

# Effectiveness of exercise interventions in older people with dementia in terms of functionality and reducing falls: a systematic review

Aikaterini Iliana Katsioni, & Konstantinos Argyropoulos

Postgraduate Program "Aging and Chronic Diseases Management", Joint degree, School of Medicine, University of Thessaly & Hellenic Open University, Greece

## Abstract

**Background:** Dementia is a common mental health problem affecting older people with prevalence ranging from 5 to 8% worldwide. Given the gradual progression of the disease, patients' functional capacity is significantly affected, leading to reduced mobility and increased falls.

**Material and Methods:** A systematic review was conducted of randomized control trials published in electronic journals reporting the effectiveness of different exercise programs in patients with dementia. The electronic data bases PubMed, Trip Medical Database and Google Scholar were used.

**Results:** We analysed 21 trials with a total number of 2,120 participants. Nineteen of them showed improvement in functionality, while only 2 did not report any changes. Almost half of the surveys (12 out of 21) found a positive correlation between exercise programs and reducing falls, while in 4 articles the authors did not notice any improvement, in 2 trials reported that exercise is likely to reduce the number of falls, and 3 found a positive correlation of exercise as a way to prevent falls in patients with dementia. The intensity of the exercise programs ranged from moderate to high and their duration from 3 to 12 months. The most common types of exercises included in the programs were balance and strengthening exercises, as well as functional training.

**Conclusions:** In conclusion, the analysis of the above studies highlights exercise as a beneficial intervention for older people with dementia, in order to improve their functionality and prevent falls. Therefore, further research is needed in order to find the most beneficial types of exercise for dementia patients.

## Keywords:

Dementia, elderly, exercise, functionality, falls, prevention, systematic review

## 1. Introduction

Dementia is a global health problem with significant effects on both society and economy. The prevalence of dementia worldwide ranges from 5-8% for people over 60 years old, while exponential growth has been observed with increasing age. Specifically, it is reported that the percentages increase significantly every 5 years of aging, with the numbers reaching 22.5% for people of 85 years old and over. In 2015 there were 47 million people diagnosed with dementia worldwide and it is projected to double every 20 years. The number of patients is expected to reach 75 million by 2030 and 130 million by 2050. Regarding the global cost of treating dementia, the expenses reached 818 billion in 2015 and are expected to increase by 35% every five years [1-3].

Given the gradual progression of the disease, patients' functional capacity is significantly affected, making them incapacitated and dependent on their relatives and caregivers. Physical functioning is defined as the ability to perform activities needed in daily life, while functional limitations are referring to the difficulties an individual may have to deal in order to complete them. Deficits in instrumental daily activities such as walking and maintaining postural balance control lead to reduced mobility and increased falls. A fall is defined as the unexpected event in which a person comes to rest on the ground or at a lower level than their starting point [4,5].

According to research, older people with dementia have a higher risk of falls and related injuries compared to their "healthy" peers [6,7]. To be more precise, dementia patients are 2 to 8 times more likely to experience a fall. Also, it is reported that 47% of people with Alzheimer disease have at least one fall per year [5,8]. The risk of serious injuries associated with falls, such as hip fractures, increases significantly in dementia patients. In addition, people with dementia and a history of falls are 5 times more likely to be transferred to geriatric institutions [9].

The aetiology of these increased falls includes a variety of factors, which even today are not fully understood by health professionals. These include age, impaired mobility, muscle weakness, balance disorders, visual disturbances, low bone

density, gait disorders, reduced functional capacity, use of multiple medications and a history of falls. The presence of many of the above is more frequent and more severe in people with dementia, increasing suffering of this patient population [5,9]. Additional factors associated with dementia include cognitive and functional impairment, behavioural disorders, psychological problems and neuroleptic symptoms [5,6].

For the reasons mentioned above, the identification of interventions that focus on improving patient functionality are vital. Exercise has repeatedly been proved to have substantially positive effects on cardiovascular function, functional capacity, postural balance, cognitive function and the psychological state of the elderly in general [10]. The literature on the effects of exercise on patients with dementia is limited but nevertheless sufficient to understand its important role. Only a few studies have investigated the effectiveness of exercise in older people with dementia, as these patients are often removed or excluded from them. The benefits of group or individual training with different types of exercises and characteristics (e.g., intensity, duration) for dementia patients have been researched more intensively in the last two decades. Due to their cognitive and functional impairment, creating a safe and effective exercise program is a challenge for therapists. Thus, this systematic review aims to investigate whether trials have shown the efficacy of exercise training in the physical functioning and the falling rates in this population.

## 2. Material and Methods

### 2.1. Objectives

In this study we examined experimental studies that have tried to interpret the effect of physical exercise on the functionality of older people with dementia. A variety of factors were considered such as balance, muscle strength, gait characteristics, mobility and coordination, in an attempt to clarify the effectiveness or not of training in the prevention of falls in this population. Exercise programs were categorized in terms of duration, intensity and the type of exercise.

## 2.2. Search strategy

For the purposes of this review, we searched PubMed, Trip Medical Database and Google Scholar with the words “dementia” AND/OR “cognitive impairment” combined with the words “exercise” OR “physical exercise” and with the words “falls” OR “fall prevention” using the filter randomised controlled trial or clinical trial. We performed the search in November 2020 and included all articles that fulfilled our criteria and were published from 2010 until October 2020. Figure 1 describes the database search. We also reviewed all reference lists of the articles to find relevant publications. The duplicate entries were removed from the results. The summaries of the remaining articles were reviewed and were included according to the following criteria.

