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# Meta-analysis of the effect of exercise intervention on cognitive function in elderly patients with type 2 diabetes mellitus

Huan-Huan Lu[1†], Yuan Zhou[1†], Chen Chen[1] and Ze-Juan Gu[1,2*]

## Abstract

**Objective** Cognitive dysfunction is a common complication of diabetes after central nervous system involvement. The impact of exercise, as an important non-pharmacological intervention strategy, on cognitive function remains controversial. Thus, we conducted a meta-analysis to assess the impact of exercise on cognitive function of elderly patients with type2 diabetes mellitus (T2DM).

**Methods** We computer searched PubMed, Web of Science, Embase, CINAHL, Cochrane Library, CNKI, Wanfang date, and VIP, and traced back the references included in the literature from 1974 to July 2024. We used RevMan5.4 software for data analysis, and also conducted sensitivity, subgroup, and publication bias analyses.

**Results** Eight eligible studies with a combined total of 747 elderly patients with T2DM were included. Meta-analysis showed that the combined effect size of exercise intervention on cognitive improvement in elderly patients with T2DM was significant [SMD = 0.65, 95% CI (0.48, 0.82), $P < 0.01$]. The following three factors had significant effects on the overall cognitive function of participants: subgroups (MoCA group [MD = 2.22 95% CI (1.26, 3.18), $P < 0.01$] and MMSE group [MD = 1.81, 95% CI (0.71,2.90), $P = 0.001$]); intervention times (3-month intervention [MD = 3.14, 95% CI (2.50, 3.78), $P < 0.01$], 6-month intervention [SMD = 0.32, 95% CI (0.12. 0.52), $P = 0.002$], and > 6 month intervention [SMD = 0.21, 95% CI (0.45, 0.81), $P < 0.01$]); intervention forms (single exercise [SMD = 0.21, 95% CI (0.45, 0.81), $P < 0.01$] and multiple exercise [SMD = 0.86, 95% CI ( 0.39,1.33), $P < 0.0001$]).

**Conclusion** Exercise intervention may improve cognitive function in elderly patients with T2DM.

**Keywords** Elderly, Type 2 diabetes, Exercise intervention, Cognitive function, Meta-analysis

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## Background

Diabetes mellitus (DM) is a metabolic disease caused by a combination of genetic and environmental factors [1]. In 2021, According to data released by the International Diabetes Federation (IDF) [2], an estimated 540 million individuals aged 20–79 years were reported to have diabetes globally, and this number is expected to grow to 640 million by 2030. With the aging of the global population and lifestyle changes, the prevalence rate of diabetes is increasing, and the mortality rates are rising each year [3]. The huge expenditure associated with diabetes results in a heavy burden on patients, families, and public health management. It is estimated that by 2030, the global economic burden of diabetes and its complications will exceed 2.1 trillion US dollars [4].

Patients with type 2 DM (T2DM) often have vascular, neural, brain, and other tissue and organ damage, which leads to cognitive decline [5], that is, mild cognitive impairment (MCI) [6]. In recent years, the risk of cognitive impairment in patients with T2DM has gradually increased [7]. Previous studies have confirmed that T2DM is an independent risk factor for cognitive dysfunction [8], that it accelerates brain atrophy and cognitive impairment in the elderly, and that it increases the risk of developing dementia in the future [9]. Compared to patients without diabetes, patients with T2DM have a 21% increased risk of MCI [10]. MCI is a clinical condition characterized by a decline in memory and executive abilities, and is the transitional stage between normal cognition and dementia [11]. Its high prevalence and high dementia conversion rate make it a golden intervention period for preventing dementia [12].

Among non-pharmacological treatments, exercise intervention is considered one of the important ways to improve cognitive function in elderly patients with T2DM [13]. Although some trials have shown that exercise can improve the cognitive function of patients with T2DM, the results are not consistent. A study by Yang et al. [14] and Zheng et al. [15] showed that exercise intervention can improve the cognitive function of elderly patients with T2DM and reduce cognitive barriers. However, another study found that cognitive function in patients with T2DM was negatively affected after 6 months of aerobic and resistance exercise. A meta-analysis [16] on the impact of exercise on the cognitive ability of elderly diabetes patients published in 2020 found that exercise improved the cognitive function of patients. However, the intervention measures included in the study were exercise, cognition, and dual task diet and exercise, and not just exercise intervention. To further determine whether exercise can improve the cognitive function of elderly patients with T2DM, this study aims to systematically analyze the existing evidence in randomized controlled trials concerning the impact of exercise on cognitive function among elderly patients with T2DM, and provide scientific guidance for exercise intervention in these patients. Our study differs from others in that the included literature are all randomized controlled trials and the intervention measure is only exercise intervention to avoid the influence of other intervention methods. We have also included several recently published studies [17–19], which may be more targeted toward exercise guidance in elderly patients with T2DM.

## Methods

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [20] guidelines and is registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the record number CRD42024482547.

