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Effectiveness of home-based video exercise programmes on physical fitness in older adults – systematic review and meta-analysis

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ABSTRACT

Background: Home-based video exercise programmes might be a suitable alternative to traditional physical activity in older adults to preserve muscle health. The aim of this systematic review and meta-analysis was to examine the effects of home-based video exercise programmes on physical fitness in older adults.
Methods: A systematic review and robust variance estimation meta-analysis with meta-regression were carried out according to the recommendations and criteria outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.
Results: Thirteen studies involving 1,056 participants were included. Meta-analysis showed statistically significant positive changes in balance ($p = 0.023$), upper extremity strength ($p = 0.049$, and strength overall ($p = 0.042$), there was also statistically significant positive effect based on all the 28 outcomes in eight studies, including 696 participants ($p = 0.008$).
Conclusion: The present systematic review and meta-analysis indicate that home-based video exercise programmes positively affect essential components of physical fitness, such as balance and strength, to prevent falls in older adults. Promoting home-based video exercise in clinical practice and ideally supporting it through supervision is vital to effectively combat the age-related physical decline, especially for those in home isolation.

KEYWORDS

aging; DVD; physical performance; muscle strength; balance

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BACKGROUND

It is widely known that the global population is getting older, which carries profound medical and socio-economic consequences (UN DESA, 2020). Older age is associated with the accumulation of health complications where cardiovascular diseases, cancer and musculoskeletal (MSK) diseases are the main contributors to the disease burden in this population (Prince et al., 2015). Notably, the latter should be of primary importance as MSK diseases can severely impact an individual's quality of life (QoL) and functional independence, an individual's ability to perform activities of daily living (ADLs) such as personal hygiene, dressing or eating (Mlinac et al., 2016) For instance, the most recent Eurostat statistics on disability have shown that nearly 50% of people aged 65 and over struggle with at least one personal care or household activity (EUROSTAT, 2022). Therefore, worldwide consensus has been reached supporting any method that may prevent a physical decline in the functional independence of older people.

The importance of physical activity (PA) in older age has been propagated long time (Eckstrom et al., 2020). PA in older age is essential for health not only because it preserves and increases muscle mass and strength – parameters of sarcopenia that decline with age (Morley et al., 2016), but PA also improves endurance, immunity, and cardiovascular function (Yoo et al., 2018; Paffenbarger et al., 2001). Therefore, age-related health complications in the older population are largely preventable by applying different exercise training practices, which often leads to improved functional capacity and QoL (Laurin et al., 2019; Hunter et al., 2004; Christie, 2011). Current PA guidelines for older adults recommend at least 150–300 minutes of moderate-intensity aerobic physical activity, or at least 75–150 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity activity throughout the week along with two or more days a week of muscle-strengthening activities, involving major muscle groups to develop and maintain cardiorespiratory, musculoskeletal, and neuromotor fitness (WHO, 2010; Garber et al., 2011). However, meeting these PA guidelines was nearly difficult during the new coronavirus disease 2019 (COVID-19) global pandemic (Meyer et al., 2020), where quarantine and social distancing, especially emphasised in older adults, had been the first-line measures to prevent the highly contagious virus from spreading further (Wilder-Smith et al., 2020). While these attempts to suppress human-to-human transmission may have been highly justifiable, prolonged homestay, specifically in the elderly population, has already proved to have many adverse effects on the individual's health (Mlinac et al., 2016; Kirwan et al., 2020; Brooke et al., 2020).

For this reason, specific home-based PA recommendations and guidelines (Joy, 2020; WHO, 2020) have been recently established to increase PA rates during restricted periods, as exercise at home was the only possibility to stay active during the pandemic. However, these recommendations do not specify the type and dosage of exercise, especially for the older population, to achieve favourable health effects. Recent systematic review and meta-analysis has examined the experimental evidence of the effects of home-based exercise programmes (home-based interventions comprised of single-mode or multimodal training focused only on strength and/or balance) on physical fitness (muscle strength, endurance, power and balance) in healthy older adults and has found small effects in all the measured parameters for the older population group (Chaabene et al., 2021). Considering that most included studies had limited visual or intervention support by the research staff, individuals may have found it challenging to commit to exercising at home. Therefore, home-based video exercise programmes might result in greater improvements in physical fitness. This systematic review with meta-analysis aimed to examine the effects of home-based video exercise programmes on physical fitness in older adults, as there is currently limited knowledge on this specific topic.

METHODS

This systematic review and meta-analysis were carried out per the recommendations and criteria outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021), and the review protocol has been registered in the international prospective register of systematic reviews (PROSPERO: CRD42022381761).

Criteria for considering studies for this review

Studies focused on home video-based exercise in older adults > 65 years written in English and published in peer-reviewed journals were considered.

Types of studies

Single group trials (SGT) and either randomised controlled trials (RCT) or non-randomised controlled trials (NRCT) with either exercise or non-exercise control groups were considered for the systematic review part, and RCTs and NRCTs with non-exercise control groups were considered for the meta-analysis.

Types of participants

Medically stable older adults (Greig et al., 1994) aged ≥ 65 years, either females or males or both, were considered for this study.