Inclusion criteria:

Publication date from 2010 to 2020

Average age >75 years old

Diagnosis of dementia or mean MMSE score <24 (indicating mild dementia)

### Exercise being the main intervention

After the bibliography search in the databases, we concluded in 148 articles. The duplicate entries and the articles published before 2010 were excluded, while simultaneously the titles of the articles were examined and 82 of them were selected. The next stage involved a full screening of the abstracts of these 82 articles to identify whether they met the inclusion criteria which are mentioned above. After removing the protocol articles, the meta-analyses and the reviews, 26 trials were selected and examined thoroughly. Then, 5 of them were excluded as they referred to only a part of the purpose of our review, the effect of exercise on functionality. Finally, 21 articles were selected (of which 15 were randomized trials) that included different exercise programs and were analysed according to their characteristics. In the studies reviewed, physical exercise had to be the main intervention either alone or in combination with other interventions. No exclusion criteria were applied for the length of intervention.

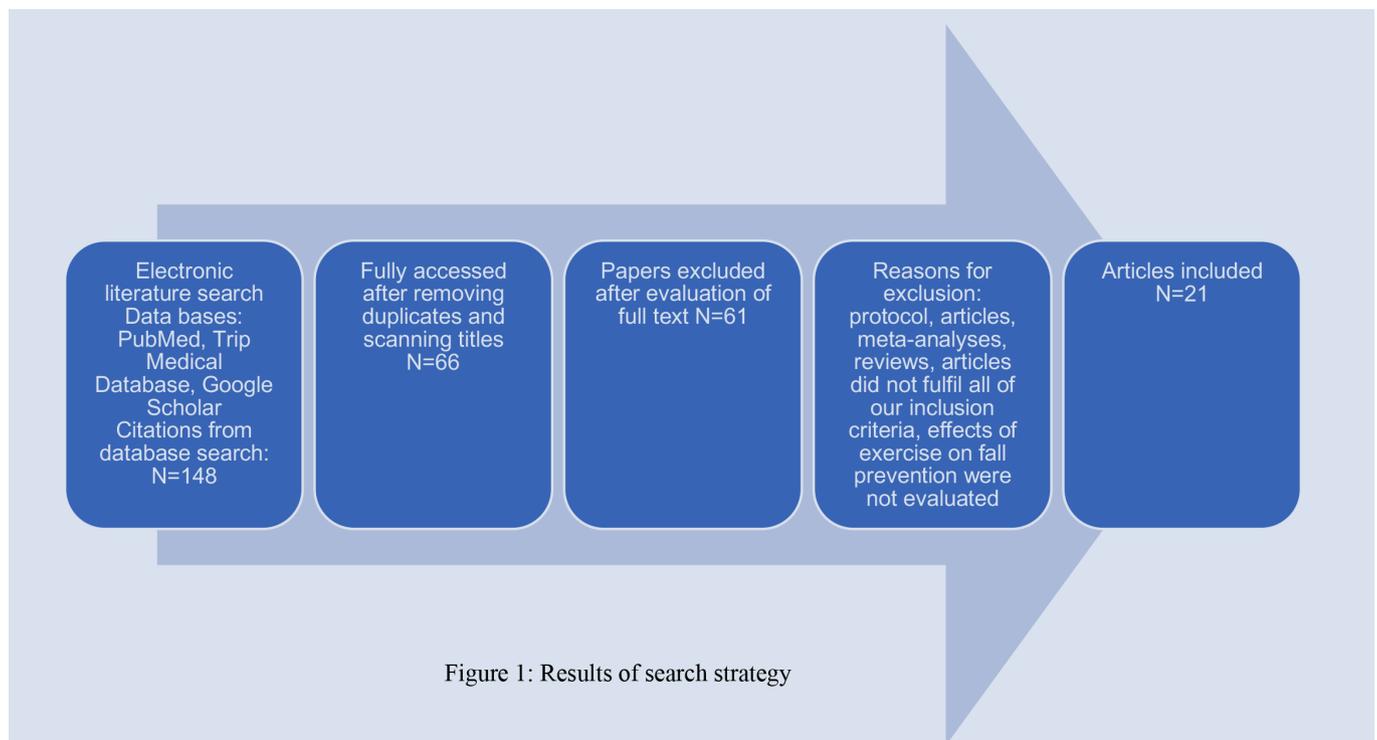


Figure 1: Results of search strategy

### 2.3. Analysis

The results were categorized according to the duration and the intensity, as well as the type of exercise performed in every research. The categories are followed:

- Short duration (1-3 months), moderate intensity
- Short duration (1-3 months), moderate to high intensity
- Short duration (1-3 months), unknown intensity
- Medium duration (3-6 months), moderate intensity
- Medium duration (3-6 months), moderate to high intensity
- Medium duration (3-6 months), unknown intensity
- Long duration (12 months), moderate to high intensity
- Long duration (12 months), unknown intensity

### 3. Results

We analysed 21 trials with a total number of 2,120 participants. Nineteen of them showed improvement in functionality, while only 2 did not report any changes. Regarding fall prevention, 12 articles found that exercise reduced the number of falls, while in 4 articles the authors did not notice any improvement. Also, 2 trials reported that exercise is likely to reduce the number of falls in older people with dementia, and eventually 3 found a positive correlation of exercise as a way to prevent falls, but did not have enough information to come to a conclusion. The characteristics of each research and their results are analysed in Table 1 below.

