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REVIEW

Multicomponent exercise training does not alter depressive symptoms in older people: a systematic review with meta-analysis of current evidence

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Abstract

Background Depression is a prevalent mental health condition among older adults, negatively impacting their quality of life and overall well-being. Physical exercise has been identified as a potential intervention for improving mental health in this population. Multicomponent training (MCT), which combines exercises targeting multiple physical capacities, is widely prescribed to older adults; however, its efficacy in reducing depressive symptoms (DS) remains unclear.

Objectives This systematic review and meta-analysis aimed to evaluate the effects of MCT on DS in older adults, assess the overall effectiveness of such interventions, and identify methodological and contextual factors that might influence outcomes.

Methods We conducted a systematic search across six databases—PubMed, LILACS, SciELO, Embase, Scopus, and Web of Science—for clinical trials evaluating MCT interventions in older adults with DS. Included studies used the Geriatric Depression Scale (GDS) to assess outcomes. MCT was defined as a training program incorporating at least three distinct physical capacities (e.g., strength, endurance, balance, flexibility). Meta-analyses were performed using a random-effects model (Hedges' g), and study quality was assessed using the TESTEX scale.

Results Ten studies ($n=781$) were included in the systematic review, with five studies ($n=305$) included in the meta-analysis. The pooled analysis revealed no significant overall effect of MCT on DS ($g=-0.090$; 95% CI $=-0.448$ to 0.269, $p=0.624$). Methodological inconsistencies, lack of load control, and high variability in MCT composition across studies were noted. The median methodological quality was moderate (median TESTEX score = 7, IQR 7–8). Recent literature has emphasized the importance of protocol specificity and suggested that current MCT designs may not effectively address mental health outcomes.

Conclusion MCT interventions did not show a significant effect on reducing DS in older adults. Given its frequent prescription in geriatric care, these findings challenge current assumptions about MCT's mental health benefits. This message is crucial for clinicians and researchers, as small variations in protocol design may hinder consistency in outcomes. Further high-quality trials are needed to clarify MCT's potential role in mental health management among older adults.

Keywords Aged, Depressive disorder · Exercise therapy · Physical fitness · Motor activity · Physical functional performance

Introduction

The World Health Organization (WHO) estimates that depression affects about 300 million people worldwide and is the biggest cause of disability [1]. In addition, according to WHO, 7% of the world's older population suffers from clinically significant depressive symptoms (DS); however, this number is probably understated because to stigma and underdiagnosis [2]. Older adults face unique psychosocial stressors such as bereavement, social isolation, cognitive decline, and frailty—all of which can exacerbate DS [3]. Moreover, becomes especially critical considering that DS disproportionately affects older adults, often co-occurring with other chronic conditions and contributing significantly

Extended author information available on the last page of the article to functional decline, loss of independence, and increased mortality risk.

In addition to the global impact of depression, the aging of the world population accentuates the need for innovative interventions to improve the quality of life of older adults [4]. Among the several strategies for treating DS, regular exercise has emerged as a vital non-pharmacologic intervention, serving as an important adjunctive treatment for individuals with DS [5].While pharmacologic treatments are widely used, they often come with undesirable side effects and may be less effective in older adults due to complications arising from polypharmacy and physiologic vulnerability [6, 7]. In this context, non-pharmacologic interventions like regular exercise are essential for enhancing the well-being and health to reduce DS in older individuals [8, 9].

Although the exact mechanisms by which exercise positively influences mental health are not yet fully understood, several factors are believed to contribute to this relationship [10]. These include increased hippocampal volume, elevated levels of brain-derived neurotrophic factor (BDNF), enhanced release of insulin-like growth factor 1 (IGF-1), reduced oxidative stress, and a decrease in pro-inflammatory cytokine production [11–13]. These biologic adaptations may lead to improvements in mood regulation, motivation, and cognitive function [14], which are commonly impaired in individuals with DS.

The antidepressant effects of regular exercise are well-documented in the literature, highlighting its role as a valuable non-pharmacologic intervention for managing DS [10, 15]. Exercise has been shown to influence key physiologic mechanisms, such as increased neurogenesis, improved neurotransmitter regulation, and reduced systemic inflammation, all of which contribute to enhanced mental health [16, 17]. In addition, psychosocial benefits, including improved self-esteem, enhanced self-efficacy, and social interaction, further amplify its positive impact [18, 19]. Together, these effects can lead to reduced anhedonia, improved energy levels, and greater engagement in daily activities—core behavioral aspects commonly affected by depression [20].

Previous studies have consistently demonstrated that both aerobic and resistance training (RT) are effective interventions for managing DS in older adults [21]. Aerobic exercise (AE), particularly at moderate to vigorous intensity (MVI), is supported by a robust body of evidence showing improvements in mood, cognitive function, sleep quality and DS [22–26]. RT, in turn, contributes significantly to mental health by enhancing muscular strength, promoting autonomy, and improving body image and hormonal balance, which are closely linked to emotional regulation [27, 28]. Despite their proven effectiveness, these modalities are often implemented in isolation, potentially limiting their comprehensive benefits. Customizing these interventions to meet individual needs is vital to ensure their effectiveness.