Types of interventions

All studies focusing on home video-based exercise programs related to physical performance were considered.

Types of outcome measures

Physical performance was measured by physical performance battery – Physiological Profile Assessment (PPA) (Lord et al., 2003), Short Performance Physical Battery (SPPB) (Guralnik et al., 1994), muscle strength tests – handgrip, biceps strength, leg extensor power, chair stand, balance tests – Balance Outcome Measure for Elder Rehabilitation (BOOMER) (Haines et al., 2007), Berg Balance Scale (Berg et al., 1992).

Search methods for identification of studies

Appropriate papers were identified by searching three electronic databases: PubMed, Scopus, and Web of Science. The same stream of keywords was used in all the databases:

(((((home) OR (home-based)) AND (exercise)) AND (((video) OR (DVD)) OR (YouTube))) AND ((“older adults”) OR (elderly))) NOT (game)

Data collection and analysis

All the potential papers were first downloaded using a reference manager, and then all duplicates were deleted. If the papers seemed suitable from a brief screening of the abstracts, three independent reviewers examined the full text in detail. Additionally, other possible papers were identified through the reference lists of papers and reviews gained by the database search.

Data extraction and management

We collected the following data for both the exercise groups and control groups: mean differences (after – before) and either standard deviation (SD) or 95% confidence interval (CI); if the mean differences were not available, we collected baseline and follow up means and either SD or 95% CI.

Assessment of risk of bias in included studies

A modified version of the Cochrane risk of bias tool (RoB 2) for randomised (Sterne et al., 2019) and risk of bias in non-randomised studies-of interventions (ROBINS-I) for non-randomised comparative studies was used to assess the methodological quality of the included studies (Sterne et al., 2016).

Statistical analysis

All analyses were performed using an R environment for statistical computing (version 4.2.2). The effect sizes for individual outcomes were calculated as standardised mean differences (Hedges’ g) (Hedges, 1981) between the intervention and control groups using the metafor (Viechtbauer, 2016) package (version 3.4). The effect sizes were pooled using a random-effects meta-regression with robust variance estimation using robumeta (Fisher et al., 2015) package (version 2.0). Robust variance estimation allows for the inclusion of multiple dependent outcomes from the same study and does not require weights or distributional assumptions (Hedges et al., 2010; Tipton, 2015). The analyses were performed for individual domains (aerobic capacity, balance, strength, physical performance) and for all domains combined and visualised using forest plots. For all analyses, we computed pooled effect size, its standard error, 95% confidence intervals and statistical significance (set at $p < 0.05$), percentage of variance due to between-study heterogeneity (I^2), and the absolute value of true heterogeneity (Tau^2). The values of $I^2 > 25\%$, $> 50\%$, and $> 75\%$ indicate, respectively, low, moderate, and high heterogeneity (Higgins et al., 2003). Sensitivity analyses were conducted by assessing the effects of influential cases on the results. The influential cases were diagnosed using a combination of several methods (externally standardised residuals, difference in fits values, Cook’s distances, covariance ratios, leave-one-out estimates of the amount of heterogeneity, leave-one-out values of the test statistics for heterogeneity, hat values, and weights) as implemented in the ‘influence’ function within the metafor package (Viechtbauer et al., 2010). Potential publication bias was explored using a funnel plot and Egger’s regression test (Sterne et al., 2005).

RESULTS

Description of studies

The yield of the search process is summarised in Figure 1. Thirteen studies involving 1,056 participants were included in this systematic review. Nine studies were randomised control trials (RCT), two were single group trials (SGT), and one was non-randomised control trials (NRCT). However, two RCTs did not include any non-exercising group. Nearly all the participants were considered healthy older adults living independently. Out of all the studies, only one study included pre-frail older adults, and another one included older adults with mobility impairment. Except for two studies that included females only, the rest included females and males. The majority of studies used telephone-supported DVD-based exercise interventions, and the duration of interventions ranged between two and six months. The basic description of the included studies is presented in Table 1.

Risk of bias in included studies

The randomised studies showed an acceptable risk of bias, according to RoB 2. Nevertheless, only a study by (Hong et al., 2017) was at low risk of bias. In (Baez et al., 2017), all the variables statistically differed between groups in baseline measurements, and Hong (Hong et al., 2018) as well as (Vestergaard et al., 2008) showed unclear baseline data; therefore, it was impossible to mark randomisation process with the low risk. Participants' dropout was the major problem in this analysis. More than 10%