Seven trials performed exercise programs of short duration (1-3 months). Of these, 2 were characterized by moderate in-

**Table 1: Trials examining physical exercise intervention among old people with dementia (MMSE: Mini Mental State Examination, BBS : Berg Balance Scale, PPA: Physiological Profile Assessment, FES-I :Falls Efficacy Scale International, TUG :Timed Up and Go test, PAQE: physical activity questionnaire for the elderly, TSP: Timed static pedaling, Icon-FES: Iconographical Falls Efficacy Scale, EQ-5D: EuroQol- 5 Dimension, SPPB: Short Physical Performance Battery, POMA: Tinetti Performance Oriented Mobility Assessment, IPEQ-W: Planned Exercise Questionnaire for the Past-week, 1-RM :1-repetition maximum at the leg press, FIM :Functional Independence Measure, GAITRite: Gait Analysis Software, CST Chair stand test, SSGS: Self-Selected Gait Speed, FGS: Fast Gait Speed, FIBS: Falls related impulsivity scale, AGIBAL: agility/dynamic balance test, UST: Unipedal Stance Time).**

Authors	N Mean age	Diagnosed Dementia Mean MMSE	Descriptive Assessments	Intervention Group (IG) Exercise type	Time Frequency Duration	Intensity	Control Group (CG) Interven- tion type	Results
1.Toots (2019)	186  85.1	YES  14.9	BBS Gait speed	n=93 Strength and balance training	45 min 5 /15days 4 months	Moderate to high	n=93 Structured entertaining activities (music, group read- ing)	Improved balance and mobility Increased muscular strength  No effect on fall prevention  Positive correlation with less fractures because of falling

2. Taylor (2017)	42 83	YES 21.2	Dynamometer Swaymeter PPA	n=42 Home-based strength and balance training	6 months	Moderate and progres- sive	NO	Improved balance  Not enough data on fall prevention
3. Zieschang (2017)	110 82.1	YES 21.7	PAQE FES-I TUG	n=55  Group strength and functional training	2 h 2/week 12 weeks	Intensive and pro- gressive	n=55 Stretching and low intensity group train- ing	Increased physical activity  Falls reduction for the high-risk subgroup of multiple fallers  Decreased number of falls 6-9 months after the exercise program
4. Brett (2019)	60 85	YES	Six Meter Walk test, Five- Times-Sit-to- Stand test, TUG test, (Modified) Functional Reach test, TSP	n=40 Group strength, balance and endurance training	45 min 1/week  Or  15 min 3/week  12 weeks	Moderate	n=20 Usual care	Prevention of the physical activity deterioration  Effective to fall pre- vention
5. Nyman (2019)	85 78	YES	TUG test BBS Icon-FES	n=42 Tai Chi classes and home practice	90 min 1/week 20 weeks		n=43 Usual care	Improved balance Reduction of falls
6. Suttanon (2013)	40 81.9	YES 21.28	PPAc score falls risk score TUG	n=19 Home-based individual- ly tailored balance, strengthening and walking exercise pro- gram	6 months	Moderate	n=21	Improved balance and mobility perfor- mance  Positive correlation on falls reduction

7. Lamb (2018)	494 77	YES	EQ-5D	n=329 Aerobic and strength training	60-90 min (group session) + 1h home based training  2/week 4 months	Moderate and progressive to high	n= 165 Usual care	Improved physical fitness and performance  No noticeable improvements on fall rate
8. Hauer (2012)	122 82.6	YES 21.8	FES-I SPPB POMA TUG PAQE	n=62 Group supervised, resistance and functional group training	2 h 2/week 3 months	Moderate and progressive	n=60 Stretching, low-intensity motor placebo activity	Improved functional performance and balance  Possible positive correlation in fall reduction
9. Wesson (2013)	22 79.8	YES 23.5	IPEQ-W PPA FES-I ICONFES	n=11 Tailored home-based balance and strength training	3/week 12 months	Progressive	n=11 Usual care	Increased mobility  Possible positive correlation with fall reduction
10. Schwenk (2014)	61 81.9	YES 21.4	POMA 1-RM Max gait speed/sec GAITRite	n=26 Group supervised, resistance and functional training	2 h 2/week 3 months	Moderate and progressive	n=35 Stretching, low-intensity motor placebo activity	Improved gait variables and balance  Reduction of falls
11. Pitkälä (2013)	210 78	YES 18	SPPB FIM	n1=70 Home-based individual tailored endurance, balance, strength and functional training  n2=70 Group endurance, balance, strength and functional training	1 h 2/ week 12 months		n=70 Usual care	Reduction of functionality deterioration because of dementia  Positive correlation with fall reduction

12. Telenius (2015)	170 86.9	YES 15.6	BBS CST	n=87 Group functional, balance and strength training	50-60 min 2/ week 12 months	High	n=83 Light physical activity and leisure activities	Improved balance Increased muscular strength of lower limbs  Possible decrease of fall rate due to improved balance
13. Perrochon (2015)	16 86.7	YES 15.5	Tinetti Balance Scale Triaxial accelerometer Gait analysis	n=16 Group endurance, balance, strength, flexibility and walking training  Individual session of gait exercises	60 min (group training) + 30 min (home based training)  2 group+1 personal/ week 8 weeks	Moderate	NO	Improved gait performance and variables  Reduction of the risk of falling
14. Kemoun (2010)	31 81.8	YES 12.6	Gait analysis	n=16 Balance, strength and walking training	1h 3/week 15 weeks	Moderate	n=15 No physical exercise	Improved balance and gait variables  Positive correlation with fall reduction
15. Ries (2015)	24 78.6	YES 14.76	BBS TUG SSGS FGS	n=24 Group balance training	45 min 2/week 3 months	Moderate and progressive	NO	Improved balance  Not enough data on fall prevention
16. De Andrade (2013)	30 77.8	YES 19.4	BBS TUG 30-second sit-to-stand test	n=14 Aerobic, balance, strength and flexibility training	1h 3/ week 16 weeks	Moderate	n=16 No physical exercise	Improved balance and functional performance  No noticeable improvements on the number of falls
17. Whitney (2017)	191 83.5	10	TUG FES-I FIBS	n=103 Balance training	45 min 2/week 6 months	Moderate	n=88 Usual care	No effect on balance, functionality and fall prevention due to low adherence

