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Effect of physical activity for reducing anxiety symptoms in older adults: a meta-analysis of randomized controlled trials

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Abstract

Background Anxiety symptoms in older adults can significantly impact their well-being. Physical activity is increasingly recognized as a potential intervention to alleviate anxiety in this population. We conducted a systematic review and meta-analysis to explore the impact of physical activity on anxiety symptoms in geriatric individuals.

Methods A systematic search was conducted in MEDLINE (via PubMed), Scopus, and Embase databases until November 29, 2023. Two independent reviewers screened articles based on predefined inclusion criteria.

Results Eleven randomized controlled trials were included. These trials, involving 770 geriatric participants, demonstrated a significant overall effect of physical activity on reducing anxiety symptoms (SMD = -0.60, 95% CI: -0.88 to -0.32). Subgroup analysis based on type of intervention and duration of follow-up was performed. The results showed all types of exercises reduced anxiety symptoms compared to the control group. Furthermore, those studies with shorter follow-up (less than 10 weeks) did not show a statistically significant reduction in anxiety symptoms. Moderate heterogeneity was observed ($I^2 = 67%$). Sensitivity analyses confirmed the robustness of the overall effect size. Funnel plot inspection and Egger's test ($p = 0.36$) suggested no signs of publication bias or small study effects.

Conclusion This meta-analysis provides strong evidence that physical activity significantly reduces anxiety symptoms in older adults. The study highlights the differential effects of cardio and strength exercises and underscores the high quality of evidence supporting the anxiolytic benefits of physical activity in geriatric populations.

Keywords Physical activity, Exercise, Anxiety, Older adults

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Introduction

Anxiety disorders are one of the most prevalent categories of mental health conditions and typically appear either before or during early adulthood [1]. Generalized anxiety disorder, social anxiety disorder, and panic disorder (with or without agoraphobia) are the most frequent anxiety disorders among the population [2]. They could also be accompanied by physical symptoms, such as shortness of breath, palpitations, and dizziness [2]. Of note, The World Health Organization (WHO) has classified anxiety disorders as the ninth most significant contributor to health-related disability, due to their high prevalence and morbidity [1, 3].

The process of aging is often associated with various physiological, psychological, and social challenges, potentially resulting in elevated levels of anxiety in the older population [4, 5]. The prevalence of anxiety in the older population is evaluated up to 15% in community samples [6]. Moreover, the impact of anxiety on the aging population could be significant and disabling [7]. Importantly, along with the aging of the global population, the prevalence of anxiety in older adults has turned out to be a serious public health concern, underscoring the necessity for effective interventions [8].

Various methods have been investigated and introduced to mitigate anxiety among this population, which are categorized into pharmacological [9] and non-pharmacological interventions, such as cognitive behavioral therapy and relaxation interventions [10–12]. For instance, music therapy has proven to be effective in managing anxiety in this population [13, 14]. Notably, a comparative analysis suggests the association of a sedentary lifestyle with higher levels of anxiety in the aging population, emphasizing the importance of physical activity in managing anxiety among the geriatric population [8]. Of note, various trials have evaluated the effect of physical activity in different forms such as pilates training, walking exercises, aerobic exercises, and resistance training, in managing anxiety in older adults [15–19]. The importance of aggregating the results of previous studies as a meta-analysis is evidenced in the literature [20]. Previous meta-analyses are available on this topic [21, 22]. Kazemnia et al. reported a decrease in anxiety symptoms after the sport intervention. Their study reported a comprehensive analysis of clinical trials; however, their conclusions were based on a before/after analysis [21, 23]. Before/after meta-analyses should be avoided for drawing evidenced based conclusions [23]. Another recent meta-analysis by Ofuso et al. [22] provided the results of 5 RCTs, however, additional RCTs are available on this topic. Hence, this systematic review and meta-analysis aims to review the published randomized clinical trial (RCT) studies addressing the effect of

physical activity on anxiety among the geriatric population comparing it to the control group.

Method

The present systematic review was conducted in accordance with the Cochrane Handbook and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [24, 25]. Our study protocol was retrospectively registered at PROSPERO under the number CRD42023488026.

Search strategy

A systematic search was performed through MEDLINE (via PubMed), Scopus, and Embase databases until December 30, 2023. The following keywords were utilized as search strategy: (“physical activity” OR “exercise” OR “train*”) AND (“older adults” OR “elderly” OR “geriatric*”) AND (“anxiety”). No language restrictions were imposed.

Study selection and data extraction

Two reviewers independently performed screening of the retrieved articles to include studies that met following inclusion criteria: (1) patient population: older adults (Above 60 years); (2) intervention: any cardio or resistance exercise that results in increase of heart rate; (3) comparison: active control groups which have not received any special recommendation for improving their physical activity; (4) outcome: anxiety level assessed by validated questionnaires; and (5) study design: only randomized controlled trial. Two reviewers will independently extract data from the included studies using a standardized data extraction form. The extracted information will include study characteristics (authors, year of publication, location), participant demographics, details of the physical activity intervention (type, duration, frequency), comparison group details, outcome measures, follow-up duration and main results. Any discrepancies between reviewers will be resolved through discussion or by consulting a third reviewer.

Risk of bias assessment

The risk of bias of the included studies was assessed using the Cochrane Collaboration’s tool for assessing the risk of bias in randomized trials (RoB2). This tool evaluates potential bias in several domains, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other biases. Disagreements were solved by the third reviewer.