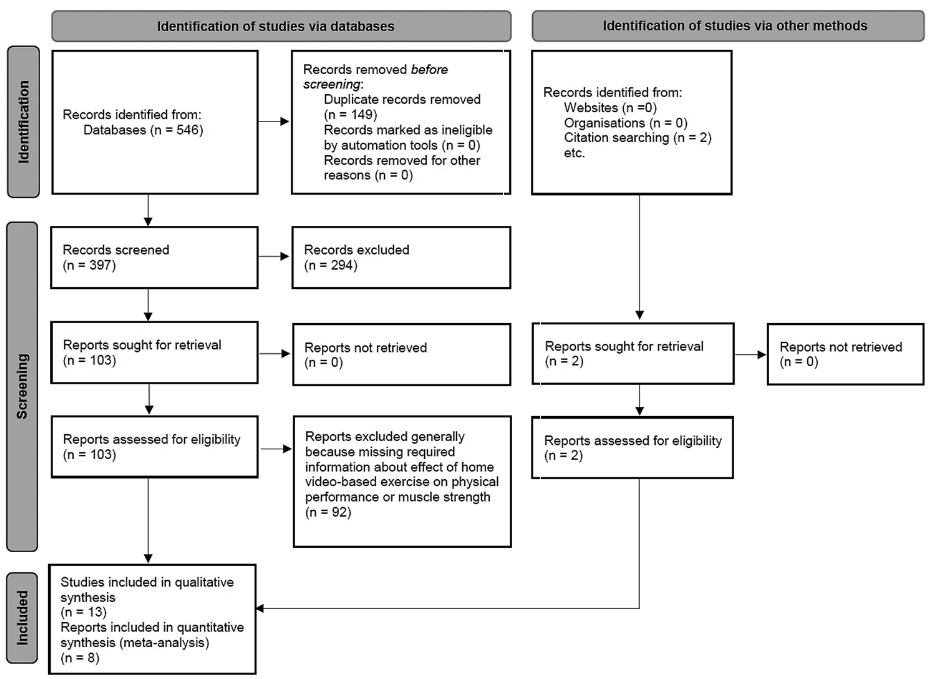


Figure 1

Table 1 Basic description of the included studies

Study	Year	Country	Design	Sample description	Sample size	Sex	Mean age (SD) of the experimental group	Format	Telephone-supported	Length of the intervention
Baez et al.	2017	Italy	RCT	Older adults	37	T	70.3 (4.5)	Tablet-based application	–	2 months
Davis et al.	2016	Canada	NRCT	Older adults	61	T	79.6 (4.5)	DVD	Yes	6 months
Geraedts et al.	2021	Netherlands	SGT	Pre-frail older adults	21	T	81.3 (4.7)	Tablet, web-based application	Yes	3 months
Haines et al.	2009	Australia	RCT	Older adults with mobility impairment	68	T	80.9 (8.9)	DVD	Yes	2 months
Hong et al.	2018	South Korea	RCT	Elderly women with a high risk of falling	34	F	78.1 (5.7)	Tablet, supervised telepresence	–	3 months
Hong et al.	2017	South Korea	RCT	Members of the Senior Citizen Centre	23	T	82.2 (5.6)	Tablet PC, supervised telepresence	–	3 months
McAuley et al.	2013	US	RCT	Low-active older adults	307	T	70.6 (0.4)	DVD	Yes	6 months
Roberts et al.	2017	US	RCT	Low-active older adults	153	T	70.0 (5.0)	DVD	Yes	6 months
Vestergard et al.	2008	Denmark	RCT	Community – dwelling frail women	61	F	81.0 (3.3)	Video tape	Yes	5 months
Vikberg et al.	2022	Sweden	SGT	Community – dwelling elderly at risk of sarcopenia	34	T	71.1. (0.3)	Pre-recorded video accessed via homepage	–	2.5 months
Wu et al.	2010	US	RCT*	Community – dwelling elderly with a risk of falling	94	T	76.1 (7.9)	DVD	Yes	4 months
Wu and Keyes	2006	US	SGT	Independent living elderly	17	T	81.0 (8.0)	Video-conference	–	4 months
Yamada et al.	2011	Japan	RCT	Community – dwelling older adults	146	T	83.0 (6.7)	DVD	–	6 months

Note: RCT = randomized control trial; NRCT = non-randomized control trial; SGT = single group trial; SD = standard deviation