### Search strategy

The PubMed, Web of Science, Embase, CINAHL, Cochrane Library, CNKI, Wanfang date, and VIP databases were searched from 1974 to July 2024. To ensure the comprehensiveness of the search, the following Mesh terms and synonyms were used. The search strategy for PubMed was as follows: ("Diabetes Mellutis" [MeSH] OR "diabetes Mellitus" [tiab] OR "diabetes" [tiab] OR "diabetic" [tiab] OR "type 2 diabetes" [tiab] OR "DM" [tiab] OR "T2DM" [tiab]) AND ("Cognition" [MeSH] OR "cognition" [tiab] OR "cognitive function" [tiab] OR "cognitive dysfunction" [tiab] OR "cognitive disorder" [tiab] OR "cognitive impairment" [tiab] OR "mild cognitive impairment" [tiab] OR "cognitive decline" [tiab] OR "older" [tiab] mental deterioration) AND ("aged" [tiab] OR "older" [tiab] OR "elderly" [tiab] ) AND ("exercise" [tiab] OR "exercise therapy" [tiab] OR "physical activity" [tiab] OR "aerobic exercise" [tiab] OR "resistance training" [tiab]). Other English databases also adopted similar strategies. For Chinese databases, search terms are translated into Chinese. In addition, a manual search of the reference lists of the included articles was conducted. Appendix 1 provides detailed retrieval strategy.

### Eligibility criteria and study selection

Studies that met the PICOS criteria were included: (1) P (Population): patients with T2DM who met WHO diagnostic criteria, with normal or mild cognitive impairment cognitive function, and age≥60 years; (2) I (Intervention): any form of exercise intervention, including aerobic exercise, resistance exercise, and balance training.; (3) C (Comparison): the control group received routine care or did not change their original lifestyle; O (Outcome): Montreal Cognitive Assessment (MoCA) scores and the mini-mental state examination scale (MMSE), which are the most widely used cognitive assessment scales both domestically and internationally, and mirror the fundamental cognitive functionality of the subject were used. The exclusion criteria were as follows: (1) literature with no access to full text or incomplete data; (2) repeated publications of the same content; (3) literature published in languages other than English or Chinese; (4) other study types apart from randomized controlled trials (RCTs); (5) studies with subjects having dementia; (6) interventions that were not purely exercise-related interventions and were combined with other interventions. It should be noted that dementia is an acquired disease characterized by cognitive decline, which leads to a decrease in functional levels compared with the past and is severe enough to interfere with daily functioning and independence [21]. Mild cognitive impairment (MCI) is an intermediate state between normal cognition and dementia, wherein patients have objective cognitive impairment but overall functional levels have not decreased [11]. Therefore, dementia patients were excluded.

### Literature screening and data extraction

Two researchers who had received evidence-based nursing training independently conducted literature screening and data extraction. Duplicate literature were removed through EndnoteX9 software. Preliminary literature screening was conducted by reading titles and abstracts; this was followed by further reading the full text, and finally, the inclusion of literature was determined based on inclusion and exclusion criteria. Two researchers independently read the full texts to extract and cross check the included literature, including author names, publication year, sample size, exercise intervention form, intervention intensity, intervention frequency, and outcome indicators. In case of disagreements during the process, discussion and analysis was conducted, and if necessary, opinions were sought from a third researcher to reach a consensus.

### Quality assessment of the study

Articles were assessed using the Cochrane Risk of Bias tool version 2 (RoB2), and the risk of bias was used independently by two researchers. The domains of this assessment were random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other biases. For each criterion, a judgment was made and each criterion was classified as one of the following categories: “low risk,” “high risk,” or “unclear.” Disagreements were resolved through discussion with a third reviewer. In addition, two researchers independently assessed the quality of evidence for each outcome following the Suggested Grading, Assessment, Development, and Evaluation methodology. Discrepancies were resolved through discussion with a third researcher.

### Statistical analysis

Meta-analysis was performed using RevMan 5.4 provided by the Cochrane Collaboration. The standardized mean difference (SMD) or mean difference (MD) was used as the statistical measure for effect analysis of continuous variables. The $\chi^2$ test was used to determine whether there was heterogeneity among the studies; if $P>0.1$ and $I^2<50\%$, then the heterogeneity between studies is relatively small, and a fixed-effects model was chosen for analysis; if $P<0.1$ and $I^2\geq50\%$, then the heterogeneity between studies is relatively high, and a random-effects model was chosen for analysis. Obvious clinical heterogeneity can be treated with methods such as subgroup analysis or sensitivity analysis; alternatively, only descriptive analysis can be performed.

## Results

### Search process

Initial examination of related literature revealed 1829 studies. Of these, 1794 studies did not meet the inclusion criteria and were excluded. Thus, 35 studies were included after preliminary testing. After reading the full texts, and excluding studies wherein the research object, interventions, and outcome indicators did not match, 27 studies were further excluded, and finally, 8 studies were included in the analysis [17–19, 22–26]. The flow chart is shown in Fig. 1.