Quality of evidence

The quality of evidence has been evaluated using the GRADE approach, and the results have been incorporated into the [results](#) section. The GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) approach is a systematic method used to assess the quality of evidence and the strength of recommendations in healthcare. It categorizes evidence quality into four levels: high, moderate, low, and very low, considering factors such as study design, risk of bias, inconsistency, indirectness, imprecision, and publication bias. GRADE helps create evidence profiles and summary tables to present the findings clearly. This method ensures that clinical practice guidelines and systematic reviews are based on reliable evidence, ultimately guiding healthcare professionals in making well-informed decisions that balance benefits and risks for patients

Statistical analysis

To pool the effect sizes of the included studies, standardized mean differences (SMD) with their 95% confidence intervals (CI) were calculated using the post-intervention mean (SD) scores in both groups. A random effects model was employed to account for the potential heterogeneity among studies. The method used to estimate the between-study variance was the Restricted maximum likelihood (REML). Cochran’s Q statistic (Q-test) and the I² statistic were used to assess heterogeneity, with high heterogeneity defined as an I² value greater than 75%. For assessing possible publication bias, funnel plots and Egger’s regression test (with a significance level of 0.1) were used, provided there were at least 10 studies included. To perform sensitivity analysis, the leave-one-out method was applied to our outcome. Subgroup analyses were conducted based on the type of exercise

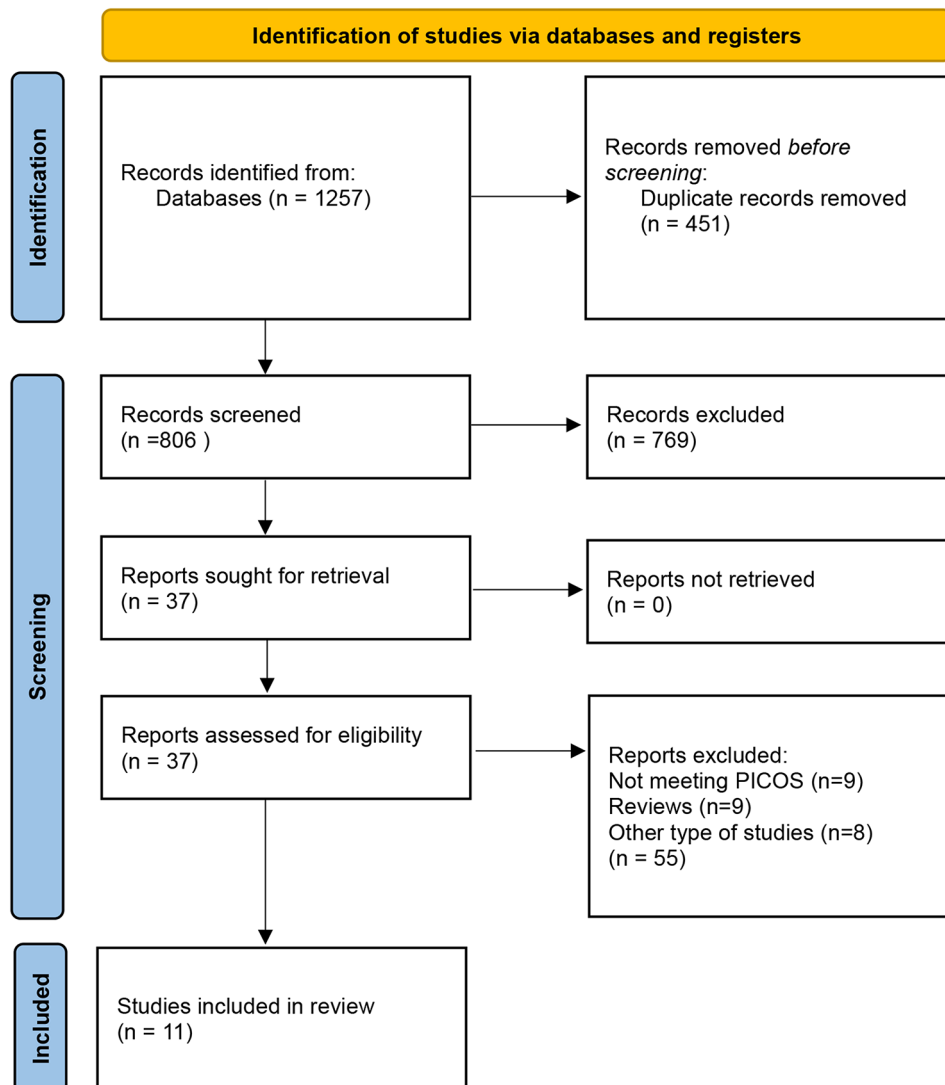


Fig. 1 PRISMA flowchart

and duration of follow-up. The analyses were considered significant with a p -value < 0.05 . The R meta-package was utilized for all statistical analyses. The code used is publicly available on GitHub (<https://github.com/Dr-Tlou/Code-for-meta-analysis>).

Results

Study selection

The initial database search yielded a total of 1257 articles. After screening titles and abstracts, 37 articles were selected for full-text review. Ultimately, 11 randomized controlled trials (RCTs) met the inclusion criteria and were included in the meta-analysis [15, 17–19, 26–33] (Fig. 1).

Characteristics of included studies

The included RCTs were conducted across diverse geographic locations and involved a total of 770 geriatric participants. The sample sizes of individual studies ranged from 14 to 203. The trials varied in duration, with intervention periods ranging from 6 weeks to 12 months. Interventions predominantly focused on various forms of physical activity, including aerobic exercises, resistance training, and combination programs. Baseline characteristics of the included studies is available in Table 1.