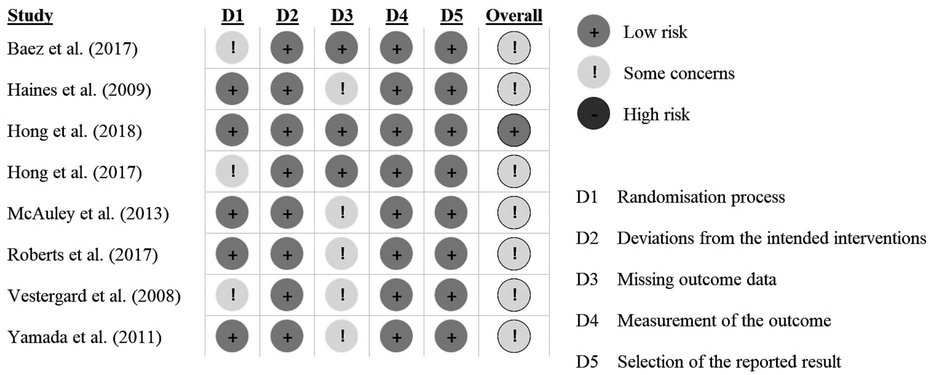


Figure 2

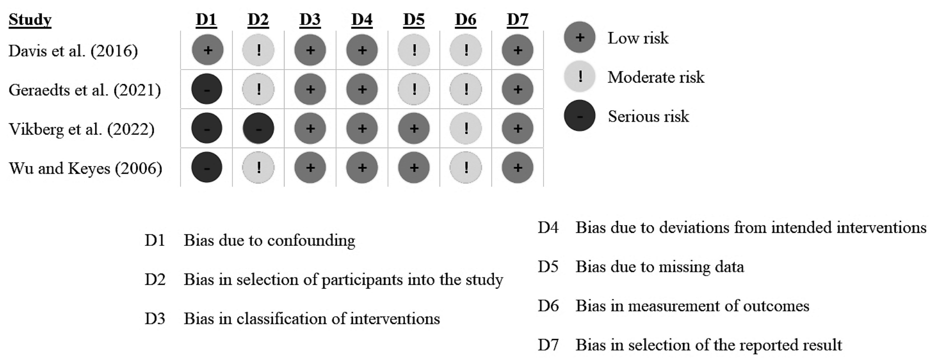


Figure 3

of participants dropped out in five out of eight studies (Figure 2). Non-randomised studies were of medium quality, according to ROBINS-I. In fact, only (Davis et al., 2016) was NRCT, but the control group had a different location from the intervention group. There was the same problem with the considerable dropout rate. The other three studies were SGS; therefore, they did not meet all criteria from ROBINS-I (Figure 3).

Systematic review

Fourteen intervention groups were included in the systematic review. Four studies used the Otago Exercise Programme (NCOA, 2023), two FlexToBa (McAuley et al., 2012), and two DVD Tai Chi programs. Several methods were used to measure physical performance and muscle strength (Table 2). Statistically significant improvements were recorded 23 times out of 40 within-group analyses. Participants mainly improved their lower extremities strength assessed by several modifications of the chair stand test (7× improvements). There were also 3× improvements in overall performance assessed by the Short Performance Physical Battery (SPPB) and 4× upper extremities strength (2× 30-sec arm curl, 1× handgrip strength and 1× biceps strength). Between

Table 2 The detail description of the studies included in this systematic review

Study	Intervention description	Outcome	Within-group effect sig.	Between-groups effect sig.
Baez et al. (2017)	Otago Exercise Programme	30-sec chair stand (Jones et al. 1999)	↑	–[a]
		TUG (Podsiadlo and Richardson, 1991)	↑	–[a]
Davis et al. (2016)	Otago Exercise Programme	PPA (Lord et al., 2003)	–	–
		SPPB (Guralnik et al., 1994)	–	–
Geraedts et al. (2021)	Otago Exercise programme	STS (Zijlstra et al., 2010)	–	N/A
		TUG (Podsiadlo and Richardson, 1991)	↑	N/A
		Chair-Rise test (Zhang et al., 2014)	↑	N/A
Haines et al. (2009)	Kitchen Table Exercise Program	BOOMER (Haines et al., 2007)	–	–
		2-min walk test (Stewart et al., 1990)	–	–
Hong et al. (2018)	Telepresence Exercise Program	2-min step test (Rikli and Jones, 2013)	–	–
		30-sec arm curl	–	–
		30-sec chair stand (Guralnik et al., 1994)	↑	↑
		8-foot up-and-go	–	–
		Berg Balance Scale (Berg et al., 1992)	↑	↑
Hong et al. (2017)	Telepresence Exercise Program	2-min step test (Rikli and Jones, 2013)	↑	–
		30-sec arm curl	–	–
		30-sec chair stand (Guralnik et al., 1994)	↑	↑
		8-foot up-and-go	–	–
McAuley et al. (2013)	FlexToBa	SPPB (Guralnik et al., 1994)	↑	↑
		30-sec arm curl	↑	↑
Roberts et al. (2017)	FlexToBa	SPPB (Guralnik et al., 1994)	↑	↑
		30-sec arm curl	↑	↑
Vestergard et al. (2008)	Video tape exercise including booklet describing them	Handgrip	↑	–
		Biceps strength	↑	–
		Leg extensor power	–	–
		Chair stand	↑	–
		Walking speed	↑	–
		Semi balance	–	–
		PPT (Reuben and Siu, 1990)	↑	–
Vikberg et al. (2022)	Online resistance training	SPPB (Guralnik et al., 1994)	↑	N/A
Wu et al. (2010)	DVD Tai-Chi program	TUG (Podsiadlo and Richardson, 1991)	–	N/A
		SLS (Wu, 2002)	–	N/A
Wu and Keyes (2006)	DVD Tai-Chi program	TUG (Podsiadlo and Richardson, 1991)	↑	N/A
		SLS (Wu, 2002)	↑	N/A
Yamada et al. (2011)	DVD training	DT walking time (Yamada et al., 2011)	–	–
		ST walking time (Lopopolo et al., 2006)	↑	↑
		TUG (Podsiadlo and Richardson, 1991)	–	–
		30-sec chair stand (Guralnik et al., 1994)	–	–