### Characteristics of the included studies

Eight studies including a total of 747 patients were included in the study. Out of these eight studies, six were conducted in China [17, 19, 22–24, 26], and one each in Japan [25] and Thailand [18]. There were 375 participants in the exercise group and 372 participants in the control group. All intervention groups in the study received exercise intervention, whereas participants in the control group of six studies [17, 22–26] received routine care, and participants in the control group of two studies [18, 19] maintained their original lifestyle. The basic characteristics of the included literature are shown in Table 1.

### Quality assessment of included studies

All eight studies [17–19, 22–26] reported random sequence allocation procedures. For the allocation concealment assessment, the risk of bias of 7 studies [17–19, 22, 23, 25, 26] remained unclear, and the risk of one study [24] was relatively low. There is no clear mention regarding the implementation of blinding by researchers and participants in the studies [17–19, 22–26]. For the blinding of outcomes assessment, only one study [19] results

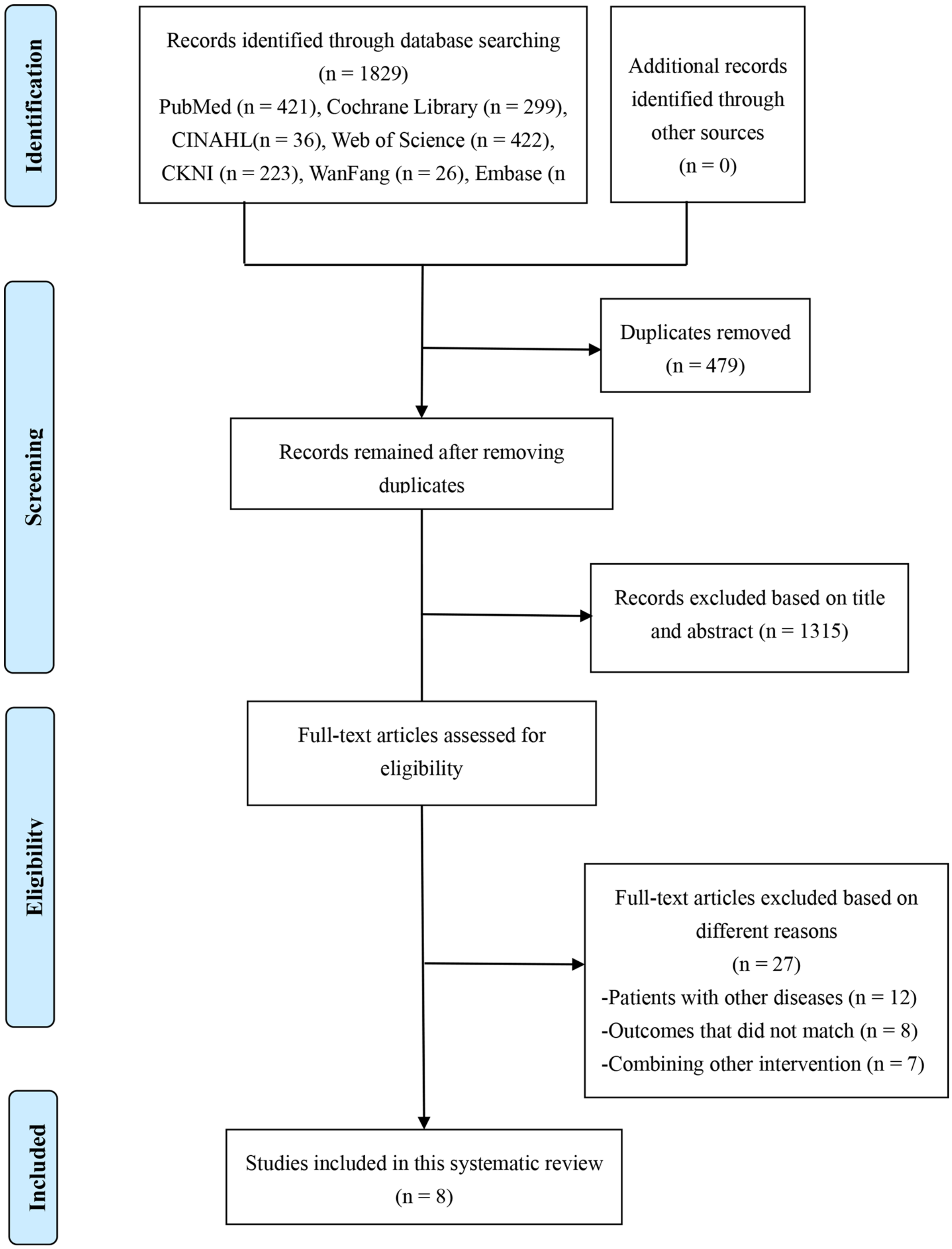


**Fig. 1** Flsowchart of literature screening

were measured by evaluators who were blinded to the study. For incomplete outcome data assessment, five studies [17–19, 24, 25] did not report participants lost to follow-up or reported reasons for participant withdrawal from the study, and corresponding measures were taken. With regard to selective reporting assessment, the risk of bias in two studies [19, 26] was unclear, whereas the risk in six studies [17, 18, 22–25] was relatively low. Among other risk of bias items, four studies [17–19, 25] had lower risk of bias and four studies [22–24, 26] reported unclear risk of bias. The inclusion of the results with regard to quality evaluation of the literature is shown in detail in Fig. 2.

