neurosci, 11. https://doi.org/10.3389/fnagi.2019.00075

Dupuy, O., Bosquet, L., Fraser, S. A., Labelle, V., & Bherer, L. (2018). Higher cardiovascular fitness level is associated to better cognitive dual-task performance in Master Athletes: Mediation by cardiac autonomic control. Brain Cognition, 125, 127-134. https://doi.org/10.1016/j.bandc.2018.06.003

Eckardt, N., Braun, C., & Kibele, A. (2020). Instability resistance training improves working memory, processing speed and response inhibition in healthy older adults: a double-blinded randomised controlled trial. Sci Rep-UK, 10(1). https://doi.org/10.1038/s41598-020-59105-0

Ericson, H., Skoog, T., Johansson, M., & Wåhlin-Larsson, B. (2018). Resistance training is linked to heightened positive motivational state and lower negative affect among healthy women aged 65-70. J Women Aging, 30(5), 366-381. https://doi.org/10.1080/08952841.2017.1301720

Filar-Mierzwa, K., Długosz, M., Marchewka, A., Dąbrowski, Z., & Poznańska, A. (2017). The effect of dance therapy on the balance of women over 60 years of age: The influence of dance therapy for the elderly. J Women Aging, 29(4), 348-355. https://doi.org/10.1080/08952841.2016.1194689

Fleg, J. L., Morrell, C. H., Bos, A. G., Brant, L. J., Talbot, L. A., Wright, J. G., & Lakatta, E. G. (2005). Accelerated longitudinal decline of aerobic capacity in healthy older adults. Circulation, 112(5), 674-682. https://doi.org/10.1161/CIRCULATIONAHA.105.545459

Flegal, K. E., Kishiyama, S., Zajdel, D., Haas, M., & Oken, B. S. (2007). Adherence to Yoga and exercise interventions in a 6-month clinical trial. BMC Complem Altern M, 7. https://doi.org/10.1186/1472-6882-7-37

Flodin, P., Jonasson, L. S., Riklund, K., Nyberg, L., & Boraxbekk, C. J. (2017). Does aerobic exercise influence intrinsic brain activity? An aerobic exercise intervention among healthy old adults. Front Aging Neurosci, 9. https://doi.org/10.3389/fnagi.2017.00267

Fox, K. R., Stathi, A., McKenna, J., & Davis, M. G. (2007). Physical activity and mental well-being in older people participating in the Better Ageing Project. Eur J Appl Physiol, 100(5), 591-602. https://doi.org/10.1007/s00421-007-0392-0

Geirsdottir, O. G., Arnarson, A., Ramel, A., Briem, K., Jonson, P. V, & Thorsdotir, I. (2015). Muscular strength and physical function in elderly adults 6-18 months after a 12-week resistance exercise program. Scand J Public Healt, 43(1), 76-82. https://doi.org/10.1177/1403494814560842

Gomes-Osman, J., Cabral, D. F., Morris, T. P., McInerney, K., Cahalin, L. P., Rundek, T., … Pascual-Leone, A. (2018). Exercise for cognitive brain health in aging: A systematic review for an evaluation of dose. Neurology: Clinical Practice, 8(3), 257-265. https://doi.org/10.1212/CPJ.0000000000000460

González-Palau, F., Franco, M., Bamidis, P., Losada, R., Parra, E., Papageorgiou, S. G., & Vivas, A. B. (2014). The effects of a computer-based cognitive and physical training program in a healthy and mildly cognitive impaired aging sample. Aging Ment Health, 18(7), 838-846. https://doi.org/10.1080/13607863.2014.899972

Gothe, N. P., Ehlers, D. K., Salerno, E. A., Fanning, J., Kramer, A. F., & McAuley, E. (2019). Physical Activity, Sleep and Quality of Life in Older Adults: Influence of Physical, Mental and Social Well-being. Behav Sleep Med, 18(6), 797-808. https://doi.org/10.1080/15402002.2019.1690493

Haraldstad, K., Rohde, G., Stea, T. H., Lohne-Seiler, H., Hetlelid, K., Paulsen, G., & Berntsen, S. (2017). Changes in health-related quality of life in elderly men after 12 weeks of strength training. Eur Rev Aging Phys A, 14(1). https://doi.org/10.1186/s11556-017-0177-3

Hardman, R. J., Meyer, D., Kennedy, G., MacPherson, H., Scholey, A. B., & Pipingas, A. (2020). Findings of a Pilot Study Investigating the Effects of Mediterranean Diet and Aerobic Exercise on Cognition in Cognitively Healthy Older People Living Independently within Aged-Care Facilities: The Lifestyle Intervention in Independent Living Aged Care (LIILAC) Study. Current Developments in Nutrition, 4(5), 1-10. https://doi.org/10.1093/cdn/nzaa077