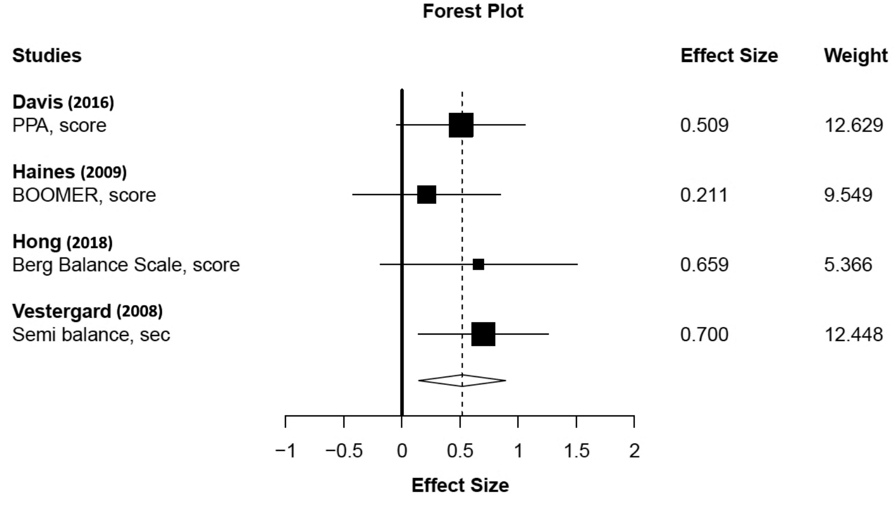
Note: ↑ = increased levels; ↓ = decreased levels; N/A not applicable; [a]Individual home-based training program vs. online group exercising
TUG = Timed Up & Go test; PPA = Physiological Profile Assessment; Short Performance Physical Battery; BOOMER = Balance Outcome Measure for Elder Rehabilitation; PPT = Physical Performance Test; ST walking time = 10-m walking under the single-task condition; DT walking time = 10-m walking under the dual-task condition

study comparisons, 8× were statistically significant improvements (2× 30-sec chair stand, 2× 30-sec arm curl, 2× SPPB, 1× Berg Balance Scale, and 1× 10-m walking under the dual-task condition (DT walking time). The results of the studies included in this systematic review are shown in Table 2.

Meta-Analysis

Effects of interventions

Meta-analysis showed statistically significant positive changes in balance (ES = 0.517 [95% CI: 0.144 to 0.891], p = 0.023, Figure 4), upper extremity strength (ES = 0.388 [95% CI: 0.002 to 0.775], p = 0.049, Figure 5), and strength overall (ES = 0.442 [95% CI: 0.023 to 0.862], p = 0.042, Figure 6). There was no heterogeneity detected in balance (I^2 = 0%, Tau^2 = 0). The heterogeneity of the results was moderate for the upper extremity strength (I^2 = 43%, Tau^2 = 0.038) and high for the strength overall (I^2 = 70%, Tau^2 = 0.114). Meta-analysis for physical performance tests yielded positive but non-significant effects (ES = 0.422 [95% CI: −0.093 to 0.938], I^2 = 57%, Tau^2 = 0.05, p = 0.078, Figure 7). The highest but non-significant effect with considerable heterogeneity (I^2 = 84%, Tau^2 = 0.583) was estimated in lower extremity strength (ES = 0.875 [95% CI: −0.662 to 2.412], p = 0.166, Figure 8). On the other hand, the smallest effect with no heterogeneity (I^2 = 0%, Tau^2 = 0) was estimated in aerobic capacity (ES = 0.279 [95% CI: −0.577 to 1.135], p = 0.284, Figure 9). The overall effect based on 28 outcomes in eight studies, including 696 participants, was statistically significant (ES = 0.361 [95% CI: 0.132 to 0.590], p = 0.008, Figure 10). Heterogeneity was moderate for the overall effect (I^2 = 58%, Tau^2 = 0.076). The sensitivity analysis did not identify any influential cases. The visual inspection of the funnel plot complemented Egger's regression test for funnel plot asymmetry (p = 0.211) and indicated that publication bias was unlikely to have influenced the results significantly.



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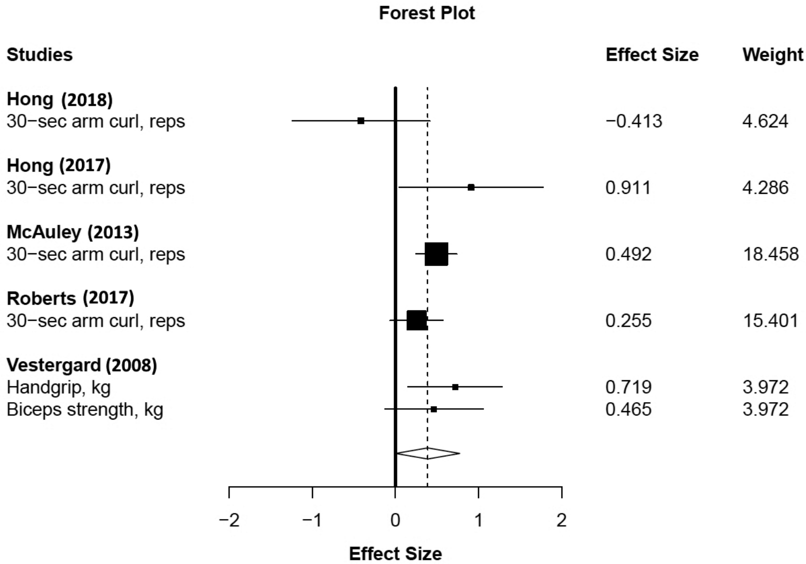