**Table 1** Basic characteristics of the literature

| Author | Country | Year | Sample size | *Age(Mean ± SD)* | | Intervention | | Minutes per session | Follow-up time | Outcome indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | (Test/Control group) | (Test/Control group) | | Test group/Control group | | | | |
| Zhu et al. [23] | China | 2015 | 37/41 | 69.92 ± 6.41 | | Baduanjin (4 times/week) | routine care | 40 min each time | 3/6/12 months | ① |
| Zhang et al. [26] | China | 2017 | 36/38 | 69.53 ± 8.02 | 69.79 ± 6.04 | Aerobic training, fitness walking (≥ 3 times/week) | routine care | 40 ~ 50 min each time | 3 months | ① |
| Wang et al. [22] | China | 2015 | 43/46 | 62.37 ± 12.38 | 64.51 ± 12.07 | Baduanjin, Relaxation Gong (3 times/week) | routine care | 60 min each time | 6/12 months | ①② |
| Wei et al. [24] | China | 2021 | 60/60 | 72.24 ± 6.25 | 71.83 ± 6.67 | Aerobic training: warm-up exercises such as low-intensity slow walking and gymnastics, and restorative exercises such as freehand exercises (5 times/week) | routine care | 40 ~ 60 min each time | 3 months | ① |
| Wang et al. [17] | China | 2023 | 40/42 | 65.73 ± 3.99 | 68.07 ± 5.47 | 5 min warm-up, 50 min aerobic dance, 5 min relaxation training: moderate intensity (3 times/week) | routine care | 60 min each time | 12 months | ①② |
| Yamamoto et al. [25] | Japan | 2021 | 36/17 | 73.2 ± 2.6 | 73.3 ± 2.5 | Resistance training: elastic band exercises for upper and lower limbs (7 times/week) | routine care | 15 min each time | 48 weeks | ② |
| Chen et al.[19] | China | 2023 | 107/111 | 67.56 ± 4.99 | 67.62 ± 5.35 | Tai chi (3 times/week) | Maintaining the original lifestyle | 60 min each time | 24/36 weeks | ①② |
| Ploydang et al.[18] | Thailand | 2023 | 16/17 | 68.9 ± 3.7 | 69.2 ± 5.3 | Nordic Water Walking Training (3 times/week) | Maintaining the original lifestyle | 60 min each time | 12 weeks | ①② |

*Note* ①Montreal Cognitive Assessment (MoCA); ②mini-mental state examination (MMSE)