Hars, M., Herrmann, F. R., Gold, G., Rizzoli, R., & Trombetti, A. (2014). Effect of music-based multitask training on cognition and mood in older adults. Age Ageing, 43(2), 196-200. https://doi.org/10.1093/ageing/aft163

Haslacher, H., Perkmann, T., Lukas, I., Barth, A., Ponocny-Seliger, E., Michlmayr, M., … Winker, R. (2012). Myeloperoxidase levels predict executive function. Int J Sports Med, 33(12), 1034-1038. https://doi.org/10.1055/s-0032-1304637

Haslacher, H., Michlmayr, M., Batmyagmar, D., Perkmann, T., Ponocny-Seliger, E., Scheichenberger, V., … Winker, R. (2015a). rs6295 [C]-allele protects against depressive mood in elderly endurance athletes. J Sport Exercise Psy, 37(6), 637-645. https://doi.org/10.1123/jsep.2015-0111

Haslacher, H., Michlmayr, M., Batmyagmar, D., Perkmann, T., Ponocny-Seliger, E., Scheichenberger, V., … Winker, R. (2015b). Physical exercise counteracts genetic susceptibility to depression. Neuropsychobiology, 71(3), 168-175. https://doi.org/10.1159/000381350

Haslacher, H., Nistler, S., Batmyagmar, D., Ponocny-Seliger, E., Perkmann, T., Scherzer, T. M., … Winker, R. (2016). Low vitamin D levels do not predict hyperglycemia in elderly endurance athletes (but in controls). Plos One, 11(6), e0157695. https://doi.org/10.1371/journal.pone.0157695

Haslacher, H., Ratzinger, F., Perkmann, T., Batmyagmar, D., Nistler, S., Scherzer, T. M., … Winker, R. (2017). A combination of routine blood analytes predicts fitness decrement in elderly endurance athletes. Plos One, 12(5). https://doi.org/10.1371/journal.pone.0177174

Hogan, C. L., Mata, J., & Carstensen, L. L. (2013). Exercise Holds Immediate Benefits for Affect and Cognition in Younger and Older Adults. Psychol Aging, 28(2), 587-594. https://doi.org/10.1037/a0032634

Hunter, G. R., Bickel, C. S., Fisher, G., Neumeier, W. H., & McCarthy, J. P. (2013). Combined aerobic and strength training and energy expenditure in older women. Med Sci Sport Exer, 45(7), 1386-1393. https://doi.org/10.1249/MSS.0b013e3182860099

Imaoka, M., Nakao, H., Nakamura, M., Tazaki, F., Maebuchi, M., Ibuki, M., & Takeda, M. (2019). Effect of multicomponent exercise and nutrition support on the cognitive function of older adults: A randomized controlled trial. Clin Interv Aging, 14, 2145-2153. https://doi.org/10.2147/CIA.S229034

Joung, H. J., & Lee, Y. (2019). Effect of Creative Dance on Fitness, Functional Balance, and Mobility Control in the Elderly. Gerontology, 65(5), 537-546. https://doi.org/10.1159/000499402

Kang, D.-W., Bressel, E., & Kim, D.-Y. (2020). Effects of aquatic exercise on insulin-like growth factor-1, brain-derived neurotrophic factor, vascular endothelial growth factor, and cognitive function in elderly women. Exp Gerontol, 132. https://doi.org/10.1016/j.exger.2020.110842

Karssemeijer, E. G. A. E., Aaronson, J. A. J., Bossers, W. J. W., Smits, T. T., Olde Rikkert, M. G. M. M., & Kessels, R. P. C. R. (2017). Positive effects of combined cognitive and physical exercise training on cognitive function in older adults with mild cognitive impairment or dementia: A meta-analysis. Ageing Res Rev, 40, 75-83. https://doi.org/10.1016/j.arr.2017.09.003

Khazaee-pool, M., Sadeghi, R., Majlessi, F., & Rahimi Foroushani, A. (2015). Effects of physical exercise programme on happiness among older people. J Psychiatr Ment Hlt, 22(1), 47-57. https://doi.org/10.1111/jpm.12168

Kim, Y.-S., O'Sullivan, D. M., & Shin, S.-K. (2019). Can 24 weeks strength training reduce feelings of depression and increase neurotransmitter in elderly females? Exp Gerontol, 115, 62-68. https://doi.org/10.1016/j.exger.2018.11.009