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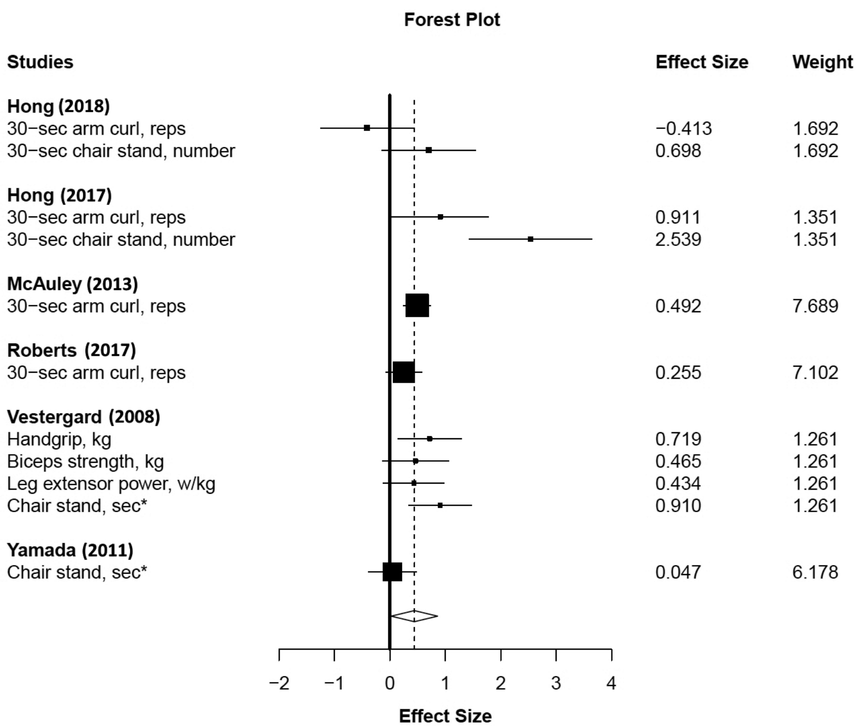

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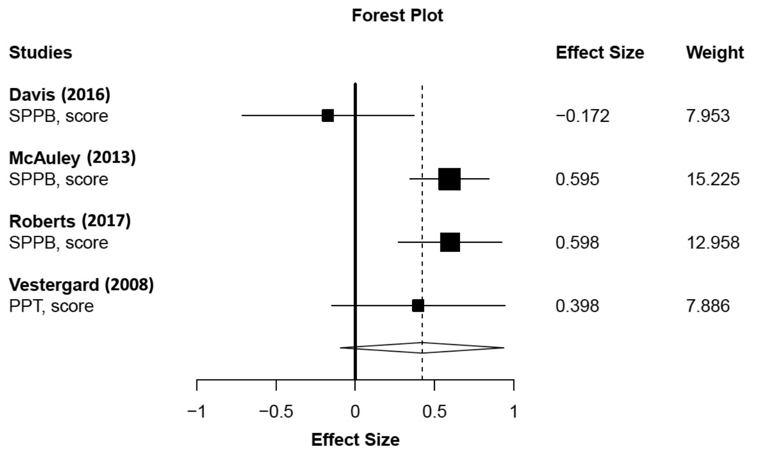

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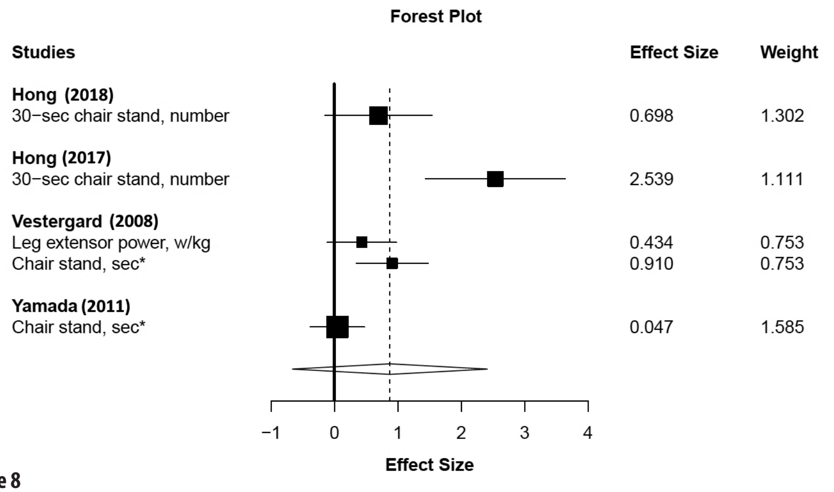