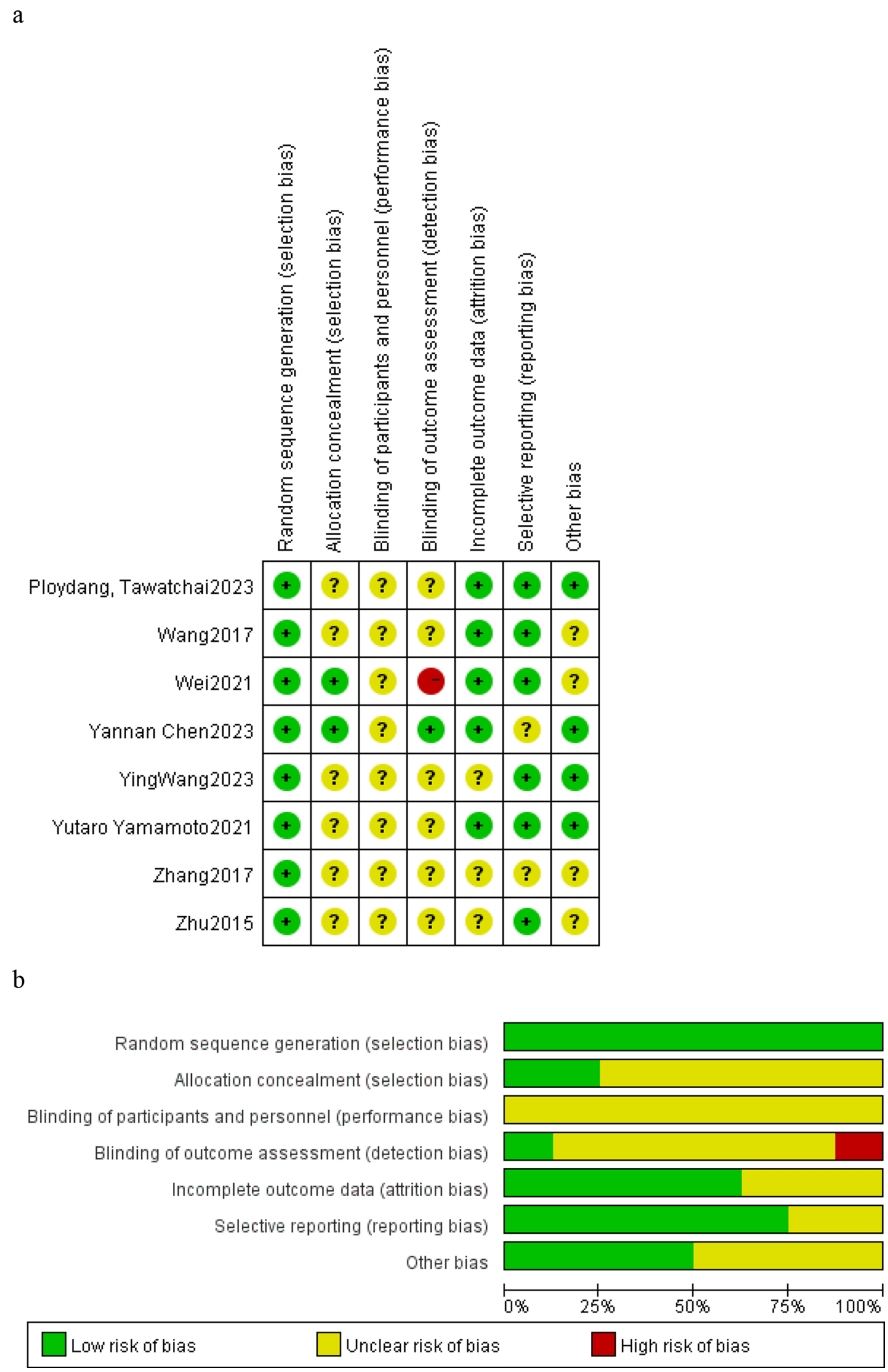


**Fig. 2** Evaluation of the quality of the included literature: (**a**) ROB summary. (**b**) ROB graph

## Outcome analysis

### *Combined effect sizes*

After merging the eight included studies [17–19, 22–26], a meta-analysis was conducted. If there were multiple intervention times in the study, the longest one was selected. If there were different measurement tools for outcome indicators, the study with MoCA score was selected. Because of the high heterogeneity ($I^2$=69%, $P$=0.002), a random effects model was used for analysis, and the results showed that exercise could significantly improve the cognitive function of elderly patients with diabetes, with a statistically significant difference [SMD=0.79, 95% CI (0.64, 0.94), $P$<0.01], forest plots are shown in Fig. 3. Sensitivity analysis showed that after

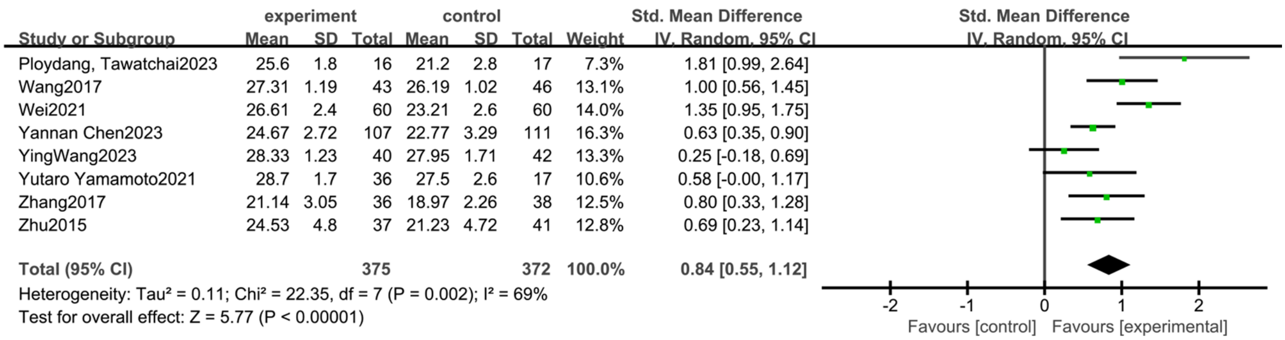


**Fig. 3** Effect of exercise intervention on cognitive function in elderly patients with type 2 diabetes mellitus

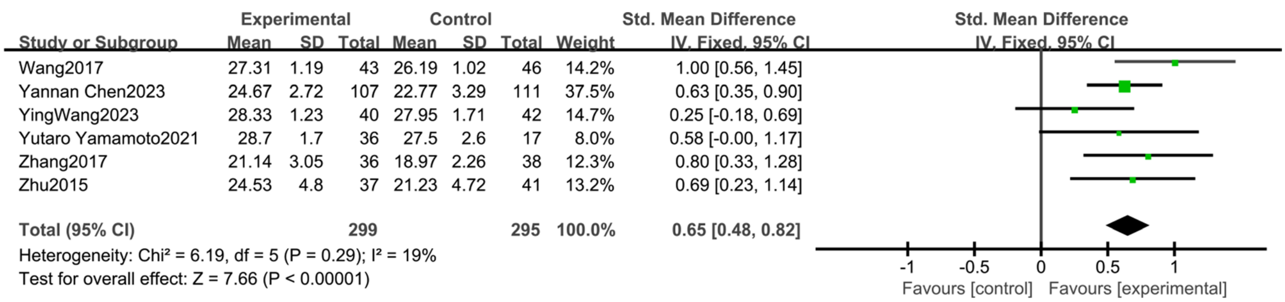


**Fig. 4** Effect of exercise intervention on cognitive function in elderly patients with type 2 diabetes mellitus after culling the literature