Effect of physical activity on anxiety symptoms

The meta-analysis revealed a significant overall effect of physical activity on reducing anxiety symptoms among geriatrics (SMD = -0.60, 95% CI: -0.88 to -0.32) (Fig. 2).

Subgroup analysis

Subgroup analysis based on type of intervention and duration of follow-up was performed. The results showed all types of exercises reduced anxiety symptoms compared to the control group (Fig. 3). Furthermore, those studies with shorter follow-up (less than 10 weeks) did not show a statistically significant reduction in anxiety symptoms.

Heterogeneity and sensitivity analysis

Moderate heterogeneity was observed among the included studies ($I^2=67%$). Sensitivity analyses were performed by excluding one study at a time, and the overall effect size remained robust, confirming the stability of the results (Fig. 4).

Publication bias

Visual inspection of the funnel plot suggested did not show possible signs of publication bias. Egger's test did not reach statistical significance ($p=0.36$), indicating no possible signs of small study effects that could impact the overall findings (Fig. 5).

Risk of bias and quality assessment

The overall risk of bias was assessed using the RoB-2 assessment tool. The overall risk of bias of included RCTs for the reduction of anxiety symptoms through physical activity was graded low, indicating a high level of confidence in the findings. (Fig. 6). The results of quality assessment are in Table 2 suggesting a moderate level of certainty regarding the primary outcome.

Discussion

To our current understanding, this systematic review and meta-analysis represent the most exhaustive examination of the influence of physical activity on anxiety in the older adults, drawing insights from outcomes derived from peer-reviewed randomized clinical trials. Our results demonstrate a notable reduction in anxiety symptoms attributable to engagement in physical activity. Through subgroup analyses, we explored the effects of various types of physical activity. Notably, all types of exercise (including resistance trainings, cardio trainings, and combination of both) exhibited independent efficacy in alleviating anxiety. Furthermore, longer duration of exercise showed larger effect on reducing anxiety.

The rising importance of mental health care in an aging population

The aging of global population is on the rise, emphasizing the need for increased attention to mental health care for the older adults. According to WHO, number and proportion of people aged 60 years and older in the population is increasing. By 2050, the prevalence of the world's population over 60 years will be double from 12 to 22% [34]. This demographic shift brings attention to the importance of mental health care for older adults. Several factors, such as exposure to adversity, significant loss in intrinsic capacity, decline in functional ability, and the experience of adverse events like bereavement, retirement, and reduced income, can lead to psychological distress [35]. Older adults are more likely to experience conditions like depression and anxiety, with around 14% of adults aged 60 and over living with a mental disorder [36]. The stigma surrounding mental health conditions and the under recognition of these issues make it crucial to prioritize mental health care for the elderly [37]. Mental health problems can significantly impact an older person's ability to carry out daily activities, emphasizing the need for early recognition, diagnosis, and treatment to prevent further decline in their well-being [38].

Mechanisms of exercise in reducing anxiety among the elderly

Exercise has been shown to be beneficial in reducing anxiety in the elderly population through various mechanisms. Research suggests that exercise reduces anxiety

Table 1 Characteristics of the included studies

Author	Year of Publication	Country	Population	Sample Size (n)	Intervention	Control	Anxiety assessment	Follow up assessments
A. Aibar-Almazán	2019	Spain	Spanish post-menopausal women	107 Control (n=52) Pilates (n=55)	Pilates training		Hospital Anxiety and Depression Scale (HADS)	12 weeks
E. C. Chin	2022	Hong Kong	Older adults with insomnia	46	Walking sessions	stretching exercises	HADS	12 weeks
P. Deka	2021	USA	Patients with a diagnosis of CAD	90	high-intensity treadmill walking, resistance training		HADS	8 weeks
R. M. Ferreira	2018	USA	Individuals from the Parkinson's Association in the State of Pará	35	resistance training		BAI	24 weeks
A. A. Ibrahim	2023	Saudi Arabia	Post-COVID-19 patients	72	walking on treadmill	Received medical care and advice	HADS	10 weeks
I. Imayama	2011	USA	Overweight/obese postmenopausal women	TOTAL = 439	aerobic exercise	not given an intervention	BSI-18	12 months
M. K. Mikkelsen	2022	Denmark	Older Patients with Advanced Cancer	84	Supervised exercise training: Warm up / PRT/ exercises / Relaxation Unsupervised exercise: Walking program	Step counting	HADS	13 weeks
A. Ruiz-Comellas	2022	Spain	Elderly with Anxiety, Depression, and Low Social Support	90	Walking	Usual care	GAD-7	4 months
R. W. S. Sit	2021	Hong Kong	Older Patients with chronic musculoskeletal pain	72	warming up (10 min), NM exercise (45 min), and cooling down (5 min).	Waiting-list	GAD-7	6 weeks
D. J. Yu	2022	Hong Kong	Middle-aged and older adults with mild cognitive impairment	37	walking group	stretching exercise	HADS	12 weeks
D. J. Yu	2023	Hong Kong	Middle-aged and older adults	30	walking exercise group	No intervention	GAD-7	12 weeks

by providing a time-out from daily stressors, reducing inflammation and oxidative stress, and stimulating the production of endorphins, which are the body's natural painkillers and mood elevators [39–41]. Additionally, exercise can alleviate symptoms of anxiety by improving physical health, reducing the negative effects of stress, and improving mood. Furthermore, physiological mechanisms, such as alterations in the serotonergic and noradrenergic pathways, have been proposed as potential means through which exercise reduces anxiety [42]. The study by Ma et al. aimed to explore the factors influencing

physical activity among Taiwanese adults with anxiety by testing a theoretical model using structural equation modeling. The research included 239 participants and assessed the direct and indirect impacts of 11 personal and cognitive-emotional variables on physical activity levels. The analysis led to a model that accurately fit the data, with nine of the variables explaining 23.3% of the variance in physical activity levels. The findings highlighted that perceived life stress events, perceived benefits of physical activity, and self-efficacy regarding physical activity were significant direct influencers of