18. Zieschang (2013)	91 82.1	YES 21.7	POMA 1RM FES-I	n=40 Group resistance and functional training	2/week 3 months	Moderate and progressive	n= 51 Stretching, low-intensity motor placebo activity	Improved functional performance and balance  Increased muscular strength  No effect on fall prevention
19. Hernandez (2010)	16 78.5	YES	BBS TUG AGIBAL	n=9 Group strength and flexibility training, dancing, leisure-sports activities	1h 3/week 6 months	Moderate	n=7 No physical exercise	Improved balance  Decreased numbers of falling
20. Yao (2013)	22 80.6	YES 17.9	UST TUG	n=22 Group Tai chi sessions for 4 weeks and 12 weeks of individual home-based Tai chi training	1h (group training) + 20 min (home based training)  2-3/week (group training) 3/week (home based) 16 weeks		NO	Improved functional performance  Positive correlation with decreased falling rates
21. De Souto Barreto (2017)	97 87.6	YES 11.1	SPPB	n=47 Group balance, strength, coordination and aerobic training	60 min 2/week 24 weeks	Moderate and progressive	n=50 Social activities (art and crafts, music)	No effect on functional performance  Reduction of falling rates

tensity [12,19], 4 as moderate to high intensity [10,14,16,21] and 1 as progressive increasing intensity without a specific clarification [15]. Subsequently, 12 articles studies used programs with medium duration (3-6 months), of which 5 were of moderate intensity [8,20,22,23,25], 5 moderate to high intensity [6,11,13,24,27] and 2 programs without a specific clarification [4,26]. Finally, 2 articles analysed long-term exercise programs (12 months) where 1 was of high-intensity [18] and the other was not clarified [17]. Regarding the type of training, 8 were performed in group sessions [10,12,14,18,21,24,25,27], 8 as an individual session [6,11,8,15,16,20,22,23] and 5 were consisted by a combination of group and individual training sessions [4,13,17,19,26].

At first glance there is great diversity in the structure of the exercise programs followed by each researcher. Strengthening exercises with or without weights, balance training, endurance training, progressive resistance training, stretching, coordination training, walking, aerobic programs, functional training, exercise programs combined with breathing control (tai chi), as well as leisure activities such as dancing, were used in the above researches. Despite the similarities between the surveys, there were many different combinations of these types of training, which complicates the analysis of our results. The majority of training programs included strengthening and balance exercises. The following table (Table 2) presents the different combinations of training used in every study.

**Table 2: Exercise programs per research**

Training programs	Authors
Balance and strength training	Toots et al, 2019 Taylor et al, 2017 Wesson et al, 2013
Balance, strength and endurance training	Brett et al, 2019
Progressive resistance and functional training	Zieschang et al, 2017 Hauer et al, 2012 Schwenk et al, 2014
Balance and strength training, walking	Suttanon et al, 2013 Kemoun et al, 2010
Aerobic and strength training	Lamb et al, 2018

Balance training	Ries et al, 2015 Whitney et al, 2017
Balance, strength, endurance and functional training	Pitkälä et al, 2013 Telenius et al, 2015
Balance, strength, endurance and flexibility training, walking	Perrochon et al, 2015
Aerobic, strength, balance and flexibility training	De Andrade et al, 2013
Aerobic, strength, balance and coordination training	De Souto Barreto et al, 2017
Strength and flexibility training, dancing and sports activities	Hernandez et al, 2010
Functional, balance and progressive resistance training	Zieschang et al, 2013
Tai chi practice	Nyman et al, 2019 Yao et al, 2013

### 3.1. Short duration (1-3 months)

#### 3.1.1 Short duration (1-3 months), moderate intensity

Two trials concerned exercise programs of short duration of moderate intensity [12,19]. More precisely, older people with dementia living in nursing homes, trained in group sessions (up to 5 people), either 3 times a week for 15 minutes or once a week for 45 minutes, while the control group received standard medical care [12]. In the second study, seniors participated in a combination of group and individual training sessions [19]. Common features of these studies were the strength, balance and endurance training, while some participants performed additional walking and flexibility exercises [19]. Both studies found a positive correlation between exercise and an improvement of physical function and fall prevention. The authors reported that exercise can slow the deterioration of physical function and reduce falls caused by dementia's symptoms [12]. Also, it was noticed an

improvement of gait parameters (gait speed, stride length) and a reduction of the risk of falling [19].

### *3.1.2 Short duration (1-3 months), medium to high intensity*

Four studies included short duration exercise programs of moderate to high-intensity [10,14,16,21]. In three of this studies, older people with dementia performed a functional training program based on their daily motor needs and activities (e.g., climbing stairs, walking, standing up, avoiding obstacles) [10,14,16]. In addition, progressive resistance exercises were performed, while the control team participated in low intensity exercise and stretching. A different program was followed by a group of dementia patients which took part in a program focused on balance exercises using balls, foam mattresses and walking sticks, while part of the exercise was combined with background music [21].