Laredo-Aguilera, J. A., Carmona-Torres, J. M., García-Pinillos, F., & Latorre-Román, P. Á. (2018). Effects of a 10-week functional training programme on pain, mood state, depression, and sleep in healthy older adults. Psychogeriatrics, 18(4), 292-298. https://doi.org/10.1111/psyg.12323

Lavretsky, H., Alstein, L. L., Olmstead, R. E., Ercoli, L. M., Riparetti-Brown, M., Cyr, N. S., & Irwin, M. R. (2011). Complementary use of Tai Chi Chih augments escitalopram treatment of geriatric depression: A randomized controlled trial. Am J Geriat Psychiat, 19(10), 839-850. https://doi.org/10.1097/JGP.0b013e31820ee9ef

Lee, P.-L., Yang, Y.-C., Huang, C.-K., Hsiao, C.-H., Liu, T.-Y., & Wang, C.-Y. (2017). Effect of exercise on depressive symptoms and body balance in the elderly. Educ Gerontol, 43(1), 33-44. https://doi.org/10.1080/03601277.2016.1260905

Lindahl, E., Tilton, K., Eickholt, N., & Ferguson-Stegall, L. (2016). Yoga reduces perceived stress and exhaustion levels in healthy elderly individuals. Complement Ther Clin, 24, 50-56. https://doi.org/10.1016/j.ctcp.2016.05.007

Liu, S., Li, L., Liu, Z., & Guo, X. (2019). Long-term Tai Chi experience promotes emotional stability and slows gray matter atrophy for elders. Front Psychol, 10. https://doi.org/10.3389/fpsyg.2019.00091

Machacova, K., Vankova, H., Volicer, L., Veleta, P., & Holmerova, I. (2017). Dance as prevention of late life functional decline among nursing home residents. J Appl Gerontol, 36(12), 1453-1470. https://doi.org/10.1177/0733464815602111

Malbut, K. E., Dinan, S., & Young, A. (2002). Aerobic training in the 'oldest old': the effect of 24 weeks of training. Age Ageing, 31(4), 255-260. https://doi.org/10.1093/ageing/31.4.255

Martins, R. A., Coelho E Silva, M. J., Pindus, D. M., Cumming, S. P., Teixeira, A. M., & Veríssimo, M. T. (2011). Effects of strength and aerobic-based training on functional fitness, mood and the relationship between fatness and mood in older adults. J Sport Med Phys Fit, 51(3), 489-496.

Mason, J. R., Tenenbaum, G., Jaime, S., Roque, N., Maharaj, A., & Figueroa, A. (2020). Arterial stiffness and cardiorespiratory fitness are associated with cognitive function in older adults. Behav Med, 1-12. https://doi.org/10.1080/08964289.2020.1825921

Matsouka, O., Kabitsis, C., Harahousou, Y., & Trigonis, I. (2005). Mood alterations following an indoor and outdoor exercise program in healthy elderly women. Percept Motor Skill, 100(3), 707-715. https://doi.org/10.2466/PMS.100.3.707-715

Matsouka, O., Bebetsos, E., Trigonis, I., & Simakis, S. (2010). The effects of an outdoor exercise program on mood states among the elderly. World Leisure Journal, 52(1), 34-40. https://doi.org/10.1080/04419057.2010.9674620

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., … Castaneda-Sceppa, C. (2007). Physical Activity and Public Health in Older Adults: Recommendation from the

American College of Sports Medicine and the American Heart Association. Med Sci Sport Exer, 39(8), 1435-1445. https://doi.org/10.1249/mss.0b013e3180616aa2

Noopud, P., Suputtitada, A., Khongprasert, S., & Kanungsukkasem, V. (2019). Effects of Thai traditional dance on balance performance in daily life among older women. Aging Clin Exp Res, 31(7), 961-967. https://doi.org/10.1007/s40520-018-1040-8

Öhman, H., Savikko, N., Strandberg, T. E., & Pitkälä, K. H. (2014). Effect of physical exercise on cognitive performance in older adults with mild cognitive impairment or dementia: A systematic review. Dement Geriatr Cogn, 38, 347-365. https://doi.org/10.1159/000365388

Oken, B. S., Zajdel, D., Kishiyama, S., Flegal, K., Dehen, C., Haas, M., … Leyva, J. (2006). Randomized, controlled, six-month trial of yoga in healthy seniors: effects on cognition and quality of life. Altern Ther Health M, 12(1), 40-47.