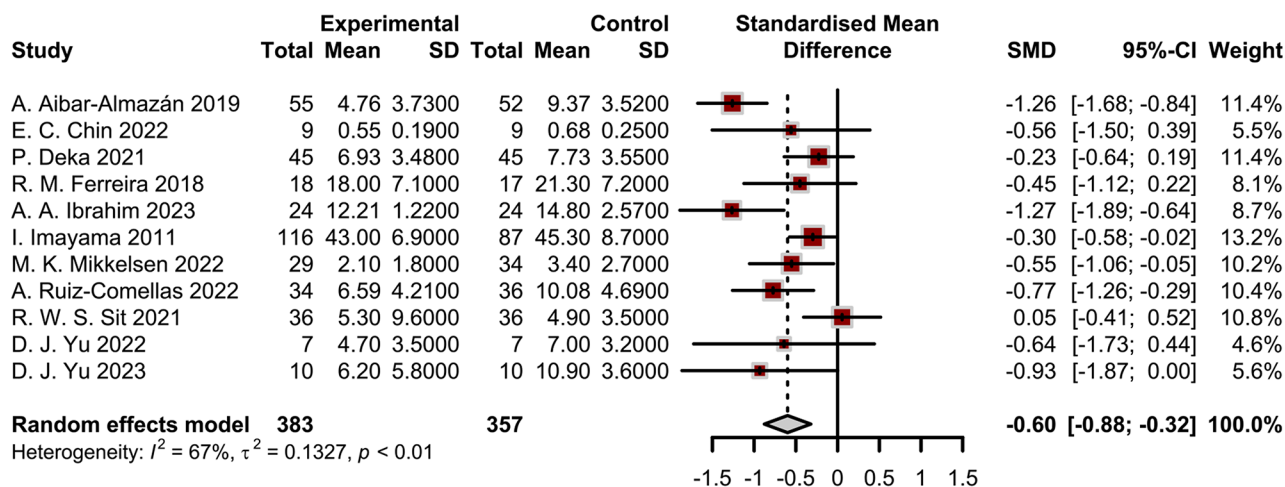


Fig. 2 Results of meta-analysis

physical activity. These results suggest that interventions designed to enhance physical activity in Taiwanese adults with anxiety should specifically address these factors to be more effective [43]. Therefore, the evidence supports the use of exercise as an effective intervention for reducing anxiety in the elderly population, with multiple biological and psychological mechanisms contributing to its beneficial effects.

Role of different type of exercises in reducing anxiety

Numerous studies have shown that aerobic exercise, such as walking, running, and cycling, can significantly reduce anxiety symptoms in older adults. The physiological mechanisms include the release of endorphins and improved cardiovascular health, which collectively enhance mood and reduce stress levels [44]. For instance, a meta-analysis by Yao et al. demonstrated that older adults engaging in aerobic exercises experienced a significant reduction in anxiety [45]. Resistance training, involving activities such as weightlifting and resistance band exercises, has also been found to alleviate anxiety symptoms [46]. This form of exercise not only improves muscle strength and endurance but also contributes to psychological well-being. A mixed method systematic review by Li et al. [47] reported that older participants who engaged in resistance elastic band training showed significant improvements in their mental health. As showed in our study, engaging in group-based exercises, such as group walking or group dance classes, can also provide social support and a sense of community, which are crucial for mitigating anxiety in older adults [48]. Social interaction during these activities can reduce feelings of isolation and loneliness, further contributing to decreased anxiety levels [49].

As we found in the results of our subgroup analysis, both cardio and resistance exercise have benefits for reducing anxiety levels in older adults. However, no

unique RCT or network meta-analysis have been performed to compare the efficacy of each type of aforementioned exercises (or a combination of both) on anxiety levels among geriatrics. Future studies are warranted to yield this gap of knowledge.

Implications

In terms of clinical implication, the research on the effect of exercise on anxiety in the elderly is important as it provides evidence that physical activity is among the most important, simplest, and cheapest approaches to anxiety treatment for this population [50]. This research can help improve the care given to the elderly population with anxiety by highlighting the effectiveness of exercise in reducing anxiety symptoms, providing a non-invasive and accessible intervention, and emphasizing the importance of early recognition and appropriate treatment to prevent negative consequences associated with anxiety in older adults. Additionally, understanding the mechanisms through which exercise reduces anxiety can inform the development of tailored exercise interventions to better support the mental health needs of the elderly population, improving public health.

Strengths and limitations

Our investigation delves into a topic that has been the focus of two other systematic review and meta-analysis studies [21, 51]. However, our study stands out for its methodological robustness, boosted by several advantages such as: (1) selective inclusion of Randomized Controlled Trials (RCTs), renowned for their stringent methodologies and controlled environments. This strict approach contributes to the heightened reliability of outcomes when compared to studies that include studies with different research types; (2) our analyses integrate more recent studies with updated methodologies and results, reinforcing the relevance of our findings; (3) the