The multicomponent training (MCT) stands out as a comprehensive approach that combines AT, RT, balance, and flexibility training into a single program tailored to the functional and psychosocial needs of older adults [29]**.** This holistic method supports autonomy and health maintenance, directly targeting physical and psychologic dimensions of aging [30]. The MCT has become one of the most commonly prescribed exercise regimens for older adults, owing to its ability to address multiple physical fitness components in a single intervention [31, 32]. Its effectiveness has been highlighted by programs such as Vivifrail, an initiative supported by the World Health Organization [27], which promotes MCT as a cornerstone strategy for maintaining and enhancing both physical and mental health in aging populations [33, 34].

Research has demonstrated MCT's potential in improving outcomes such as strength, balance, cognition, and functional mobility, which are critical for preserving independence and preventing falls in older adults [29–31]. For instance, studies have shown that MCT interventions can significantly enhance functional capacity and reduce frailty risk, offering a holistic approach to aging health [24, 28].

Although MCT encompasses the most effective elements of both AT and resistance RT, the literature still lacks consistency regarding its psychologic outcomes [26]. This highlights the need to examine whether integrating both modalities into a single organized program results in equivalent—or better—effects on DS in older persons, taking into account the most recent studies that compared AT with RT [21, 35]. Since MCT that showed several benefits to the older people and there is a lot of positive evidence regarding health and functional capacity, it is plausible to think that MCT can have a positively impact on DS and mental health by improving psychologic well-being, cognitive resilience and promoting social interaction.

Despite the growing body of evidence supporting the benefits of exercise in mental health, the specific effects of MCT on DS in older adults remain unclear, with existing findings presenting inconsistencies. Furthermore, given the multifactorial nature of DS in aging, identifying effective, multidimensional interventions is not only relevant, but also urgent. The primary objective of this work is to evaluate and consolidate current findings to better understand the effect size of MCT on DS in this population. Ultimately, the goal is to inform the design of more effective, targeted interventions and support the development of integrated care strategies to enhance both mental health and quality of life in aging populations.

Methods

This study is a systematic review with meta-analysis, conducted in accordance with the PRISMA 2020 guidelines to ensure transparency and rigor in the reporting process

[36]. The PRISMA checklist was followed to systematically search, select, and analyze relevant studies, providing a thorough and comprehensive overview of the current research in this area.

Eligibility criteria

The eligibility criteria for this review were developed using the PICOS framework, a widely recognized tool for structuring systematic reviews and meta-analyses of clinical trials. This structure represents: P = Population, I = Intervention, C = Comparator, O = Outcome, and S = Study Design [37]. The detailed criteria for each component are presented in Table 1 below, providing a clear outline of the inclusion and exclusion parameters applied in this review.

Search strategy

The literature search for this review was conducted between July and September 2023 across six electronic databases: PubMed (Medline), SciELO, Scopus, Embase, LILACS, and Web of Science. Only articles published in English, Portuguese, and Spanish were considered. A comprehensive search strategy was employed, using a combination of keywords and Boolean operators to maximize the retrieval of relevant studies. The primary keywords included: "elderly" or "older adults," "multicomponent exercise" or "multicomponent exercise training" or "multicomponent exercise program," and "depressive symptoms." These keywords were combined using the Boolean operators OR and AND to ensure a thorough search of relevant literature. Detailed search strategies for each specific database are provided in Table 2.

Selection and data collection process

Data extraction was conducted manually and independently by two reviewers (A.F.C. and A.L.R.D.) to ensure accuracy and consistency. In cases of disagreement, a third reviewer (S.V.R.) was consulted to resolve any discrepancies. Mendeley reference management software was used to identify and exclude duplicate studies, streamlining the selection process.

Initially, eligible articles were screened based on titles and abstracts. Full-text articles were then reviewed to confirm their suitability for inclusion. The data extraction focused on key variables such as: author, year of publication, country of study, and a detailed description of the intervention (including exercise session organization, intensity, weekly frequency, duration per session, load control, rest intervals, number of exercises, sets, repetitions, types of exercises, total duration in weeks, and session supervision). In addition, information on participant characteristics (age

Table 1 PICOS criteria for study eligibility

PICOS	Criteria
Population	Studies involving individuals aged 60 years or older, regardless of sex, without a prior diagnosis of depression or other conditions that could significantly affect outcomes, such as chronic pain, cancer, dementia, or Alzheimer's disease
Intervention	Intervention studies that utilized MCT and incorporating at least three distinct physical capacities (e.g., resistance and muscle strength, balance, walkability, and others). Studies involving interventions with any form of supplementation were excluded
Comparator	Included either no physical activity (inactive control group) or any other type of physical intervention implemented (active control group)
Outcome	The primary outcome was DS, measured using the Geriatric Depression Scale
Study design	Included were original articles from clinical trials and community trials, both controlled and uncontrolled, randomized and non-randomized