Regarding the effect of exercise in patient's functional capacity, it was reported that after the end of training, an improvement was observed as well as a development of mobility with better stability [10,21]. Other authors reported that there was an enhancement of motor performance, muscle strength, motor control, and dynamic balance by increasing stride length and reducing double support stance period [14,16]. As for the effect on the number of falls, the results are divided. One study stated that exercise reduced the number of falls [16], while another claimed that exercise is probably an effective intervention for fall prevention [14]. Some researchers reported that exercise had a beneficial effect on the number of falls in a long-term period [10], while others did not have enough data to draw a conclusion [21]. Finally, it is important to mention that people who fall more frequently, showed better results and overall improvement [10,14]

### *3.1.3 Short duration (1-3 months), of unknown intensity*

Only one study included a short-term progressively increasing intensity training program without further clarification [15]. A group of older people with performed an individual

balance and strength training program combined with a set of house safety recommendations. The program took place at the trainees' residence with the help and supervision of their caregivers as well as with the help of illustrated brochures, while the control team received the usual medical care. Although this study had a small sample size, concluded that there were potential benefits as there was improved functionality, and a downward trend in falling rates [15].

## **3.2. Medium duration (3-6 months)**

### *3.2.1. Medium duration (3-6 months), moderate intensity*

Five studies included programs of medium duration and moderate intensity, four of which took place in individual sessions [8,20,22,23] and one in group sessions [25]. In one of the studies, the researchers created a program of balance created a program of balance, strength and walking training based on the existing Otago exercise program. The participants exercised at their home under the supervision of a physiotherapist and the help of illustrated leaflets. The control team followed an educational program about dementia from a specialist occupational therapist. The authors claimed that training can slow down the deterioration of motor performance and balance limitations in people with Alzheimer's disease, while having a positive effect on reducing falls [8]. A different aspect of the Otago program was created in another study as an intervention with balance exercises, taking into account the risk factors for falls in people with dementia who live in nursing homes. The results of the study did not show any effect on balance, functionality and fall prevention. One possible explanation for this conclusion was the poor adherence [23].

A group of older people diagnosed with dementia took part in a program based on balance, strengthening and walking exercises, while the final phase of the intervention included leisure activities such as dancing. The researchers concluded that the program had a beneficial effect on gait's quality and variables (increased speed and stride length, reduced dual support time), with a consequent positive im-

pact on reducing the risk of falls [20]. Furthermore, in a Portuguese study a number of dementia patients performed a group program of strength training, stretching, dancing and sports activities, while the control group received standard medical care. At the end of the program, the researchers concluded that the exercise improved balance, motor performance and gait quality, while at the same time a reduced risk of falls was observed [25].

A study followed the recommendations of the physical exercise protocol for people at risk of falls and movement disorders (American College of Sports Medicine) and developed an exercise program that included cognitive parameters. Specifically, aerobic exercises were performed in combination with strength, balance and flexibility training. During the exercise, the participants were asked to pronounce words according to semantic criteria (e.g., colours, animals, flowers) or to count down. This research showed that functional and motor performance improved at multiple levels, such as lower limb muscle strength, improved gait quality, increased flexibility, and better performance in dual-work activities. However, the difference in the number of falls between the two groups was small and not statistically significant [22].

### *3.2.2 Medium duration (3-6 months), medium to high intensity*

Five studies performed moderate to high intensity exercise programs. One of them followed the HIFE (High-Intensity Functional Exercise) program, where 39 high-intensity exercises were performed with a gradual increase from moderate to high intensity [6], when the other focused mainly on progressively developing intensity balance exercises adding also strength training [11]. Both studies reported an improvement in balance and mobility after the end of the program. Regarding the number of falls, there wasn't any effect of the exercise program on their prevention, but there was a positive correlation with a reduction of fractures after falling (possibly due to better motor performance and quicker reflex responses) [6]. In contrast, less falls were reported in

participants with adherence over 70% and a decrease in the fear of falling, which is a risk factor for increased falls. However, there was insufficient data to generalize this conclusion [11].

A different approach was used in a group functional training program based on the participants' daily needs in combination with balance exercises and progressively increasing resistance. The training was done in groups of four to six people under the supervision of a physiotherapist, while the control group performed low intensity training and stretching. This research showed an enhancement of functional performance, balance and muscle strength but had no significant effect on preventing falls [24].

In a French study, participants took part to a group aerobic training program, combined with strengthening, balance and coordination exercises, compared to the control group that participated in social activities (e.g., relaxation with music, singing, dancing, art and crafts). The researchers found no differences in functionality and motor performance between the participants of the two groups, although the exercise group appeared to have fewer falls [27]. Finally, a group of researchers used a combined program of aerobic exercise and muscle strengthening in group and individual sessions. The intensity and weight used in the training gradually evolved. The researchers found that there was a short-term improvement in physical fitness, but no differences observed in the rate of falls [13].

### *3.2.3 Medium duration (3-6 months), of unknown intensity*

Two studies concerned medium duration programs with no detailed intensity specification. In both studies, a tai chi group and individual practice was performed in pairs with the help of a caregiver. After the end of the intervention, the participants of both studies had improved mobility and functionality, as well as better balance. The authors observed a decrease in the number of falls, however they claimed that further research is needed [4,26].

### 3.3 Long-term duration (12 months)

#### 3.3.1. Long-term duration (12 months), moderate to high intensity

Only one study followed a long-term program with moderate to high intensity, versus a control group that followed a series of low-intensity activities, listening to music and having conversations. Specifically, the participants performed strengthening and balance exercises of the HIFE program in group sessions.

The authors reported that the exercise group showed improved balance and increased muscle strength of the lower limbs. In addition, they looked at the long-term benefits of training where, despite significant losses over time, the intervention team still had better results. Regarding falls, they supported that a reduction in falls is possible, based on better balance, which is a significant risk factor for falls [18].

#### 3.3.2. Long-term duration (12 months), of unknown intensity

Only one study included a long-term exercise program without an accurate characterization of intensity. The researchers divided their sample into three groups where the two performed functional training combined with strength, balance and endurance training which took place either at the participants' residence or in group sessions respectively. The control group received the usual medical care. Both home-based training and group training had a positive effect on reducing the impairment of trainees' functionality compared to the control group. In addition, a decrease in the number of falls was observed. However, the home training participants showed better results in muscle strength and fitness compared to the other two groups [17].