excluding the studies by Wei et al. [24] and Tawatchai et al. [18], the heterogeneity decreased ($I^2=19\%$, $P=0.29$), and the combined effect size did not significantly change. Meta analysis showed that exercise intervention could improve the cognitive function of elderly patients with diabetes, with a statistically significant difference [SMD=0.65, 95% CI (0.48, 0.82), $P<0.00001$]; forest plots are shown in Fig. 4. Through an in-depth analysis of the literature, it was found that the study by Wei et al. [24] had a lower intensity of exercise intervention, a shorter intervention time (3 months), and one week of adaptive training. In the study by Ploydang et al. [18], participants were first stratified by gender, age, and MoCA score, and then grouped using simple random sampling, which may be the reason for the high heterogeneity between groups.

#### *Subgroup analysis based on different measurement tools*

According to different measurement tools for outcome measures, the included studies were divided into two subgroups: MoCA and MMSE. Seven studies [17–19, 22–24, 26] were included in the MoCA group, with 694 patients, and the random effects model was used in this group ($I^2=88\%$, $P<0.1$). The results showed that exercise intervention could improve the cognitive function of elderly patients with T2DM, with a statistically significant difference [MD=2.22, 95% CI (1.26, 3.18), $P<0.01$]; Five studies [17–19, 22, 25] were included in the MMSE group, with 335 patients in total, and this group was also analyzed using the random effects model ($I^2=84\%$, $P<0.1$). The results showed that exercise intervention could improve the cognitive function of elderly patients with T2DM, with a statistically significant difference [$I^2=84\%$, MD=1.81, 95% CI (0.71, 2.90), $P=0.001$]. The reason for the high heterogeneity in the analysis may be the diversity of exercise intervention methods included in the literature, as well as differences in intervention time and exercise frequency.

#### *Subgroup analysis based on different intervention times*

According to different intervention times, subgroup analysis was conducted and the studies divided into three subgroups: 3 months, 6 months, and more than 6 months after intervention. As per the fixed effect model analysis, the results showed that all the studies with intervention durations of 3 months [18, 23, 24, 26] [$I^2=50\%$, MD=3.14, 95% CI (2.50, 3.78), $P<0.01$], 6 months [19, 22, 23] [$I^2=14\%$, SMD=0.32, 95% CI (0.12, 0.52), $P=0.002$], and more than 6 months [17, 19, 22, 23, 25] [$I^2=32\%$, SMD=0.21, 95% CI (0.45, 0.81), $P<0.01$] reported improvement in cognitive function with exercise among elderly patients with T2DM. The difference was statistically significant (Table 2).

#### *Subgroup analysis based on different forms of exercise*

Subgroup analysis was performed based on the form of movement (single form or multiple forms). The single exercise group included 382 patients from four studies [18, 19, 23, 25]. The results using a random effects model analysis ($I^2=59\%$, $P<0.0001$) showed that single exercise intervention could improve cognitive function among

**Table 2** Summary of subgroup meta-analyses

| Subgroup | | Number of studies included | Effect model | Mata analysis | | | $I^2$ | *P* |
|---|---|---|---|---|---|---|---|---|
| | | | | MD/SMD | 95% CI | *P* | | |
| outcome indicator | MoCA | 7[17–19,22–24,26] | stochastic | 2.22 | 1.26, 3.18 | < 0.01 | 88% | < 0.1 |
| | MMSE | 5[17–19,25] | stochastic | 1.81 | 0.71, 2.90 | 0.001 | 84% | < 0.1 |
| intervention time | 3 months | 4[18,23,24,26] | fixation | 3.14 | 2.50, 3.78 | < 0.01 | 50% | 0.11 |
| | 6 months | 3[19,22,23] | stochastic | 0.32 | 0.12, 0.52 | 0.002 | 14% | 0.31 |
| | > 6 months | 5[17,19,22,23,25] | stochastic | 0.21 | 0.45, 0.81 | < 0.01 | 32% | 0.21 |
| sports format | single campaign | 4[18,19,23,25] | stochastic | 0.81 | 0.42, 1.19 | 0.06 | 59% | < 0.0001 |
| | multisport | 4[17,22,24,26] | stochastic | 0.86 | 0.39, 1.33 | 0.003 | 78% | 0.0003 |

