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The Impact of Tai Chi Exercise on Sleep Quality in the Elderly: A Systematic Review and Meta-Analysis

Chenyu Wang[1], ORCID https://orcid.org/0009-0007-7609-7303

Email: chenyu_wang1233@163.com

[1]Southwest University, Chongqing, China

Chuanqiushui Wang[2], ORCID https://orcid.org/0009-0005-7859-6443

Email: 19982641028@163.com

Xuemei Wu[3], ORCID https://orcid.org/0009-0009-2869-9291

Email: wuxuemei0814@163.com :

***Corresponding author:**

Jiong Luo, ORCID https://orcid.org/0009-0006-2158-5804

Email: 784682301@qq.com

Southwest University, Chongqing, China

Abstract

Background: At present, tai chi has become the “prescribed action” for many elderly people in the morning, and the benefits of this kind of exercise, which is called “slow kung fu” or “soft exercise”, on the sleep quality of the elderly are worth exploring. This form of exercise is known as “slow kung fu” or “soft exercise,” and exploring its potential to enhance sleep quality in older adults is worthwhile.

Material and methods: Based on the PERSiST guideline and PRISMA statement, we searched for domestic and international journal articles published between 2015 and 2025 with the help of Web of Science, Embase, PubMed, MEDLINE, and CNKI databases using the Chinese and English subject terms of tai chi/tai chi chuan, sleep/quality of sleep/sleep disorders/insomnia, and elderly/senior citizens. The included literature was processed and analyzed using RevMan 5.3 and Stata SE 17 software.

Results: 1) Tai chi significantly affected subjective sleep quality, daytime dysfunction, and comprehensive sleep quality of senior citizens, with intervention effect sizes of WMD of -0.23 ($p<0.05$), -0.38 ($p<0.001$), and -1.8 ($p<0.001$), in that order; 2) Under the PSQI total score index, the duration of a single session of tai chi practicing must be guaranteed to be more than 60 min for its effect size on the seniors' sleep improvement effect (WMD=-2.11, $p<0.001$), and long-term intervention requires more than 8 weeks for the superimposed effect of sleep quality improvement to reach a significant level (WMD=-2.53, $p<0.001$); 3) regardless of the presence of insomnia symptoms in seniors, the PSQI scores were significantly reduced after the intervention, and the effect of creating tai chi on the sleep intervention of seniors (WMD=-1.8, $p<0.001$) was significantly better than that of traditional taijiquan (WMD=-1.60, $p<0.001$).

Conclusion: Taijiquan can significantly improve the sleep quality of the elderly, but its improvement benefit is affected by the exercise time, if the exercise time is more than 60 minutes each time, and the total

time is more than 8 weeks, then it can show better effect; at the same time, the traditional taijiquan movement stance creation to make it adapt to the elderly with different health conditions, then it can get better effect.

Key words: **taijiquan; sleep quality; systematic evaluation; meta-analysis**

1. Introduction

As defined by the World Health Organization (WHO), a society is classified as aging when the proportion of individuals aged 65 and over accounts for 7% of the total number of people. It is considered an advanced-age society at 14%, and an ultra-advanced-age society when this proportion exceeds 20%. As of December 2024, the number of elderly people aged 65 years in China has reached 220 million, accounting for 15.6% of the national population. The National Health and Wellness Commission reported that by 2035, the proportion of China's senior population aged 60 and above is expected to exceed 30%, thereby entering a stage of severe aging(Chen, 2022). How to achieve successful aging and improve the quality of life of the elderly is becoming an important public health issue.

Sleep quality is a powerful and effective predictor of quality of life (LIU & WANG, 2024). Studies by Chinese scholars have indicated that healthy aging begins with good sleep (L. Tian et al., 2024). Excellent sleep may play a role in slowing down aging by slowing down the rate of telomere shortening(Liu et al. 2017). It has been demonstrated that alterations in sleep patterns as individuals age are linked to a decreased probability of achieving successful aging. Furthermore, preserving healthy sleep patterns is strongly and positively correlated with maintaining physical function, cognitive vitality, emotional stability, and social engagement(Carvalho et al., 2018; L. Tian et al., 2024). High-quality sleep is advantageous for sustaining optimal cognitive function and lowering the