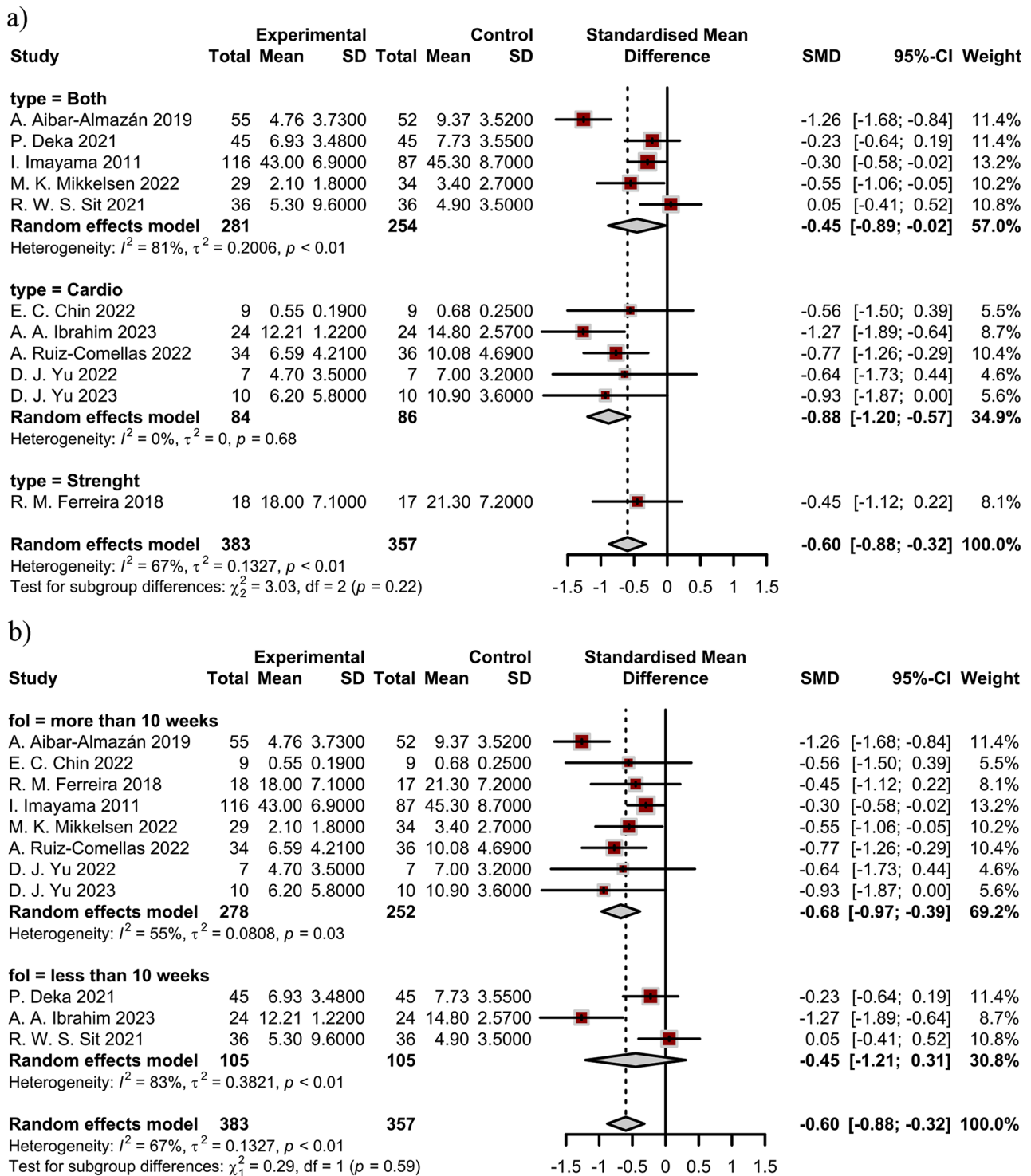


Fig. 3 Results of subgroup analysis: (a) type of intervention; and (b) duration of follow-up

quality of evidence of the studies included in our analyses was assessed as high; (4) we conducted subgroup analyses to systematically evaluate the impact of potential confounding factors, such as variations exercise, and duration; and 4) the heterogeneity of results among the

studies included in our investigation is noticeably lower than the mentioned studies. It is important to acknowledge the limitations we encountered. First, the included studies had relatively small participant numbers, prompting the need for future research with larger groups to