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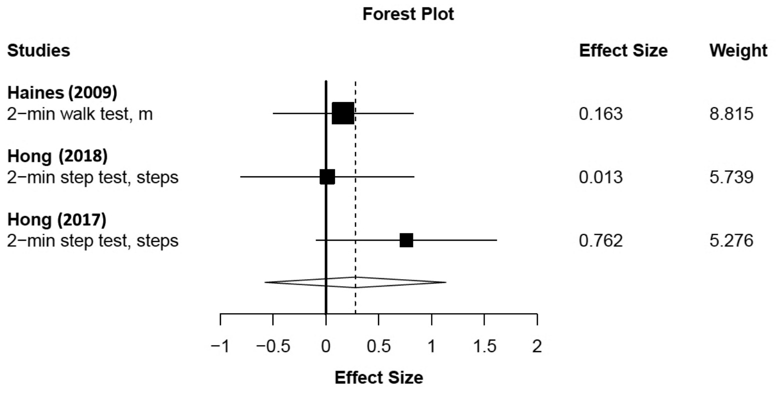

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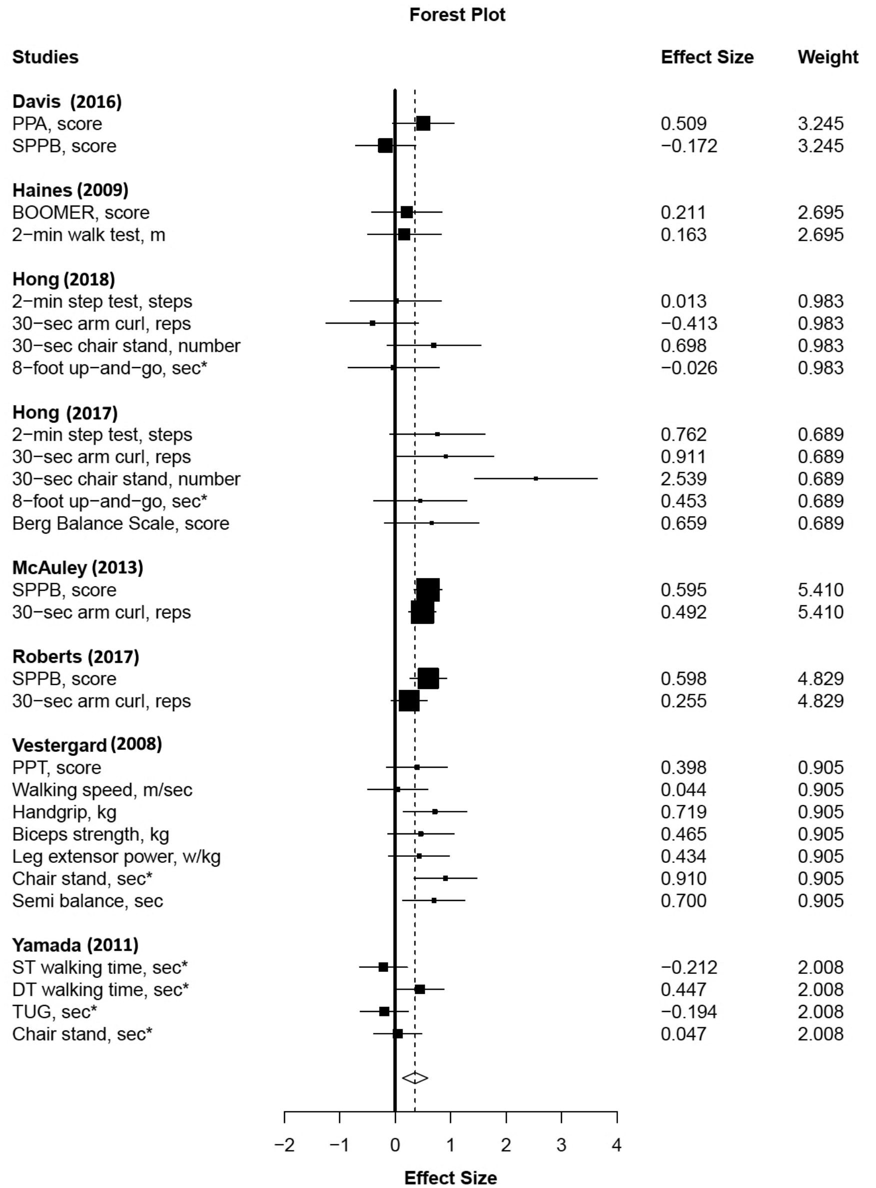

Figure 10

DISCUSSION

The results of this present study indicate that home-based video exercise programmes have moderate effects on important components of physical fitness, such as balance and muscle strength, in medically stable older adults. This study did not find statistically significant effects on physical performance per se. These results could be, therefore, used to promote home-based video exercise programmes in clinical practice, especially in times of home isolation, to community-dwelling older individuals as a preventative exercise for people at increased risk of falls due to frailty and/or sarcopenia.

The major public health concern nowadays is the age-related loss of muscle mass and strength, termed sarcopenia, because it is associated with many adverse outcomes, including frailty, decreased mobility and increased likelihood of falls (Gadelha et al., 2018; Bauer et al., 2008). Extensive evidence suggests that physical inactivity or decreased levels of PA are the primary cause of sarcopenia and other non-communicable diseases (Cunningham et al., 2020; Bell et al., 2016). In fact, reduced levels of PA are common in ageing (Suryadinata et al., 2020; Westerterp, 2018), but social isolation brought about by the COVID-19 pandemic has affected it even more (Oliveira et al., 2022). Nevertheless, a study by (McPhee et al., 2016) has shown that active older people can reduce the risk of such diseases, and, in addition, they also experience much improved functional capacity and better QoL. PA is a low-cost lifestyle behaviour that has consistently been associated with physical and mental health improvements in the older adult population (Awick et al., 2017).