Table 2 Search terms and descriptors used in the systematic review

Data Bases	Combinations of descriptors/terms
PubMed	(elderly) OR (older adults)) AND (multicomponent exercise)) OR (multicomponent exercise training)) OR (multicomponent exercise program)) AND (depressive symptoms)
Scopus	('elderly'/exp OR elderly OR 'older adults'/exp OR 'older adults') AND 'multicomponent exercise' OR 'multicomponent exercise training' OR 'multicomponent exercise program') AND ('depressive symptoms'/exp OR 'depressive symptoms')
Embase	(elderly OR 'older adults') AND 'multicomponent exercise' OR 'multicomponent exercise training' OR 'multicomponent exercise program') AND 'depressive symptoms'
Web of Science	(ALL = (elderly) OR ALL = (older adults)) AND ALL = (multicomponent exercise)) OR ALL = (multicomponent exercise training)) OR ALL = (multicomponent exercise program)) AND ALL = (depressive symptoms)
LILACS	(elderly) OR (older adults) AND (exercise) AND (depressive symptoms)
SciELO	(idosos) *AND* (exercício) *AND* (sintomas depressivos)

and sex), assessment instruments used, outcomes evaluated, and key results were also collected.

Data from the included studies were recorded in a structured spreadsheet, based on the predefined eligibility criteria and specified variables [38]. This process was conducted independently by two reviewers (A. F. C. and A. L. R. D.) to guarantee the precision of the extracted data. Any disagreements were addressed through a consensus meeting, involving all researchers to reach a final agreement.

Risk of bias and study quality

The quality of the included studies was assessed using the new Tool for the Assessment of Study Quality and Reporting in Exercise (TESTEX) scale [39], which is specifically designed to evaluate the reliability of studies involving physical exercise interventions. The TESTEX scale consists of two domains: 1) Study Quality (5 points) and 2) reporting quality (10 points), with a maximum total score of 15 points.

The TESTEX scale emphasizes criteria relevant to physical exercise research, focusing on key aspects of study design, exercise quality, and reporting accuracy while excluding irrelevant factors [40]. Each criterion is scored as 1 point for evidence of adherence and 0 points for lack of evidence (see Appendix A) [39]. This approach ensures a more accurate and comprehensive evaluation of both the methodological rigor and reporting quality in exercise research [40–42].

Data synthesis

Meta-analyses were performed using the random-effects model, which accounts for the expected heterogeneity among studies. Only studies with control groups were included in the meta-analysis. The standardized mean difference (SMD) of Hedge, along with a 95% confidence interval (CI) and precise p values, was calculated for pre- and post-test data from individual studies, when available, and then aggregated. A subgroup analysis was conducted based on the type of control group (active vs. inactive).

To address potential publication bias, the Trim and Fill method was used to estimate the effect size, adjusted for missing studies. The interpretation of the SMD was based on the following thresholds: $g = 0.20–0.49$ indicating a small effect, $g = 0.50–0.79$ indicating a moderate effect, and $g \geq 0.80$ indicating a large effect [43]. In both main and subgroup analyses, negative values of SMD indicated a tendency for a reduction in DS, favoring the MCT groups. The significance level was set at $p < 0.05$. All meta-analytical computations were performed using Comprehensive Meta-Analysis software (*version 2*).

Heterogeneity among studies was assessed using the I^2 statistic, which indicates the proportion of total variability attributable to heterogeneity rather than chance. The following thresholds were used for interpretation: low heterogeneity ($I^2 = 25\% – 49\%$), moderate heterogeneity ($I^2 = 50\% – 74\%$), and high heterogeneity ($I^2 \geq 75\%$) [30]. For studies where means and standard deviations were not reported, the authors were contacted to provide this information, or data were converted from means and confidence intervals when necessary. In one study [31], where results were presented as means and standard errors, the standard error was converted to standard deviation to ensure consistency in the analysis [44].

Results

Study selection

A total of 272 records were initially identified through database searches. Following the removal of duplicates and the screening of titles and abstracts, 245 studies were excluded for not meeting the inclusion criteria. Subsequently, 27 full-text articles were assessed for eligibility. Of these, ten were excluded due to duplication and seven were removed for failing to meet the predefined eligibility criteria. Ultimately, ten studies were included in the final review and meta-analysis (see Fig. 1).

Study characteristics

A total of 781 participants were included across the ten studies selected for this SR [33, 45–53]. Of these studies, five included both male and female participants, while the other five focused exclusively on female participants, highlighting a gender imbalance that may influence generalizability [33, 45, 46, 48–50, 52, 53]. The included studies were published between 2012 and 2023, with participants' mean ages ranging from 66.5 to 82.4 years, reflecting a predominantly older adult population [48, 50]. In terms of geographic distribution, the studies were conducted in diverse regions: four in Brazil, two in Spain, and one each in South Korea, Singapore, Japan, and the United States, demonstrating the global interest in the effects of MCT on older adults' mental health [45, 47–51]; Sample sizes varied substantially across studies, with some including fewer than 30 participants per group, while others enrolled more robust samples [45] (e.g., Tan et al., 2023, with 324 participants distributed across three groups). The mean age and gender distribution across studies are detailed in Table 3.