## 4. Discussion

The analysis of our results showed that in the majority of the studies (18 out of 21) there was an improvement in functionality following a training program regardless of its structure and characteristics. As for the question of whether

exercise can be an effective intervention to prevent falls in the elderly with dementia, almost half of the surveys (12 out of 21) found a completely positive correlation between exercise programs and reducing falls.

The diversity that we encounter in exercise programs and in the characteristics of population samples makes it difficult to compare our results. Factors such as the total duration of the program, the place of residence of the elderly (community or nursing home), the stage of dementia (mild, moderate, severe), the psychological state, the functional capacity before the execution of the exercise program, the comorbidity and the medications received by the participants differ and contribute to the diversity mentioned above. Other elements of the intervention also play an important role such as the existence of music, the environment (at home or in a special area) and the social interaction (group or individual exercise).

Similar results were found in a review, which showed that exercise improved physical activity and reduced the risk of falls by 31% (reduction from 1000 to 214 falls per person) with obvious results even 6 months after the end of the program [28]. Other researchers also reported that a long-term exercise program improved participants' functionality and reduced falls by 30-32% [29]. A meta-analysis of the Finnish Alzheimer Disease Exercise Trial, reported that patients at different stages of dementia can benefit in different ways [7]. More specifically, the elderly with mild dementia shows a greater improvement in motor performance and physical function, while the elderly with moderate dementia shows a greater reduction in the risk of falls. However, there is little and not always valid evidence for cases of severe dementia, as only a small number of studies have included these patients.

The majority of the training programs (12 out of 21) lasted from three to six months, while in terms of their intensity, moderate and moderate to high intensity prevail with the same frequency. Regarding the combinations of these two features, the most frequently used programs were 3-6 months of moderate intensity (5 out of 21) and moderate to high intensity (5 out of 21). The two most common types of

exercises included in the training were balance (14 out of 21 programs) and strengthening exercises (13 out of 21). In addition, it is important to note that all programs have been shaped by the abilities of the participants, and there has always been help and supervision from physiotherapists or caregivers. A detailed categorization of the types of exercises according to the frequency of use is presented in Table 3.

**Table 3: Types of training according to the frequency of use**

Types of training	Authors
Balance training	Toots et al, 2019 Taylor et al, 2017 Brett et al, 2019 Suttanon et al, 2013 Wesson et al, 2013 Pitkälä et al, 2013 Telenius et al, 2015 Perrochon et al, 2015 Kemoun et al, 2010 Ries et al, 2015 De Andrade et al, 2013 Whitney et al, 2017 Zieschang et al, 2013 De Souto Barreto et al, 2017
Strength training	Toots et al, 2019 Taylor et al, 2017 Brett et al, 2019 Suttanon et al, 2013 Lamb et al, 2018 Wesson et al, 2013 Pitkälä et al, 2013 Telenius et al, 2015 Perrochon et al, 2015 Kemoun et al, 2010 De Andrade et al, 2013 Hernandez et al, 2010 De Souto Barreto et al, 2017
Endurance training	Brett et al, 2019 Pitkälä et al, 2013 Telenius et al, 2015 Perrochon et al, 2015

Functional training	Zieschang et al, 2017 Hauer et al, 2012 Schwenk et al, 2014 Pitkälä et al, 2013 Telenius et al, 2015 Zieschang et al, 2013
Aerobic training	Lamb et al, 2018 De Andrade et al, 2013 De Souto Barreto et al, 2017
Flexibility training	Perrochon et al, 2015 De Andrade et al, 2013 Hernandez et al, 2010
Progressive resistance training	Zieschang et al, 2017 Hauer et al, 2012 Schwenk et al, 2014 Zieschang et al, 2013
Walking	Suttanon et al, 2013 Perrochon et al, 2015 Kemoun et al, 2010
Coordination training	De Souto Barreto et al, 2017
Dance- sports activities	Hernandez et al, 2010
Tai chi	Nyman et al, 2019 Yao et al, 2013

Despite the benefits found in this review, the characteristics that an exercise program should have for maximum effectiveness have not yet been found. The design of training programs is based on the characteristics and abilities of the participants, creating a confusion for researchers. Data such as the duration of the session, the frequency of repetition and the types of exercises differ from research to research due to differences in the cognitive and motor function of the participants, but also due to the presence of many other diseases. The rate of cognitive impairment and the way in which each patient will be affected varies, so that a safe exercise protocol cannot be established for older people with dementia.

A study suggested working out 2 to 3 times per week as the optimal exercise frequency for older people with mild and moderate dementia, which is in line with the majority of studies used in our review [30]. Also, in a review it was reported that one hour of training is required three times a week for 24 weeks in order to improve functionality and prevent falls in older people with dementia [31]. Similarly,

a review and meta-analysis of 781 participants conducted in Hong Kong concluded that studies with more intensive exercise programs achieved better results in terms of both functionality and fall prevention, while no specific conclusion was drawn on type and content of training [32]. Regarding the intensity of exercise, better results were observed as its intensity increased, with the higher balance and functional performance being achieved after high-intensity exercise [33].

Many studies have tried to explain the mechanism by which exercise improves functionality and reduces falls in older people with dementia, but none have been able to justify this observation, as there is insufficient evidence. Thus, many different mechanisms have been proposed in an attempt to resolve this issue. A number of people argued that exercise has a beneficial effect on neurogenesis and brain function, reducing, in the long run, the rate of changes in its structure as dementia progress [28]. In addition, others added that exercise can improve executive function, leading to improved motor and functional response [32]. Finally, it is proposed that better functionality and reduced falls are probably results of the increase in muscle strength and the improvement of balance after exercise [7].