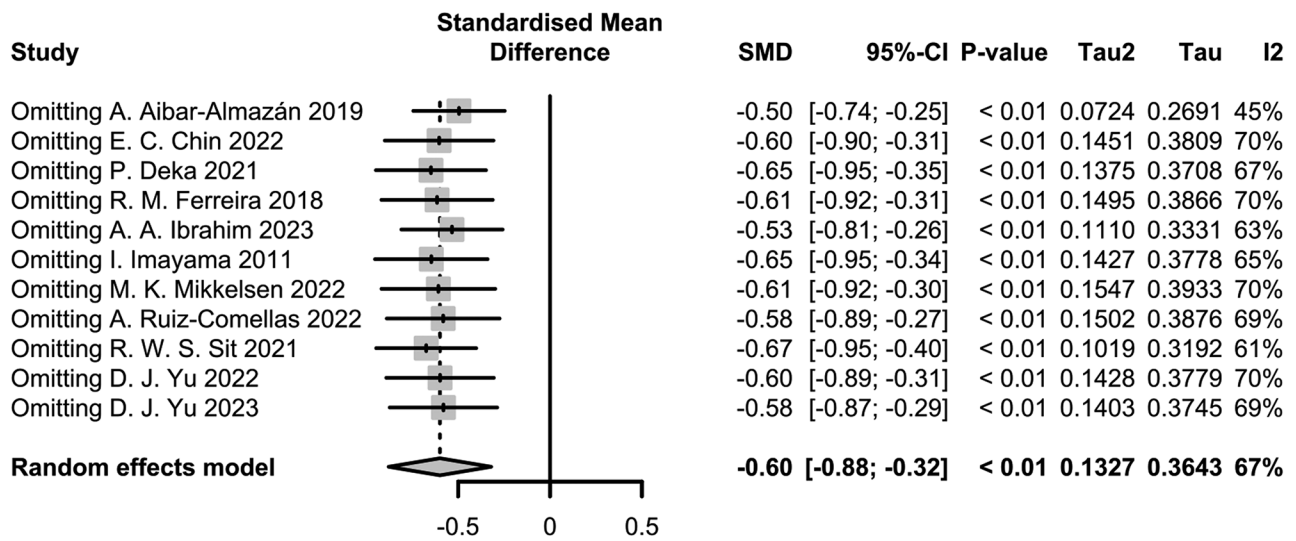


Fig. 4 Results of sensitivity analysis

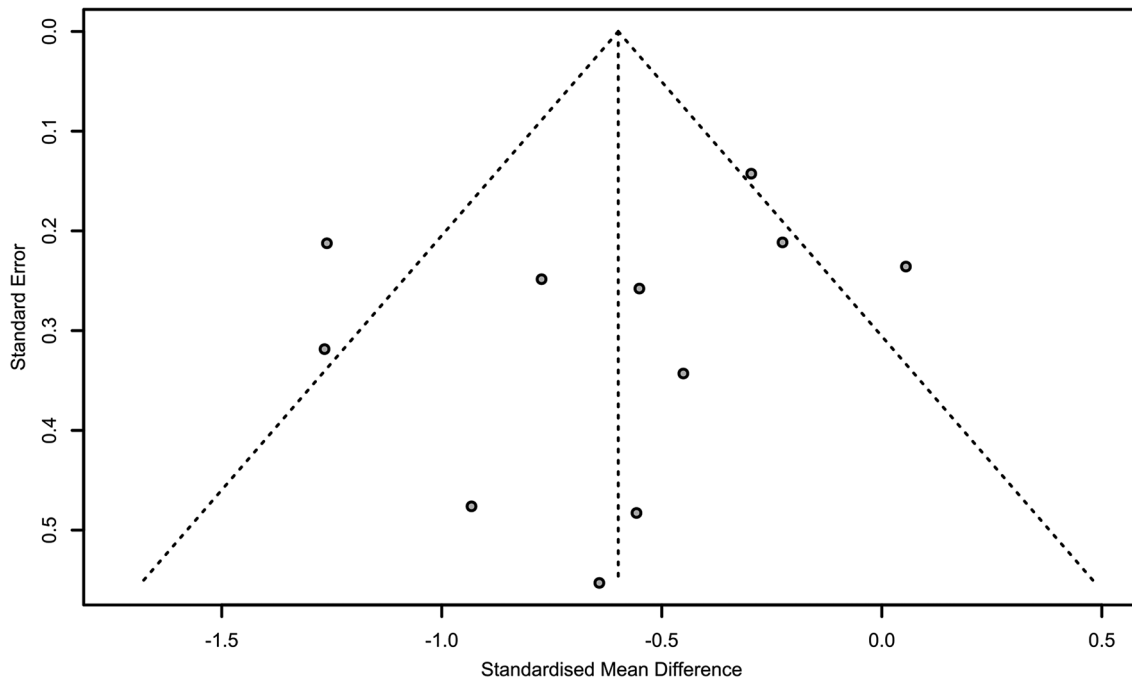


Fig. 5 Funnel plot (Egger test: p-value=0.36)

enhance the certainty and accuracy of our results. This consideration is pivotal for advancing our comprehension of the subject matter. Second, there was no study with main focus on comparing different types of exercises together. Finally, few studies have been conducted on the effect of resistance exercises. The majority of included studies were focused on cardio exercises or a combination of both cardio and strength training.

Conclusion

This systematic review and meta-analysis provide compelling evidence of RCTs on the significant impact of physical activity on reducing anxiety symptoms in the elderly population. The demonstrated efficacy of physical activity, particularly cardio and strength exercises, in alleviating anxiety, underscores the importance of incorporating tailored exercise interventions into strategies for anxiety management in the elderly. The limitations related to the relatively small participant numbers in the included studies highlight the need for future research



Fig. 6 Results of risk of bias assessment

Table 2 Summary of GRADE assessment for quality of evidence

Outcome	No. of Studies	Effect Estimate (95% CI)	Risk Of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality of Evidence (GRADE)
Primary outcome	11	-0.60 [-0.88, -0.32]	Not serious	Not serious	Serious	Not serious	Not serious	Moderate

with larger groups to enhance the certainty and accuracy of our results.

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Author contributions
A.S., S.G: Project Administration, Data curation, Writing- Original Draft, Writing – Review & Editing, Visualization M.M.TA, M.B., H.F, Z.N, S.PO: Validation, Resources, Methodology, Software, Formal analysis, Writing – Original Draft.

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Data availability
All data has been presented in the manuscript.

Declarations

Ethics approval and consent to participate
Not applicable, this systematic review and meta-analysis was registered in PROSPERO.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References
1. Penninx BW, Pine DS, Holmes EA, Reif A. Anxiety disorders. Lancet. 2021;397(10277):914–27.