Among the studies included in this review, all studies assessed DS using the GDS, although different versions of the instrument were employed. The GDS-15, a 15-item version, was the most frequently used [48, 50], while others adopted culturally adapted formats such as the GDS-SF-K

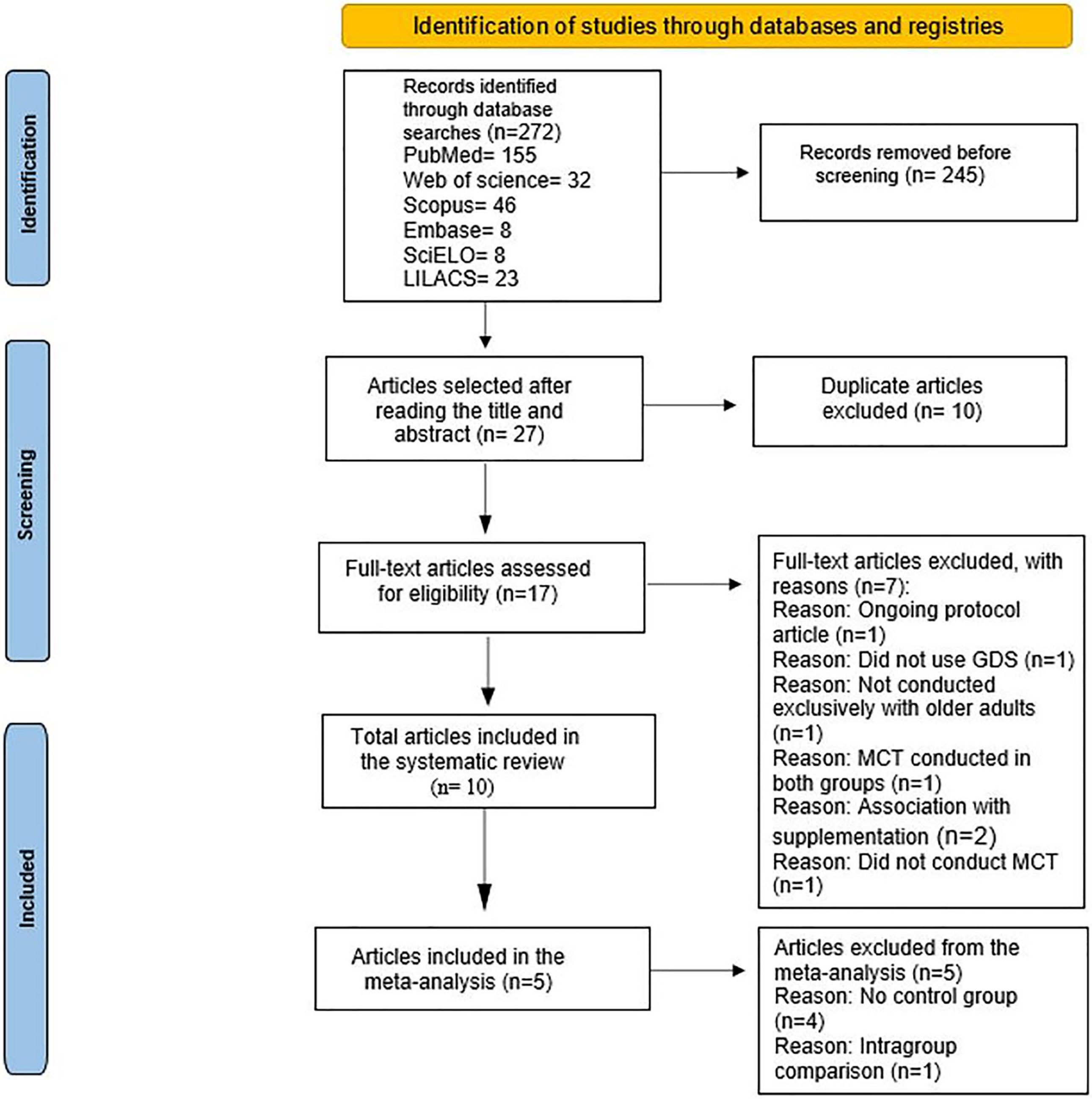

Fig. 1 PRISMA flow diagram of study selection. *GDS* geriatric depression Scale, *MCT* multicomponent training

for the Korean population [47], or more concise forms like the GDS-5 [53].

A variety of intervention protocols and CG conditions were observed. In terms of CG strategies, one author used an active CG involving general health education counseling [45], while other authors employed inactive CGs, such as low-intensity usual activities or educational sessions without exercise [46, 47, 49]. Two studies featured three-arm designs: one compared MCT with cognitive stimulation therapy (CST) and an inactive CG [45], while another compared MCT to RT and a non-intervention control group [51]. The remaining four studies did not include control groups, relying instead on intragroup comparisons to assess outcomes [33, 48, 50, 53].