For these reasons highlighted above, it was essential to investigate current evidence of the effects of home-based exercise on physical fitness in the older population. The first systematic review with meta-analysis on this topic published in 2021 aggregated data from 17 randomised controlled trials and found beneficial effects, although small in magnitude, of home-based exercise programmes on various components of physical fitness, including muscle strength, endurance, power, and balance in healthy older adults, irrespective of sex (Chaabene et al., 2021). Our study included 13 home-based video exercise programmes and found moderate effects on physical fitness parameters, specifically on balance and muscle strength. One of the reasons for the overall moderate effect found in our study might be the mode of the exercise programmes. The Otago Exercise Programme (NCOA, 2023), FlexToBa (McAuley et al., 2012), and Tai-Chi are of low intensity and focus mainly on improving balance and strength parameters. This explains our results regarding the non-significant effect of such programmes on physical performance, specifically on aerobic capacity, as central and peripheral adaptations that increase VO_2 max, also known as maximal oxygen uptake or exercise capacity, are typical after endurance training (Kohrt et al., 1991) also demonstrated that home-based single-mode strength training had moderate effects on muscle strength and balance, while multimodal training produced no statistically significant effects on these parameters, which aligns with our results too. Moreover, the moderate effect found in this study may also suggest either better compliance and/or movement skill competency during the execution of exercise according to pre-recorded video demonstrations at home. However, this needs to be investigated in future studies.

The beneficial effects of different types of exercise to countermeasure muscle wasting with age are already well-documented. For example, it is well established that resistance training is of benefit to older adults by stimulating hypertrophy and increases in muscle strength (Hunter et al., 2004; Christie, 2011), while endurance training is widely recognised for its protective effects against various age-associated chronic conditions, such as diabetes or insulin resistance, that are thought to impair muscle function (Lurin et al., 2019; Lanza et al., 2008). This study's results demonstrate that home-based video exercise programmes might be potent in mitigating age-related declines in physical fitness parameters such as balance and muscle strength, which may prevent the risk of falls in older adults (Thomas et al., 2019). In fact, research indicates that age-associated postural control impairment is related more to strength declines, especially in the lower limbs, than age-associated changes in sensorial integration (Andrade et al., 2017). Thus, promoting and disseminating such exercise protocols may also serve as a preventative measure in age-related sarcopenia, which has been questioned due to disuse physiology (Narici et al., 2010). However, it must be pointed out that regarding home-based exercise, non-adherence might be the biggest culprit in success. Compared to PA done outside or at the gym with or without an instructor, individuals may find it more challenging to commit to exercising at home. For example, non-adherence to home exercise in rehabilitation, where the success of specific medical interventions depends largely on patient adherence to prescribed rehabilitation regimes, including specific exercises to do unsupervised at home to aid recovery, is as high as 50% (Argent et al., 2018). Nevertheless, a recent study by Schwartz et al. (Schwartz et al., 2021) demonstrated that PA protocol delivered live via a video-conferencing platform to older cohorts was very effective in adherence rates, which were as high as 90%, and 97% of participants indicated that they would participate in such a program in the future.

There are limitations in our systematic review and meta-analysis that must be considered. Among them is the relatively small number of included studies with a different type of exercise along with large heterogeneity (except for the balance where we detected zero heterogeneity), which could undermine the accuracy of the study comparisons. Furthermore, we must consider that different characteristics vary among the studies and do not allow a direct comparison of the retrieved results. For example, the majority of studies used different assessment tools for the evaluation of fitness parameters. Most studies also did not assess the physical and training status, which may have led to a biased conclusion.

Quality of the evidence

This review and meta-analysis included 13 studies which used RCT, NRCT and SGT designs. The risk for bias and quality of reporting data was assessed as acceptable for RCT, and NRCT was of medium quality. All included studies assessed effects on the completers only, which may result in an overstatement of the effects due to the high dropout rate.

Potential biases in the review process

This systematic review and meta-analysis are limited to published research; therefore, our review may be biased due to the possible threat of publication and reporting bias.

Agreements and disagreements with other studies or reviews

This present study confirms and extends previous findings (Chaabene et al., 2021) by demonstrating that home-based exercise positively affects components of physical fitness in older adults. The overall medium effect with moderate heterogeneity found in our study suggests that home-based video exercise programmes seem more potent in improving components of physical fitness, such as strength and balance, in older adults.

CONCLUSIONS

The results of the present systematic review and meta-analysis indicate that home-based video exercise programmes positively affect essential components of physical fitness, such as balance and strength, to prevent falls in older adults. Therefore, any positive change in physical fitness parameters measured in this study can only serve as evidence for the benefits of home-based PA in the older population. Thus, promoting it in clinical practice and ideally supporting it through supervision is vital to effectively combat the age-related physical decline, especially for those who end up in home isolation. On the other hand, the main focus in research on home-based (video) exercise should be placed now on improving adherence and investigating preferences and motivational forces of (older) people to keep up with home-based exercise modality.

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