2. Szuhany KL, Simon NM. Anxiety disorders: a review. *JAMA*. 2022;328(24):2431–45.
3. Global regional. National incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the global burden of Disease Study 2016. *Lancet*. 2017;390(10100):1211–59.
4. Balsamo M, Cataldi F, Carlucci L, Fairfield B. Assessment of anxiety in older adults: a review of self-report measures. *Clin Interv Aging*. 2018;13:573–93.
5. Kang H, Kim H. Ageism and Psychological Well-being among older adults: a systematic review. *Gerontol Geriatr Med*. 2022;8:23337214221087023.
6. Bryant C, Jackson H, Ames D. The prevalence of anxiety in older adults: methodological issues and a review of the literature. *J Affect Disord*. 2008;109(3):233–50.
7. de Beurs E, Beekman AT, van Balkom AJ, Deeg DJ, van Dyck R, van Tilburg W. Consequences of anxiety in older persons: its effect on disability, well-being and use of health services. *Psychol Med*. 1999;29(3):583–93.
8. Dantas EHM, Figueira OA, Figueira AA, Höckelmann A, Vale RGS, Figueira JA, Figueira HA. The Association between Physical Activity and Anxiety in Aging: A Comparative Analysis. *Healthcare (Basel)*. 2023;11(15).
9. Crocco EA, Jaramillo S, Cruz-Ortiz C, Camfield K. Pharmacological management of anxiety disorders in the Elderly. *Curr Treat Options Psychiatry*. 2017;4(1):33–46.
10. Thorp SR, Ayers CR, Nuevo R, Stoddard JA, Sorrell JT, Wetherell JL. Meta-analysis comparing different behavioral treatments for late-life anxiety. *Am J Geriatr Psychiatry*. 2009;17(2):105–15.
11. Subramanyam AA, Kedare J, Singh OP, Pinto C. Clinical practice guidelines for geriatric anxiety disorders. *Indian J Psychiatry*. 2018;60(Suppl 3):S371–82.
12. Klainin-Yobas P, Oo WN, Suzanne Yew PY, Lau Y. Effects of relaxation interventions on depression and anxiety among older adults: a systematic review. *Aging Ment Health*. 2015;19(12):1043–55.
13. Sung HC, Chang AM, Lee WL. A preferred music listening intervention to reduce anxiety in older adults with dementia in nursing homes. *J Clin Nurs*. 2010;19(7–8):1056–64.
14. Brown Wilson C, Arendt L, Nguyen M, Scott TL, Neville CC, Pachana NA. Non-pharmacological interventions for anxiety and dementia in nursing homes: a systematic review. *Gerontologist*. 2019;59(6):e731–42.
15. Aibar-Almazán A, Hita-Conterras F, Cruz-Díaz D, de la Torre-Cruz M, Jiménez-García JD, Martínez-Amat A. Effects of Pilates training on sleep quality, anxiety, depression and fatigue in postmenopausal women: a randomized controlled trial. *Maturitas*. 2019;124:62–7.
16. Chin EC, Yu AP, Leung CK, Bernal JD, Au WW, Fong DY, et al. Effects of Exercise frequency and intensity on reducing depressive symptoms in older adults with insomnia: a pilot randomized controlled trial. *Front Physiol*. 2022;13:863457.
17. Yu DJ, Yu AP, Leung CK, Chin EC, Fong DY, Cheng CP, et al. Comparison of moderate and vigorous walking exercise on reducing depression in middle-aged and older adults: a pilot randomized controlled trial. *Eur J Sport Sci*. 2023;23(6):1018–27.
18. Ferreira RM, Alves W, de Lima TA, Alves TGG, Alves Filho PAM, Pimentel CP, et al. The effect of resistance training on the anxiety symptoms and quality of life in elderly people with Parkinson's disease: a randomized controlled trial. *Arq Neuropsiquiatr*. 2018;76(8):499–506.
19. Ibrahim AA, Hussein HM, Ali MS, Kanwal R, Acar T, Shaik DH, et al. A randomized controlled trial examining the impact of low vs. moderate-intensity aerobic training in post-discharge COVID-19 older subjects. *Eur Rev Med Pharmacol Sci*. 2023;27(9):4280–91.
20. Tong G, Guo G. Meta-analysis in Sociological Research: power and heterogeneity. *Sociol Methods Res*. 2022;51(2):566–604.
21. Kazemina M, Salari N, Vaisi-Raygani A, Jalali R, Abdi A, Mohammadi M, et al. The effect of exercise on anxiety in the elderly worldwide: a systematic review and meta-analysis. *Health Qual Life Outcomes*. 2020;18(1):363.
22. Ofosu EF, de Nys L, Connelly J, Ryde GC, Whittaker AC. Dimensions of physical activity are important in managing anxiety in older adults: a systematic review and Meta-analysis. *J Aging Phys Act*. 2023;31(4):679–92.
23. Cuijpers P, Weitz E, Cristea IA, Twisk J. Pre-post effect sizes should be avoided in meta-analyses. *Epidemiol Psychiatr Sci*. 2017;26(4):364–8.
24. Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JP, Thomas J. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev*. 2019;10:Ed000142.
25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Int J Surg (London England)*. 2021;88:105906.
26. Chin EC, Yu AP, Leung CK, Bernal JD, Au WW, Fong DY et al. Effects of Exercise frequency and intensity on reducing depressive symptoms in older adults with insomnia: a pilot randomized controlled trial. *Front Physiol*. 2022;13.
27. Deka P, Pathak D, Klompstra L, Muñoz-Gómez E, Espí-López GV, Marques-Sule E. Reduction in fear of physical activity among older persons with coronary artery disease by physical therapist-assisted Exercise: a Randomized Trial. *J Am Med Dir Assoc*. 2021;22(12):2607–8.