The frequency of MCT interventions ranged from once per week to three times per week, with session durations varying from 30 to 60 min. The total duration of interventions spanned from 7 weeks to 6 months, reflecting moderate to long-term engagement across studies. Some protocols included additional components, such as walking

Table 3 Sociodemographic characteristics of the included studies

Author, year	Country	Age	Gender	n
Tan et al. (2023)	Singapore	MCT = 73,4 ± 5,2 MCT + CST = 72,6 ± 5,1 CG = 71,7 ± 5,0	Fem/male	MCT (n = 80) MCT + CST (n = 57) CG (n = 187)
Ugartemendia-Yerobi et al. (2023)	Spain	MCT = 80.4 ± 6.9 CG = 80,0 ± 8,5	Fem/male	MCT (n = 21) CG (n = 20)
Song et al. (2022)	South Korea	MCT = 79,6 ± 5,5 CG = 78,0 ± 5,2	Female	MCT (n = 62) CG (n = 64)
Todo et al. (2021)	Japan	MCT = 82,4 ± 7,5	Female	MCT (n = 30)
Cassiano et al. (2020)	Brazil	MCT = 66,5 ± 4,8	Fem/male	MCT (n = 48)
Bacha et al. (2020)	Brazil	MCT = 68,3 ± 5,9 VGK = 69,4 ± 6,4	Fem/male	MCT (n = 6) VGK (n = 8)
Kim et al. (2020)	Korea	MCT = 76,2 ± 5,4	Female	MCT (n = 60)
Ansai et al. (2015)	Brazil	MCT = 81,9 ± 1,9 RT = 82,8 ± 2,8 CG = 82,6 ± 2,6	Female	MCT (n = 23) RT (n = 23) CG (n = 23)
Nascimento et al. (2013)	Brazil	MCT = 67,5 ± 6,2 CG = 67,1 ± 5,1	Fem/male	MCT (n = 27) CG (n = 28)
Toto et al. (2012)	USA	MCT 78,1 ± 8,0	Female	MCT (n = 14)

MCT multicomponent training, *CG* control group, *CST* cognitive stimulation therapy, *VGK* video game Kinect, *RT* Resistance training; mean ± standard deviation; *USA* United States of America; *Fem* female

sessions, [50] or monthly supervised sessions combined with daily unsupervised home-based activities [33].

The physical qualities targeted in the MCT programs typically combined cardiovascular endurance, muscular strength, flexibility, balance, and in some cases, dual-task or postural training—offering a comprehensive approach to physical fitness in older adults. However, despite the multidimensional nature of these interventions, results varied across studies. While some reported significant reductions in DS—particularly those including dual-task elements or cognitive stimulation [45, 47, 48, 53] — others found no statistically significant changes [46, 49–52].

The MCT programs analyzed in the included studies varied in the number and combination of physical capacities addressed. Specifically, five studies targeted four physical components [46, 48, 50, 52, 54], two studies incorporated three components [45, 47], one study included six distinct physical capacities [49], and two studies targeted five capacities [33, 53]. Across all studies, RT were present in 100% of the interventions, followed by balance exercises (90%) and AE (70%). Flexibility, coordination, agility, and postural training appeared less frequently and were typically integrated as secondary components Table 4.

Regarding outcomes, results were mixed. While 60% of the studies did not report statistically significant reductions in DS, four studies found notable improvements in mood and affect following the interventions [45, 47, 48, 53]. These positive outcomes were frequently associated with more cognitively enriched or functionally diverse MCT protocols, suggesting that specific program characteristics may play a decisive role in their effectiveness.

Risk of bias among the studies

The methodological quality of the included studies was assessed using the TESTEX scale (see Table 5), with total scores ranging from from to 12 out of a possible 15 points, indicating considerable variability in research rigor. Most studies demonstrated moderate to low quality, with only two studies achieving scores of 10 or higher [51, 53], suggesting greater methodological robustness.

Several common methodological weaknesses were identified across the studies. Only three studies (30%) reported proper randomization procedures [45, 49, 51], and just 1 study described allocation concealment [51]. Adherence rates above 85% were reported in only 1 study (10%), and data on adverse events and participant attendance were provided in just 2 studies (20%) each. These omissions may limit the interpretability and reproducibility of the interventions.

The lowest overall scores (4 points) were observed in two studies [33, 53], both of which lacked key information related to intervention monitoring and study design. In contrast, one study stood out with a score of 12 [51], fulfilling most quality criteria, including detailed reporting on exercise volume, intensity, adherence, and intention-to-treat analysis.

These findings underscore the need for improved methodological reporting and implementation in future studies on