## 5. Conclusions

In conclusion, the analysis of the above studies highlights exercise as a beneficial intervention for older people with dementia, in order to improve their functionality and prevent falls. However, the number of surveys that have been conducted is insufficient and often the results are not statistically significant. The increased risk of falls in patients with dementia and the deterioration of functionality as the disease progresses is something that should not be ignored, as it can lead to inability to self-care, increased risk of injury and lower quality of life. Therefore, further research is needed in order to find the most beneficial types of exercise for dementia patients, in terms of functionality and fall reduction, but also, in particular, to highlight these optimal characteristics, in terms of their duration and intensity.

## Declarations

The authors have no conflicts of interest to disclose.

**Acknowledgements:** Not applicable.

**Authors' contributions:** Conception & design, drafting, critical revision and final approval of the manuscript: All authors.

**Ethical approval:** Not applicable.

**Funding:** Not applicable.

**Informed consent:** Not applicable.

**Study registration:** Not applicable.

## References

1. Stephan BCM, Birdi R, Tang EYH, et al. Secular Trends in Dementia Prevalence and Incidence Worldwide: A Systematic Review. *J Alzheimers Dis* 2018, 66:653-680. doi:10.3233/JAD-180375.
2. Garre-Olmo J. Epidemiologia de la enfermedad de Alzheimer y otras demencias [Epidemiology of Alzheimer's disease and other dementias]. *Rev Neurol*. 2018, 66:377-386. Spanish. PMID: 29790571.
3. Rizzi L, Rosset I, Roriz-Cruz M. Global epidemiology of dementia: Alzheimer's and vascular types. *Biomed Res Int* 2014, 2014:908915. doi: 10.1155/2014/908915.
4. Nyman SR, Ingram W, Sanders J, Thomas PW, Thomas S, Vassallo M, et al. Randomised Controlled Trial of The Effect of Tai Chi on Postural Balance of People with Dementia. *Clin Interv Aging* 2019, 14:2017-2029. doi: 10.2147/CIA.S228931.
5. Thom JM, Clare L. Rationale for combined exercise and cognition-focused interventions to improve functional independence in people with dementia. *Gerontology* 2011, 57:265-75. doi: 10.1159/000322198
6. Toots A, Wiklund R, Littbrand H, Nordin E, Nordström P, Lundin-Olsson L, et al. The Effects of Exercise on Falls in Older People with Dementia Living in Nursing Homes: A Randomized Controlled Trial. *J Am Med Dir Assoc* 2019, 20:835-842.e1. doi: 10.1016/j.jamda.2018.10.009.
7. Öhman H, Savikko N, Strandberg T, Kautiainen H, Raivio M,

- Laakkonen ML, et al. Effects of Exercise on Functional Performance and Fall Rate in Subjects with Mild or Advanced Alzheimer's Disease: Secondary Analyses of a Randomized Controlled Study. *Dement Geriatr Cogn Disord* 2016, 41:233-41. doi: 10.1159/000445712.
8. Suttanon P, Hill KD, Said CM, Williams SB, Byrne KN, LoGiudice D, et al. Feasibility, safety and preliminary evidence of the effectiveness of a home-based exercise programme for older people with Alzheimer's disease: a pilot randomized controlled trial. *Clin Rehabil* 2013, 27:427-38. doi: 10.1177/0269215512460877.
  9. Fernando E, Fraser M, Hendriksen J, Kim CH, Muir-Hunter SW. Risk Factors Associated with Falls in Older Adults with Dementia: A Systematic Review. *Physiother Can* 2017, 69:161-170. doi: 10.3138/ptc.2016-14.
  10. Zieschang T, Schwenk M, Becker C, Uhlmann L, Oster P, Hauer K. Falls and Physical Activity in Persons with Mild to Moderate Dementia Participating in an Intensive Motor Training: Randomized Controlled Trial. *Alzheimer Dis Assoc Disord* 2017, 31:307-314. doi: 10.1097/WAD.0000000000000201.
  11. Taylor ME, Lord SR, Brodaty H, Kurrle SE, Hamilton S, Ramsay E, et al. A home-based, carer-enhanced exercise program improves balance and falls efficacy in community-dwelling older people with dementia. *Int Psychogeriatr* 2017, 29:81-91. doi: 10.1017/S1041610216001629.
  12. Brett L, Stapley P, Meedy S, Traynor V. Effect of physical exercise on physical performance and fall incidents of individuals living with dementia in nursing homes: a randomized controlled trial. *Physiother Theory Pract*. 2019, 37:38-51. doi: 10.1080/09593985.2019.1594470.
  13. Lamb SE, Sheehan B, Atherton N, Nichols V, Collins H, Mistry D, et al. Dementia And Physical Activity (DAPA) trial of moderate to high intensity exercise training for people with dementia: randomised controlled trial. *BMJ* 2018, 361:k1675. doi: 10.1136/bmj.k1675.
  14. Hauer K, Schwenk M, Zieschang T, Essig M, Becker C, Oster P. Physical training improves motor performance in people with dementia: a randomized controlled trial. *J Am Geriatr Soc* 2012, 60:8-15. doi: 10.1111/j.1532-5415.2011.03778.x.
  15. Wesson J, Clemson L, Brodaty H, Lord S, Taylor M, Gitlin L, et al. A feasibility study and pilot randomised trial of a tailored prevention program to reduce falls in older people with mild dementia. *BMC Geriatr* 2013, 13:89. doi: 10.1186/1471-2318-13-89.
  16. Schwenk M, Zieschang T, Englert S, Grewal G, Najafi B, Hauer K. Improvements in gait characteristics after intensive resistance and functional training in people with dementia: a randomised controlled trial. *BMC Geriatr* 2014, 14:73. doi: 10.1186/1471-2318-14-73.
  17. Pitkälä KH, Pöysti MM, Laakkonen ML, Tilvis RS, Savikko N, Kautiainen H, et al. Effects of the Finnish Alzheimer disease exercise trial (FINALEX): a randomized controlled trial. *JAMA Intern Med* 2013, 173:894-901. doi: 10.1001/jamainternmed.2013.359.
  18. Telenius EW, Engedal K, Bergland A. Long-term effects of a 12 weeks high-intensity functional exercise program on physical function and mental health in nursing home residents with dementia: a single blinded randomized controlled trial. *BMC Geriatr* 2015, 15:158. doi: 10.1186/s12877-015-0151-8.
  19. Perrochon A, Tchalla AE, Bonis J, Perucaud F, Mandigout S. Effects of a Multicomponent Exercise Program on Spatiotemporal Gait Parameters, Risk of Falling and Physical Activity in Dementia Patients. *Dement Geriatr Cogn Dis Extra* 2015, 5:350-60. doi: 10.1159/000435772.
  20. Kemoun G, Thibaud M, Roumagne N, Carette P, Albinet C, Toussaint L, et al. Effects of a physical training programme on cognitive function and walking efficiency in elderly persons with dementia. *Dement Geriatr Cogn Disord* 2010, 29:109-14. doi: 10.1159/000272435.
  21. Ries JD, Hutson J, Maralit LA, Brown MB. Group Balance Training Specifically Designed for Individuals With Alzheimer Disease: Impact on Berg Balance Scale, Timed Up and Go, Gait Speed, and Mini-Mental Status Examination. *J Geriatr Phys Ther* 2015, 38:183-93. doi: 10.1519/JPT.0000000000000030.
  22. De Andrade LP, Gobbi LT, Coelho FG, Christofoletti G, Costa JL, Stella F. Benefits of multimodal exercise intervention for postural control and frontal cognitive functions in individuals with Alzheimer's disease: a controlled trial. *J Am Geriatr Soc* 2013, 61:1919-26. doi: 10.1111/jgs.12531.
  23. Whitney J, Jackson SHD, Martin FC. Feasibility and efficacy of a multi-factorial intervention to prevent falls in older adults with cognitive impairment living in residential care (ProF-Cog). A feasibility and pilot cluster randomised controlled trial. *BMC Geriatr* 2017, 17:115. doi: 10.1186/s12877-017-0504-6.
  24. Zieschang T, Schwenk M, Oster P, Hauer K. Sustainabili-