28. Imayama I, Alfano CM, Kong A, Foster-Schubert KE, Bain CE, Xiao L et al. Dietary weight loss and exercise interventions effects on quality of life in overweight/obese postmenopausal women: a randomized controlled trial. *Int J Behav Nutr Phys Activity*. 2011;8.
29. Lee P, Cai S, Lu EY, Ng BFL, Jensen MP, Tsang HWH. Qigong reduces depressive symptoms of Taiwanese Elderly with Chronic Physical illness: a Randomized Controlled Trial. *J Altern Complement Med*. 2020;26(1):76–8.
30. Mikkelsen MK, Lund CM, Vinther A, Tolver A, Johansen JS, Chen I, et al. Effects of a 12-Week Multimodal Exercise intervention among older patients with Advanced Cancer: results from a Randomized Controlled Trial. *Oncologist*. 2022;27(1):67–78.
31. Ruiz-Comellas A, Valmaña GS, Catalina QM, Baena IG, Mendioroz Peña J, Roura Poch P et al. Effects of Physical Activity interventions in the Elderly with anxiety, Depression, and low social support: a clinical Multicentre Randomised Trial. *Healthc (Switzerland)*. 2022;10(11).
32. Sit RWS, Choi SYK, Wang B, Chan DCC, Zhang D, Yip BHK, Wong SYS. Neuromuscular exercise for chronic musculoskeletal pain in older people: a randomised controlled trial in primary care in Hong Kong. *Br J Gen Pract*. 2021;71(704):E226–36.
33. Yu DJ, Yu AP, Bernal JD, Fong DY, Chan DKC, Cheng CP, Siu PM. Effects of exercise intensity and frequency on improving cognitive performance in middle-aged and older adults with mild cognitive impairment: a pilot randomized controlled trial on the minimum physical activity recommendation from WHO. *Front Physiol*. 2022;13.
34. Ageing, and health [[https://www.who.int/news-room/fact-sheets/detail/ageing-and-health#:~:text=By%202030%2C%201%20in%206,will%20double%20\(2.1%20billion\)](https://www.who.int/news-room/fact-sheets/detail/ageing-and-health#:~:text=By%202030%2C%201%20in%206,will%20double%20(2.1%20billion).)].
35. Majnarić LT, Bosnić Z, Guljaš S, Vučić D, Kurevija T, Volarić M et al. Low psychological resilience in older individuals: an Association with increased inflammation, oxidative stress and the Presence of Chronic Medical conditions. *Int J Mol Sci*. 2021;22(16).
36. WHO. World Health Organization. Health topics. Ageing. World Health Organization 2023; 2023 [<https://www.who.int/health-topics/ageing>].
37. da Silva AG, Baldaçara L, Cavalcante DA, Fasanella NA, Palha AP. The impact of Mental Illness Stigma on Psychiatric emergencies. *Front Psychiatry*. 2020;11:573.
38. de Mendonça Lima CA, Ivbijaro G. Mental health and wellbeing of older people: opportunities and challenges. *Ment Health Fam Med*. 2013;10(3):125–7.
39. Svensson M, Brundin L, Erhardt S, Hällmarker U, James S, Deierborg T. Physical activity is Associated with Lower Long-Term incidence of anxiety in a Population-Based, large-scale study. *Front Psychiatry*. 2021;12.
40. Anderson E, Shivakumar G. Effects of exercise and physical activity on anxiety. *Front Psychiatry*. 2013;4:27.
41. DeBoer LB, Powers MB, Utschig AC, Otto MW, Smits JA. Exploring exercise as an avenue for the treatment of anxiety disorders. *Expert Rev Neurother*. 2012;12(8):1011–22.
42. Aylett E, Small N, Bower P. Exercise in the treatment of clinical anxiety in general practice – a systematic review and meta-analysis. *BMC Health Serv Res*. 2018;18(1):559.
43. Ma WF, Lane HY, Laffrey SC. A model testing factors that influence physical activity for Taiwanese adults with anxiety. *Res Nurs Health*. 2008;31(5):476–89.
44. Basso JC, Suzuki WA. The effects of Acute Exercise on Mood, Cognition, Neurophysiology, and Neurochemical pathways: a review. *Brain Plast*. 2017;2(2):127–52.
45. Yao L, Fang H, Leng W, Li J, Chang J. Effect of Aerobic Exercise on Mental Health in older adults: a Meta-analysis of Randomized controlled trials. *Front Psychiatry*. 2021;12:748257.
46. Strickland JC, Smith MA. The anxiolytic effects of resistance exercise. *Front Psychol*. 2014;5:753.
47. Li A, Sun Y, Li M, Wang D, Ma X. Effects of elastic band resistance training on the physical and mental health of elderly individuals: a mixed methods systematic review. *PLoS ONE*. 2024;19(5):e0303372.

48. McCartan CJ, Yap J, Firth J, Stubbs B, Tully MA, Best P et al. Factors that influence participation in physical activity for anxiety or depression: a synthesis of qualitative evidence. *Cochrane Database Syst Reviews*. 1996;2020(3).
49. Kenyon K, Kinakh V, Harrison J. Social virtual reality helps to reduce feelings of loneliness and social anxiety during the Covid-19 pandemic. *Sci Rep*. 2023;13(1):19282.
50. de Oliveira L, Souza EC, Rodrigues RAS, Fett CA, Piva AB. The effects of physical activity on anxiety, depression, and quality of life in elderly people living in the community. *Trends Psychiatry Psychother*. 2019;41(1):36–42.
51. Wu F, Zhang J, Yang H, Jiang J. The Effect of Physical Exercise on the Elderly's anxiety: based on systematic reviews and Meta-analysis. *Comput Math Methods Med*. 2022;2022:4848290.

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