Table 4 Characteristics of the MCT interventions in the included studies

Author/year	Physical qualities of MCT	Weekly frequency	Session duration	Total intervention	Control group	Results
Tan et al. (2023)	Cardiovascular endurance, strength, dual-task, and balance	2	60 min	6 months	General health education counseling	Significant reduction in all three measures at 3 months for both MCT and MCT + CST
Ugartemendia-Yerobi et al. (2023)	Mobility, strength, balance, and respiratory exercises	3	50 min	12 weeks	Low-intensity usual activities	No significant reductions observed
Song et al. (2022)	Stretching, cardiovascular endurance, and strength	1 + Encouragement to do at home	40 min	12 weeks	Educational sessions and delivery of educational booklets	Significant intra-group reduction observed for MCT
Todo et al. (2021)	Stretching, flexibility, strength, balance, and posture strengthening	1 or 2	40 to 60 min	3 months	Not applicable	No significant reductions observed
Bacha et al. (2020)	Dynamic and static balance, cardiovascular endurance, strength, coordination, and stretching	2	60 min	7 weeks	Interactive video Game	Significant reduction observed in both groups
Cassiano et al. (2020)	Strength, flexibility, balance, and coordination	2 + 1 walking session	60 min	16 weeks	Not applicable	Significant median reduction observed
Kim et al. (2020)	Cardiovascular endurance, strength, flexibility, and balance	1 time per month + daily individual exercises*	30 min	12 weeks	Not applicable	No significant reductions observed
Ansai et al. (2015)	Cardiovascular endurance, strength, and balance	3	60 min	16 weeks	No PEI conducted	No significant reductions were observed for MCT
Nascimento et al. (2013)	Stretching, strength, balance, agility, coordination, and cardiovascular endurance	3	60 min	16 weeks	No PEI conducted	No significant reductions were observed for MCT
Toto et al. (2012)	Cardiovascular endurance, strength, flexibility, and balance	At least 1	60 min	10 weeks	Not applicable	No significant reductions observed

MCT multicomponent training, *CST* cognitive stimulation therapy, *min* minutes; * = monthly; *PEI* physical exercise intervention

MCT for older adults. Particular attention should be given to strengthening internal validity through better randomization procedures, tracking of adherence and attendance, and transparent reporting of adverse events.

Figure 2 presents the overall effect and subgroup analyses of MCT versus CG conditions on DS in older adults. The overall meta-analysis revealed no statistically significant effect in favor of MCT (Hedges' g = −0.090; 95% CI −0.448 to 0.269; $p = 0.624$). Subgroup analyses offered additional insights. When MCT was compared to active CGs, results showed a trend toward favouring the active CGs (positive SMD); however, the difference was not statistically significant (g = 0.199; 95% CI −0.375 to 0.774; p = 0.496). Conversely, comparisons between MCT and inactive control groups indicated a trend favoring MCT (negative SMD), though this effect also failed to reach statistical significance (g = −0.206; 95% CI −0.415 to 0.040; $p = 0.101$).

Statistical heterogeneity was low and non-significant ($I^2 = 0.00$, $p = 0.730$), indicating a high level of consistency across the included studies. Publication bias was assessed

Table 5 Methodological quality of the included studies assessed using the TESTEX scale

Authors	1	2	3	4	5	PTL (0–5)	6a	6b	6c	7	8a	8b	9	10	11	12	PTL (0–10)	TOT (0–15)
Tan et al. (2023)	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	4	5
Uga-Yerobi et al. (2023)	1	0	0	1	0	2	0	0	0	0	1	1	1	0	1	1	5	7
Song et al. (2022)	1	0	0	1	1	3	0	0	0	0	1	1	1	0	0	0	3	6
Todo et al. (2021)	1	NA	0	NA	0	1	0	0	0	0	1*	1*	1	NA	0	0	3	4
Bacha et al. (2020)	1	1	0	1	1	4	0	0	0	0	1	0	1	1	0	0	3	7
Cassiano et al. (2020)	1	NA	0	NA	0	1	0	0	0	0	1*	1*	1	NA	1	1	5	6
Kim et al. (2020)	1	NA	0	NA	0	1	0	0	0	0	1	1	1	NA	0	0	3	4
Ansai et al. (2015)	1	1	1	1	0	4	0	1	1	1	1	1	1	0	1	1	8	12
Nascimento et al. (2013)	1	0	0	1	1	3	0	0	0	0	1	1	1	0	1	1	5	8
Toto et al. (2012)	1	NA	0	NA	1	2	1	1	1	0	1*	1*	1	NA	1	1	8	10

NA Not applicable, *intragroup comparisons, *PTL* partial, *TOT* Total

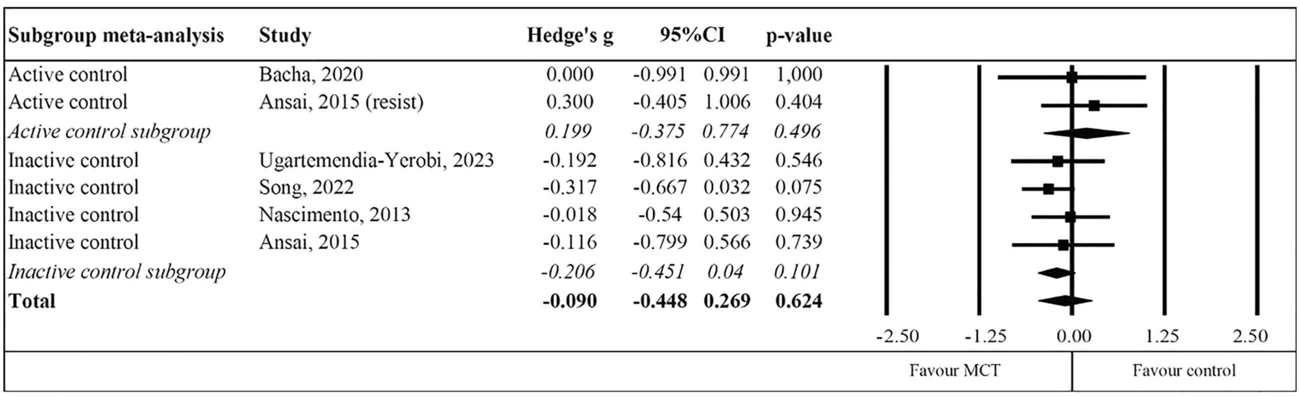

Fig. 2 Forest plot displaying the standardized mean differences (SMDs) and 95% confidence intervals for the effects of MCT on DS in older adults. Subgroup analyses compare MCT with active CGs and inactive CGs, alongside the overall pooled effect across studies