risk of cognitive decline in later years (International, 2023). Additionally, it contributes to lowering the risk of anxiety and depression while alleviating depressive symptoms(Leblanc et al., 2015). It has also been demonstrated that good sleep quality enhances immunity and decreases the likelihood of chronic diseases and chronic co-morbidities in older adults(Zhang et al., 2024). However, with age, the circadian rhythm system robustness decreases, and the prevalence of sleep disorders increases in the senior population (Zisapel, 2007). Data from the U.S. National Institutes of Health show that 40%-50% of community-dwelling seniors have chronic insomnia. The insomnia rate among the elderly population in Seoul, South Korea, was as high as 67%. A meta-analysis conducted in 2016 reported that 35.9% of older adults in China experienced sleep disorders (Cao, 2017), while a 2022 study indicated that this figure had risen to 46.0% (Liu et al., 2014). Sleep disorders may not only cause abnormal immune status and cognitive decline in the elderly(Zhang et al, 2022), but also increase the prevalence of anxiety, depression, and other psychiatric problems(Y. Tian & Li, 2017), and more significantly elevate the problems of somatic and psychiatric disorders, which seriously affect the quality of life in elderly individuals. For instance, the majority of prospective studies indicate that both prolonged and shortened sleep durations are linked to an elevated risk of cognitive decline and dementia. An increased risk of dementia by approximately one-third is linked to sleeping fewer than six hours per night (Sabia et al., 2021). A 1% annual decrease in deep sleep is linked to a 28% higher risk of all-cause dementia and a 32% greater risk of Alzheimer's disease (Himali et al., 2023).

Exercise is an important tool for improving the quality of life of the elderly, enhancing their sense of access, happiness, and security, and implementing active ageing, and is highly valued by the State. For the advent of the senior society, appropriate exercise intervention can be used as a preventive measure to delay the direction of the aging trend. As a kind of aerobic exercise that integrates physical and mental regulation, taijiquan, with its soothing movements, controllable intensity, and focus on coordination of breathing and intention, is widely loved by the senior population. Taijiquan may have a positive effect on sleep quality through mechanisms such as regulating autonomic function, lowering cortisol levels, and improving mood states(Gong et al., 2024). The results of one study showed that taijiquan had the same effect as conventional exercise in improving insomnia, and the beneficial

effects lasted for 24 months(Siu et al.,2021). The parasympathetic activity of elderly people who practiced taijiquan for a long period of time was significantly higher than that of sedentary elderly people(Lu & Kuo, 2003), which is advantageous for both the physical and mental well-being of older adults. Taijiquan emphasizes slow, fluid movements, deep breathing, concentration, and relaxation, and these elements are widely believed to be effective in stimulating the vagus nerve (the parasympathetic trunk), thereby enhancing parasympathetic tone. A meta-analysis showed very few and mild adverse events with tai chi exercise, with a safety profile comparable to that of a control group(Wayne et al., 2014). For older adults who are frail, suffer from arthritis, cardiovascular disease, or have poor balance, the low-impact nature of tai chi and its emphasis on the integration of mind and body make it safer and more compliant.

In recent years, as the research on tai chi exercise intervention for sleep problems in the elderly continues to deepen, a lot of new evidence has emerged in the related field. The number of studies has increased significantly and there has been a significant development in sample size, experimental design, exercise intensity and duration. However, no consensus has been reached on the optimal amount and intensity of exercise for improving sleep quality through taijiquan interventions, which to a certain extent restricts the standardized application and promotion of taijiquan in community recreation, and prevents taijiquan from maximizing its potential value in improving sleep in the elderly.

In summary, the global population is entering the stage of aging, and improving the quality of life of the elderly has become an urgent public health issue. Sleep quality, as a key predictor of quality of life, has a profound impact on cognitive function, emotional state, immune health, and other aspects of the elderly, but the rate of sleep disorders in the senior population has increased significantly in recent years, which has seriously constrained their quality of life and health. The present study aims, on the basis of these findings, to explore further the potential effects that regular taijiquan exercise has on an individual's sleep quality. The objective is to provide scientific and effective intervention strategies and practical paths to meet the challenges of population aging and achieve successful aging, and elevate seniors' overall health and quality of life. This is a goal that carries both scholarly and societal weight.

2. Research materials and methods

2.1 Literature search

The present systematic review and meta-analysis had two main objectives: (1) to assess the impact of Tai Chi exercise on enhancing sleep quality in the geriatric populations, as measured by the Pittsburgh Sleep Quality Index and its respective subdomains; and (2) to quantify the impact of a regular Tai Chi exercise regimen on sleep quality in senior citizens. The first author conducted a systematic search of Web of Science, Embase, PubMed, Medline, and CNKI databases in Ma 2025 in accordance with PERSiST and PRISMA statements (Ardern et al., 2022; Page et al., 2021). Using the Chinese key words of ("Tai Chi" or "Tai Chi Chuan"), ("Sleep" or "Sleep Quality" or "Sleep Disorders" or "Insomnia"), and ("Aged" or "Elderly"), and the English key words of "Sleep Initiation and Maintenance Disorders", "aged", and "tai ji", Boolean operators are employed to identify relevant studies. The present literature search, conducted for this systematic review and meta-analysis, has focused exclusively on publications from the past decade, because a relevant Meta-analysis had been conducted in 2015 to integrate and analyze the previous literature comprehensively, and based on the results of this research, new evidence in the research field was supplemented and updated during the following decade, to more accurately grasp the dynamics of the development of this research topic and trends in recent years, and provide more prompt and applicable guidance for clinical practice or related research.