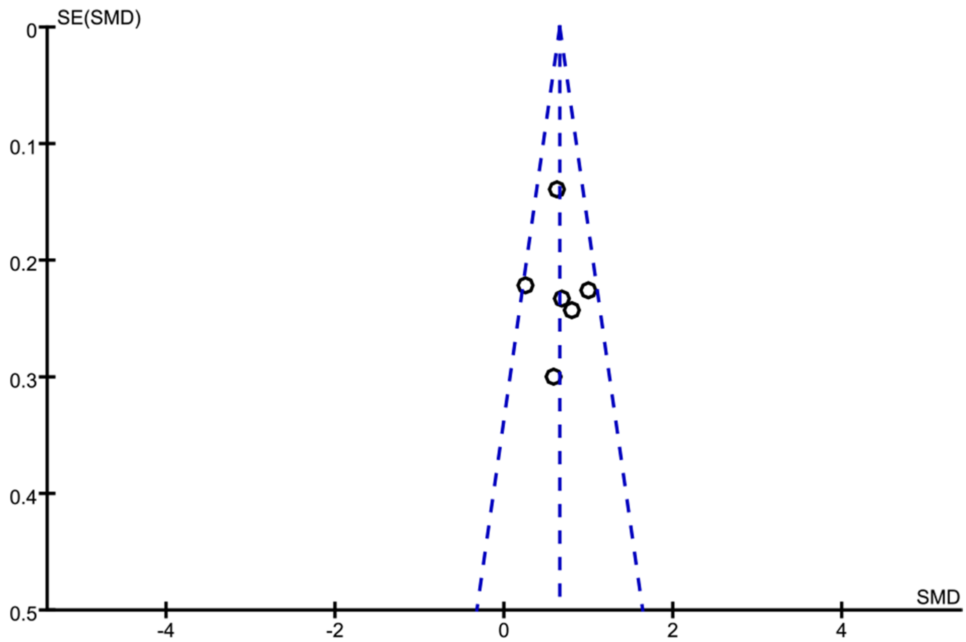


**Fig. 5** Funnel plot of the effect of exercise intervention on cognitive function in elderly patients with type 2 diabetes mellitus

elderly patients with T2DM [SMD = 0.81, 95% CI (0.42, 1.19), $P = 0.06$]. The heterogeneity of our analysis was relatively high, which may be related to the different types of exercises in the study (aerobic exercise, resistance training, etc.). The exercise frequencies in the four studies also differed, with the highest and lowest frequencies differing by nearly two times, and the longest and shortest intervention times differing by nearly three times. These factors may also have contributed to the high heterogeneity. A total of 365 patients were included in four studies [17, 22, 24, 26] and analyzed as per the random effects model ($I^2 = 78\%$, $P = 0.0003$). The results showed that diversified exercise intervention could improve cognitive function in elderly patients with T2DM [SMD = 0.86, 95% CI (0.39, 1.33), $P < 0.0001$]. The heterogeneity of our analysis was relatively high, which may be related to the different numbers of movements in diverse sports. In addition, there was a significant difference in intervention duration among the four articles, with the longest being 12 months and the shortest being 3 months, which may also be a source of heterogeneity.

### Sensitivity analysis and publication bias

After excluding the included studies one by one depending on different measurement tool groups, different follow-up time groups, and different exercise mode groups, no significant change was observed in the combined effect size, and the results were relatively robust. Further, on observing the funnel plot included in the meta-analysis study, the results showed that there was no significant asymmetry in the funnel plot, and the possibility of publication bias was relatively small, as shown in Fig. 5.

## Discussion

### Effect of exercise intervention on cognitive function

In this study, we conducted a meta analysis of eight randomized controlled trials to verify the impact of exercise on cognitive function of elderly patients with diabetes. Our research results show that exercise can effectively improve the cognitive function of elderly patients with diabetes. In a prospective longitudinal study [27] of elderly patients with T2DM in Israel, the researchers found that physical exercise had a positive impact on reducing the risk of cognitive decline among elderly patients, and continued participation in planned physical activities was the most beneficial. A systematic evaluation and meta-analysis by Cai et al. [28] on the impact of exercise on the cognitive function of elderly patients with T2DM found that exercise improved the cognitive function of these patients. This is consistent with our research findings. When MCI memory executive function declines, it weakens the patient's self-management ability, leading to poor blood sugar control and further damaging the patient's cognitive function [29]. Therefore, diabetes patients with MCI should undertake early exercise and other interventions to prevent further deterioration of cognitive function and reduce the risk of dementia.

However, the mechanism through which exercise improves cognitive function in patients with DM is currently unclear. The study by Wang et al. [30] showed that exercise intervention can activate the insulin signaling pathway and inhibit the expression of inflammatory factors. There are also studies [31–33] suggesting that exercise can enhance the levels of brain-derived neurotrophic factors, thereby improving the cognitive function of the brain. In addition, studies have found that the beneficial effects of exercise on the cognitive function of patients with T2DM may be most significant in the field of executive function [16]. The research results of Huang et al. [34] also support this conclusion. Because of the lack of relevant research on the impact of exercise intervention on different areas of cognitive function in elderly patients with T2DM, this study only explored the effect of exercise on the overall cognitive function of these patients. Future research still needs to continuously explore the impact of exercise on different areas of cognitive function.