using a funnel plot (Fig. 3), which did not reveal statistically significant asymmetry (Egger's test: $p = 0.11$). However, visual inspection suggested a possible absence of smaller studies favoring MCT, as indicated by the filled circles in the plot. To address this potential bias, the Trim and Fill method was applied. The adjusted effect size showed a slight shift in favor of MCT, although it remained statistically non-significant (g = −0.260; 95% CI = −0.454 to 0.064, $p = 0.101$), with three studies imputed through this method.

Discussion

To the best of our knowledge, this is the first systematic review and meta-analysis specifically evaluating the effects of MCT on DS in older adults. Although the pooled results did not demonstrate a statistically significant reduction in DS, this review contributes valuable insights into a growing field of research and helps identify key directions for future investigation.

Ten studies were included in this review, with five of them meeting the criteria for inclusion in the meta-analysis. Four studies were excluded due to the absence of a control group [33, 48, 50, 53], and one was excluded for not reporting between-group p values [Song et al., 2022]. Among the included studies, eight investigated DS as a primary outcome. Our findings diverge from previous systematic reviews on the antidepressant effects of physical exercise, which have shown favorable effects of AT [22, 23], and resistance training [24, 25]. These discrepancies may be attributed to the heterogeneity in training protocols [55], participant characteristics, and study design, highlighting the complexity of exercise interventions targeting DS in older adults.

Subgroup analyses revealed no statistically significant differences between MCT and either active or inactive controls. However, a slight trend favoring active controls (g = 0.199)

Fig. 3 Funnel Plot Assessing Publication Bias. Open circles (○) represent observed studies; filled circles (●) indicate studies imputed by the Trim and Fill method

could suggest that these groups might be perceived as more engaging or structured than MCT, potentially leading to higher adherence, as suggested in a study conducted in Korean participants [33]. Conversely, MCT showed a non-significant but favorable trend when compared to inactive controls (g = −0.206), indicating that regular exercise — even if not superior to active control interventions—may still be more beneficial than no structured activity. Nonetheless, these interpretations must be made cautiously, given the limited number of studies and relatively small sample sizes.

The average methodological quality of the included studies was moderate, with a median TESTEX score of 6.5, suggesting that many studies had limitations in reporting key methodological details. Only three studies scored above the midpoint of the scale, and critical elements such as adherence rates and adverse events were frequently not reported in the exercise intervention studies. Given that the efficacy of exercise interventions is closely linked to factors like training dose and participant adherence [56], these reporting gaps undermine the ability to fully interpret the findings. The lack of comprehensive reporting may have contributed to the absence of statistically significant effects in the meta-analysis [57], as the variability in study protocols and adherence could have obscured potential benefits of MCT on DS.

Furthermore, there was considerable inconsistency in how MCT protocols were delivered. Only two studies reported the number of sets [45, 51], and just one described circuit training with specific durations per station [48]. Intervention durations ranged from 7 weeks to 6 months, and frequencies from one to three sessions per week. However, only three studies implemented training at least three times per week, which is the minimum frequency often recommended for reducing DS [58]. Notably, none of the included studies clearly reported how training loads were monitored or adjusted over time—such as progression of resistance, intensity, or workload distribution—limiting the ability to assess the adequacy of the exercise stimulus. This omission is critical, as appropriate load progression is a key principle in exercise prescription [59], particularly in programs aiming to elicit both physical and psychologic adaptations.

In fact, the format and structure of the MCT program can indeed influence the results observed. Variations in training modalities and protocol characteristics could significantly affect the biologic and behavioral factors, such as adherence, motivation, and the physiologic response to exercise [60–62], which in turn may either enhance or limit the mental health benefits, including the reduction of DS [58]. Moreover, it is possible to speculate that the interaction between biologic and behavioral factors, mediated by more consistent and individualized protocols, could potentiate the outcomes of MCT in reducing DS [63]. The adaptation of MCT programs to the specific needs of participants, considering their physical capacity, preferences, and motivation levels, may be a crucial strategy for improving results, making the training not only more effective but also more sustainable over time.

Importantly, the baseline severity of DS appears to be a crucial factor influencing the impact of MCT. Some included studies enrolled participants with low or normal GDS scores, leaving limited room for measurable improvement. In contrast, studies with higher baseline GDS values [46, 49], reported significant within-group improvements, reinforcing the idea that baseline symptom severity may moderate treatment effects. Several studies have demonstrated that individuals with more severe DS are more likely to show improvements following interventions, such as exercise [64, 65]. These findings highlight the need to stratify participants by baseline DS severity in future trials to better evaluate treatment responses. Such stratification could help identify subgroups that benefit most from MCT and refine intervention protocols to optimize effectiveness.