Pandya, S. P. (2020). Yoga Education Program for Improving Memory in Older Adults: A Multicity 5-Year Follow-Up Study. J Appl Gerontol, 39(6), 576-587. https://doi.org/10.1177/0733464818794153

Pereira, J. R., Gobbi, S., Teixeira, C. V. L., Nascimento, C. M. C., Corazza, D. I., Vital, T. M., … Shigematsu, R. (2014). Effects of Square-Stepping Exercise on balance and depressive symptoms in older adults. Motriz. Revista de Educacao Fisica, 20(4), 454-460. https://doi.org/10.1590/S1980-65742014000400013

Peters, R. (2006). Ageing and the brain. Postgrad Med J, 82(964), 84-88. https://doi.org/10.1136/pgmj.2005.036665

Powell, K. E., King, A. C., Buchner, D. M., Campbell, W. W., DiPietro, L., Erickson, K. I., … Whitt-Glover, M. C. (2019). The Scientific Foundation for the Physical Activity Guidelines for Americans, 2nd Edition. J Phys Act Health, 16(1), 1-11. https://doi.org/10.1123/jpah.2018-0618

Rios Romenets, S., Anang, J., Fereshtehnejad, S.-M., Pelletier, A., & Postuma, R. (2015). Tango for treatment of motor and non-motor manifestations in Parkinson's disease: A randomized control study. Complement Ther Med, 23(2), 175-184. https://doi.org/10.1016/j.ctim.2015.01.015

Rosanti, S., da Silva, G. E., & dos Santos, F. H. (2014). Longitudinal effects of physical activity on self-efficacy and cognitive processing of active and sedentary elderly women. Dementia e Neuropsychologia, 8(2), 187-193. https://doi.org/10.1590/S1980-57642014DN82000016

Ruiz-Montero, P. J., Ramiro, M. T., Sánchez, T. R., & Marmol, E. G. (2020). Pilates-Aerobic exercise program's effects in physical fitness level and quality of life related to physical and mental health in elderly women. Psychology, Society and Education, 12(2), 91-105. https://doi.org/10.25115/psye.v10i1.2894

Salazar, M. C. R., Báez, A. L. M., Gallego, E. A. Q., & Granada, L. M. R. (2017). Hatha yoga effects on Alzheimer patients (AP). Acta Colombiana de Psicologia, 20(1), 139-153. https://doi.org/10.14718/ACP.2017.20.1.7

Secher, N. H., Seifert, T., & Van Lieshout, J. J. (2008). Cerebral blood flow and metabolism during exercise: Implications for fatigue. J Appl Physiol, 104(1), 306-314. https://doi.org/10.1152/japplphysiol.00853.2007

Serra, M. M., Alonso, A. C., Peterson, M., Mochizuki, L., Greve, J. M. D., & Garcez-Leme, L. E. (2016). Balance and muscle strength in elderly women who dance samba. Plos One, 11(12). https://doi.org/10.1371/journal.pone.0166105

Solberg, P. A., Hopkins, W. G., Ommundsen, Y., & Halvari, H. (2012). Effects of three training types on vitality among older adults: A self-determination theory perspective. Psychol Sport Exerc, 13(4), 407-417. https://doi.org/10.1016/j.psychsport.2012.01.006

Solberg, P. A., Kvamme, N. H., Raastad, T., Ommundsen, Y., Tomten, S. E., Halvari, H., … Hallén, J. (2013a). Effects of different types of exercise on muscle mass, strength, function and well-being in elderly. Eur J Sport Sci, 13(1), 112-125. https://doi.org/10.1080/17461391.2011.617391

Solberg, P. A., Halvari, H., & Ommundsen, Y. (2013b). Linking exercise and causality orientations to change in well-being among older adults: Does change in motivational variables play a role? J Appl Soc Psychol, 43(6), 1259-1272. https://doi.org/10.1111/jasp.12088

Starkweather, A. R. (2007). The effects of exercise on perceived stress and IL-6 levels among older adults. Biol Res Nurs, 8(3), 186-194. https://doi.org/10.1177/1099800406295990

Stone, R. C., Rakhamilova, Z., Gage, W. H., & Baker, J. (2018). Curling for confidence: Psychophysical benefits of curling for older adults. J Aging Phys Activ, 26(2), 267-275. https://doi.org/10.1123/japa.2016-0279

Szentes, N., Tékus, V., Mohos, V., Borbély, É., & Helyes, Z. (2019). Exploratory and locomotor activity, learning and memory functions in somatostatin receptor subtype 4 gene-deficient mice in relation to aging and sex. GeroScience, 41(5), 631-641. https://doi.org/10.1007/s11357-019-00059-1