The randomized controlled trials included in this study included various forms of exercise such as walking, slow walking, gymnastics, and eight dan brocade, which can be divided into aerobic exercise, strength training, and balance exercise. Exercise frequency in these studies was ≥3 times a week, with a duration of 105 to 300 min/week, with the exercise intensity mainly being moderate. This is consistent with the recommendations made by WHO in 2020 regarding physical activity in older adults [35]. We found that both aerobic exercise and resistance training contribute to the improvement of cognitive function in patients with T2DM [36, 37]. Unlike previous studies that explored exercise patterns (aerobic exercise, resistance training, and balance exercise combinations), we added subgroup analysis based on exercise forms, analyzing the number of exercises included in the same type of exercise. Subgroup analysis showed that both single exercise and multiple exercise interventions have a positive impact on cognitive function among elderly patients with T2DM. This indicates that when providing exercise guidance to patients, we can develop exercise plans for different forms of exercise based on their preferences and needs, providing a variety of choices for different patients, thereby improving exercise compliance and maximizing exercise benefits [38]. However, the heterogeneity of this subgroup analysis was high. Although we have explained the source of heterogeneity, more high-quality randomized controlled trials need to be performed in the future to verify the impact of different exercise forms on the cognitive function of elderly patients with diabetes.

The subgroup analysis results of this study show that exercise intervention for 3 months [18, 23, 24, 26], 6 month [19, 22, 23] and more than 6 months [17, 19, 22, 23, 25] can improve the cognitive function of elderly patients with T2DM. Research suggests that, considering the early signs of neurodegeneration in older adults affected by aging, 6–12 months of exercise may not be sufficient to produce detectable cognitive effects [39]. However, Ten et al. [40] implemented aerobic exercise intervention in elderly patients with mild cognitive impairment. After 6 months of intervention, it was found that the volume of the left and right hippocampus had increased, reducing the probability of dementia progression. The diversity of different backgrounds and intervention measures may be the reason for contradictory findings. In addition, this study found that the effect was more significant 3 months after intervention compared with 6 months or more after intervention. The reason for this may be that long-term regular exercise can effectively maintain the benefits of cognitive function improvement. Accordingly, as the exercise cycle prolongs, the health benefits are maintained, and the effect of further improvement in cognitive function is not significant. This is similar to the findings of a Cochrane systematic review [41], which found that the improvement effect of exercise on cognitive health in elderly individuals is not significant.

Among the "five carriages" of DM management, physical exercise is an economical, convenient, and safe one [42], and is particularly important for the early management of elderly T2DM patients with MCI. We should not only focus on exercise intervention time but also pay attention to exercise intensity and frequency. Research has shown that exercise lasting between 45 and 60 min, with moderate or vigorous intensity, with any frequency or length, is beneficial for cognitive function in adults over 50 years of age [43]. However, there is still no consensus on the impact of high-intensity training and low-intensity continuous training on cognitive function of elderly, and further research is needed to prove it.

Proper exercise intervention can be used to improve the cognitive function of elderly patients with T2DM, and should be regarded as a useful strategy in the clinical practice of the elderly. Although there is heterogeneity in the comprehensive impact of different results, these results provide guidance for the medical staff and researchers to implement exercise for elderly patients with diabetes. Owing to the patient's cognitive decline, it is necessary to strengthen the integration of hospital and community resources and conduct regular home visits and telephone follow-ups to ensure the quality of exercise intervention [44]. In addition, medical departments may consider developing information platforms and wearable assessment tools to dynamically monitor patients' physical activity [45], heart rate, effectiveness, and other functions and to set up automatic reminders to further improve the role of remote guidance and monitoring in hospitals. At the same time, it is recommended that caregivers use exercise diaries to record the patient's exercise behavior to improve their motivation for physical activity [46].

### Limitations

Our study has some limitations. First the number of included studies was low and the quality of these studies was average. The study subgroups were analyzed without controlling for the effects of confounding factors (gender, age) and form of exercise. Whether blinding was used in some of the literature, information on the trainers of the exercise intervention, and information on the occurrence of adverse events were unclear. Although we performed combined effect sizes and subgroup analyses, subgroup analyses based on intensity and frequency factors were lacking. Such analyses should be added to future research to supply more high-quality evidence for the time to come.

## Conclusion

In summary, exercise is an important strategy for improving cognitive function in elderly patients with T2DM. In the future, more high-quality, large sample, randomized controlled trials are needed to explore the impact of different exercise parameters on the cognitive function of elderly patients with diabetes.

### Abbreviations

| | |
|---|---|
| CNKI | China national knowledge infrastructure |
| DM | Diabetes mellitus |
| IDF | International Diabetes Federation |
| T2DM | Type 2 diabetes mellitus |
| MCI | Mild cognitive impairment |
| RCT | Randomized controlled trial |
| MoCA | Montreal cognitive assessment |
| MMSE | Mini-mental state examination |
| WMD | Weighted mean difference |
| RoB | Risk of bias |
| CI | Confidence intervals |
| SD | Standard deviation |
| SEM | Standard error of the mean |
| SMD | Standardised mean difference |
| WHO | World health organization |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-024-05352-z.

Supplementary Material 1

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### Author contributions

Huanhuan Lu contributed to the study concept and design. Huanhuan Lu and Yuan Zhou jointly screened the literature and extracted the relevant content of the literature. Huanhuan Lu, Yuan Zhou, and Chen Chen reviewed and analyzed the results. Huanhuan Lu wrote the first draft of the manuscript, and Yuan Zhou and Zejuan Gu revised it. All authors contributed to revising and approving the final version of the manuscript.

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No have.

### Data availability

No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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