- ty of motor training effects in older people with dementia. *J Alzheimers Dis* 2013, 34:191-202. doi: 10.3233/JAD-120814.
25. Hernandez SS, Coelho FG, Gobbi S, Stella F. Efeitos de um programa de atividade física nas funções cognitivas, equilíbrio e risco de quedas em idosos com demência de Alzheimer [Effects of physical activity on cognitive functions, balance and risk of falls in elderly patients with Alzheimer's dementia]. *Rev Bras Fisioter* 2010, 14:68-74. Portuguese. PMID: 20414564.
26. Yao L, Giordani BJ, Algase DL, You M, Alexander NB. Fall risk-relevant functional mobility outcomes in dementia following dyadic tai chi exercise. *West J Nurs Res* 2013, 35:281-96. doi: 10.1177/0193945912443319.
27. De Souto Barreto P, Cesari M, Denormandie P, Armaingaud D, Vellas B, Rolland Y. Exercise or Social Intervention for Nursing Home Residents with Dementia: A Pilot Randomized, Controlled Trial. *J Am Geriatr Soc* 2017, 65:E123-E129. doi: 10.1111/jgs.14947.
28. Demurtas J, Schoene D, Torbahn G, Marengoni A, Grande G, Zou L, et al. Physical Activity and Exercise in Mild Cognitive Impairment and Dementia: An Umbrella Review of Intervention and Observational Studies. *J Am Med Dir Assoc* 2020, 21:1415-1422.e6. doi: 10.1016/j.jamda.2020.08.031.
29. Lewis M, Peiris CL, Shields N. Long-term home and community-based exercise programs improve function in community-dwelling older people with cognitive impairment: a systematic review. *J Physiother* 2017, 63:23-29. doi: 10.1016/j.jphys.2016.11.005.
30. Lam FM, Huang MZ, Liao LR, Chung RC, Kwok TC, Pang MY. Physical exercise improves strength, balance, mobility, and endurance in people with cognitive impairment and dementia: a systematic review. *J Physiother* 2018, 64:4-15. doi: 10.1016/j.jphys.2017.12.001.
31. Forbes D, Thiessen EJ, Blake CM, Forbes SS, Forbes S. Exercise programs for people with dementia. *Sao Paulo Medical Journal* 2014, 132:195-196. <https://doi.org/10.1590/1516-3180.20141323T2>
32. Chan WC, Yeung JW, Wong CS, Lam LC, Chung KF, Luk JK, et al. Efficacy of physical exercise in preventing falls in older adults with cognitive impairment: a systematic review and meta-analysis. *J Am Med Dir Assoc* 2015, 16:149-54. doi: 10.1016/j.jamda.2014.08.007.
33. Long A, Robinson K, Goldberg S, Gordon AL, et al. Effectiveness of exercise interventions for adults over 65 with moderate-to-severe dementia in community settings: a systematic review. *Eur Geriatr Med* 2019, 10:843-852. doi:10.1007/s41999-019-00236-7.