Tada, A. (2018). Psychological effects of exercise on community-dwelling older adults. Clin Interv Aging, 13, 271-276. https://doi.org/10.2147/CIA.S152939

Tarazona-Santabalbina, F. J., Gómez-Cabrera, M. C., Pérez-Ros, P., Martínez-Arnau, F. M., Cabo, H., Tsaparas, K., … Viña, J. (2016). A Multicomponent Exercise Intervention that Reverses Frailty and Improves Cognition, Emotion, and Social Networking in the Community-Dwelling Frail Elderly: A Randomized Clinical Trial. J Am Med Dir Assoc, 17(5), 426-433. https://doi.org/10.1016/j.jamda.2016.01.019

Tsai, C.L., Wang, C.H., Pan, C.Y., & Chen, F.C. (2015). The effects of long-term resistance exercise on the relationship between neurocognitive performance and GH, IGF-1, and homocysteine levels in the elderly. Front Behav Neurosci, 9. https://doi.org/10.3389/fnbeh.2015.00023

United Nations (2020). World Population Ageing 2019. Department of Economic and Social Affairs. https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Report.pdf

Urrútia, G., & Bonfill, X. (2010). PRISMA declaration: A proposal to improve the publication of systematic reviews and meta-analyses. Med Clin-Barcelona, 135(11), 507-511. https://doi.org/10.1016/j.medcli.2010.01.015

Vaccaro, M. G., Izzo, G., Ilacqua, A., Migliaccio, S., Baldari, C., Guidetti, L., … Emerenziani, G. Pietro. (2019). Characterization of the Effects of a Six-Month Dancing as Approach for Successful Aging. Int J Endocrinol, 2019. https://doi.org/10.1155/2019/2048391

van Uffelen, J. G. Z., Paw, M. J. M. C. A., Hopman-Rock, M., & van Mechelen, W. (2008). The Effects of Exercise on Cognition in Older Adults With and Without Cognitive Decline: A Systematic Review. Clin J Sport Med, 18(6), 486-500. https://doi.org/10.1097/JSM.0b013e3181845f0b

Vaughan, S., Wallis, M., Polit, D., Steele, M., Shum, D., & Morris, N. (2014). The effects of multimodal exercise on cognitive and physical functioning and brain-derived neurotrophic factor in older women: a randomised controlled trial. Age Ageing, 43(5), 623-629. https://doi.org/10.1093/ageing/afu010

Vogel, T., Brechat, P.-H., Lepretre, P.-M., Kaltenbach, G., Berthel, M., & Lonsdorfer, J. (2009). Health benefits of physical activity in older patients: a review. Int J Clin Pract, 63(2), 303-320. https://doi.org/10.1111/j.1742-1241.2008.01957.x

Vrinceanu, T., Esmail, A., Berryman, N., Predovan, D., Vu, T. T. M., Villalpando, J. M., … Bherer, L. (2019). Dance your stress away: comparing the effect of dance/movement training to aerobic exercise training on the cortisol awakening response in healthy older adults. Ann Ny Acad Sci, 22(6), 687-695. https://doi.org/10.1080/10253890.2019.1617690

Yuan, J., Zhang, Z., Wen, H., Hong, X., Hong, Z., Qu, Q., … Cummings, J. L. (2016). Incidence of dementia and subtypes: A cohort study in four regions in China. Alzheimers Dement, 12(3), 262-271. https://doi.org/10.1016/j.jalz.2015.02.011

Zafar, M., Bozzorg, A., & Hackney, M. E. (2017). Adapted Tango improves aspects of participation in older adults versus individuals with Parkinson's disease. Disabil Rehabil, 39(22), 2294-2301. https://doi.org/10.1080/09638288.2016.1226405

Zanuso, S., Sieverdes, J. C., Smith, N., Carraro, A., & Bergamin, M. (2012). The effect of a strength training program on affect, mood, anxiety, and strength performance in older individuals. Int J Sport Psychol, 43(1), 53-66.

Zheng, H., Li, J., Salmon, C. T., & Theng, Y.-L. (2020). The effects of exergames on emotional well-being of older adults. Comput Hum Behav, 110. https://doi.org/10.1016/j.chb.2020.106383

Zhu, X., Yin, S., Lang, M., He, R., & Li, J. (2016). The more the better? A meta-analysis on effects of combined cognitive and physical intervention on cognition in healthy older adults. Ageing Res Rev, 31, 67-79. https://doi.org/10.1016/j.arr.2016.07.003