Despite the lack of statistically significant findings, it is worth noting that other types of exercise interventions, including low-intensity activities such as yoga, and Tai Chi, have been associated with reductions in DS [66]. Unlike these approaches, which often incorporate structured relaxation, breathing, and mindfulness components, MCT interventions tend to emphasize functional physical fitness without necessarily including elements known to support psychologic well-being. Many of the reviewed studies failed to provide a clear definition or structure of MCT, contributing to difficulties in monitoring training loads and standardizing/replicable intervention. This variability may, in turn, help explain the inconsistent findings regarding MCT's impact on DS.

A very recent position statement by leading international experts emphasizes two key points relevant to this review [67]. First, it clarifies the optimal composition of MCT. Second, it underscores those different types of exercise—whether performed in isolation or combination—may influence DS in distinct ways. However, the current body of evidence supporting the effectiveness of exercise specifically for sustained brain health remains limited and of low certainty [68], reinforcing the need for more rigorous and targeted investigations in this area.

In addition, the potential influence of psychosocial mechanisms should not be overlooked. Social engagement, peer support, and the perception of competence associated with group-based exercise can all enhance self-efficacy and mental well-being [26]. It is important to consider that the social components of group-based exercise programs may serve not only as a complementary aspect of the physical activity but also play a critical role in psychologic improvement. The feeling of belonging, shared experiences, and social bonding inherent in group settings could amplify the positive effects of physical exercise on DS [69].

Specifically, the perception of competence and mastery, which may be heightened through positive feedback from peers and the supportive group dynamic, could further boost self-efficacy and motivation [70]. These factors, although not always explicitly measured, may contribute significantly to exercise-related reductions in DS. Several studies in this review included group sessions, which may have unintentionally delivered social benefits alongside physical ones.

Another important aspect to consider relates to the gender composition of the study samples [71]. It was observed that the majority of participants across the included studies were women. This predominance may be attributed to the well-documented trend that women are generally more inclined to participate in health-related research, particularly studies involving group-based physical activities such as stretching, AE, dance, yoga, walking, and machine-based cardiovascular training [72]. Furthermore, women are more likely to engage in research focused on mental health, which may have influenced the gender imbalance observed in the studies included in this review.

Strengths and limitations

This review represents the first review with metanalysis to evaluate the effects of MCT on DS in older adults, addressing a previously underexplored area. A major strength is the use of the GDS, a validated and widely used tool, which enhances consistency across studies and strengthens outcome comparisons. However, several limitations must be acknowledged. Many studies lacked detailed descriptions of MCT protocols—particularly in terms of load control and session structure—limiting reproducibility and interpretation. The broad age range and international diversity of participants, while increasing generalizability, may also introduce heterogeneity. Finally, the small number of included studies and their generally modest methodological quality weaken the robustness of the conclusions and highlight the need for higher-quality research in this field.

Future insights

Future clinical trials should adopt standardized and well-described MCT protocols, clearly reporting intensity, duration, frequency, load progression, and exercise type to improve replicability and interpretability. Larger, methodologically robust studies with diverse older populations and validated tools for assessing depressive symptoms are needed. Greater attention should be given to monitoring training load and exploring both physiologic and psychosocial mechanisms, which may mediate the mental health benefits of MCT.

Conclusion

Although this review did not find significant evidence that MCT reduces DS in older adults, this finding should be interpreted cautiously. Several limitations may have influenced the results, including the small number of studies, overall moderate methodological quality, and high variability in MCT protocol structures. Notably, no study clearly reported how training loads were monitored or adjusted over time, which is a critical factor in determining the effectiveness of interventions. In addition, differences in how MCT was conceptualized and implemented—ranging from the type and number of components to session frequency and progression—make it difficult to draw firm conclusions. Despite these inconsistencies, MCT remains relevant due to its established benefits on physical function and quality of life.

Appendix A: TESTEX Scale: Tool for the Assessment of Study Quality and Reporting in Exercise

The TESTEX (Tool for the Assessment of Study Quality and Reporting in Exercise) scale is a validated instrument designed specifically to assess the quality and reporting standards of clinical trials involving physical exercise interventions. The scale includes 12 criteria divided into two domains: Study Quality and Reporting Quality, with a maximum score of 15 points.

A. Study Quality (Maximum = 5 points).

(1) Eligibility criteria specified
(2) Randomization specified
(3) Allocation concealment specified
(4) Groups similar at baseline
(5) Assessor blinding for at least one key outcome

B. Reporting Quality (Maximum = 10 points).

(6) Outcome measures assessed in ≥ 85% of participants
(7) Intention-to-treat analysis
(8) Between-group statistical comparisons reported
(9) Point measures and variability data reported
(10) Activity monitoring in control groups (e.g., physical activity logs)
(11) Relative exercise intensity prescribed
(12) Exercise volume and energy expenditure reported

Each item is scored as 1 point if clearly reported and justified in the manuscript, or 0 points if not. This structure allows for an objective evaluation of methodological rigor and reporting transparency in trials, particularly those involving structured exercise protocols.

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