2.2 Eligibility criteria and data items

The initial step involved the first author removing all duplicate studies. Following this, two researchers separately checked the titles and brief summaries of the remaining studies, not disregarding their relevance. Any disagreements that emerged were addressed through dialogue or consultation with an additional researcher, after which the full texts of the studies were evaluated to determine their eligibility. Any discrepancies that emerged were reconciled through deliberation or

mediation by an independent reviewer, after which the complete manuscripts were evaluated for inclusion. The criteria for literature selection, exclusion, search， and screening were established by the PRISMA guidelines(Page et al., 2021).

Inclusion criteria: (1) Eligibility was restricted to randomized controlled trials published in the last decade ； (2) studies conducted on or potentially beneficial to groups of senior citizens; (3) intervention group engaging in any type of tai chi exercise program and control group performing a different form of intervention than tai chi exercise; (4) use of the Pittsburgh Sleep Quality Scale as an outcome indicator. Exclusion criteria : (1) non-randomized controlled studies, (2) literature with mismatched interventions, (3) duplicate publications, literature from the same trial, (4) literature for which the full text was not available, and (5) literature with non-compliant outcome indicators.

After identifying literature for inclusion, for each included study, two researchers collected and reported data on the following variables. The variables examined encompassed author, title, year, research design, participants' characteristics, gender, intervention program, and outcomes. Data extraction was conducted in the form of mean (M) and standard deviation (SD). In cases where experimental data were unavailable, authors were asked via email to provide the above data. A third researcher then re-analyzed the data previously validated for extraction.

2.3 Risk of bias and certainty of evidence

The risk of bias in the included studies was evaluated using the Cochrane Risk of Bias Tool(Cumpston et al., 2019). Two independent reviewers (Cqs.W. and X.W.) conducted the assessment, and all disagreements were settled by mutual agreement. If needed, a third reviewer (J.L.) was consulted to reach a final decision.

2.4 Effect Measurement and Synthesis Methods

This study's outcome measures consisted of continuous variable data. The selected studies were meta-analyzed using Review Manager 5.4.1 software and Stata 17.0. The overall effects were shown as weighted mean differences (WMD). The confidence intervals (CI) were also presented. Statistical

significance was defined as $p < 0.05$. The Q-test and I^2 values were employed to assess the degree of heterogeneity. If $I^2 \leq 50\%$, $p \geq 0.1$, heterogeneity was considered to be small and analyzed using a fixed-effects model. If $I^2 > 50\%$ and $P \leq 0.1$, the heterogeneity was indicated to be significant, and the effect sizes of the results were combined using a random-effects model, and the heterogeneity sources were investigated through sensitivity analysis and subgroup analysis.

We examined data from the PSQI and its components to see how Tai Chi exercise affects sleep quality in the older population. This comprehensive evaluation allowed us to determine the overall effect regarding effects of Tai Chi on sleep quality among the elderly. The PSQI is a subjective measure of sleep quality that evaluates multiple dimensions of the sleep cycle and is designed to evaluate participants' sleep quality during the previous month(Buysse et al., 1989). The scale assesses seven dimensions—nocturnal rest quality, onset latency, total sleep time, sleep maintenance efficacy, nocturnal disruptions, hypnotic agent utilization, and diurnal impairment, each scored 0–3, with summed scores (0–21) indicating poorer sleep quality at higher values(Buysse et al., 1989). When the data were reported as mean difference (MD) with standard error (SE), the SE was converted to standard deviation (SD) using the Cochrane Handbook Calculator(Cumpston et al., 2019).

3. Results

3.1 Study Selection

A total of 353 studies were identified through the systematic search. Among these, 119 records were not retained due to duplication. The titles and abstracts of the remaining 234 studies were rigorously reviewed and filtered, culminating in an in-depth evaluation of 93 articles. After the full-text review was completed, 12 studies were ultimately determined to meet the predefined inclusion criteria（Fig. 1）.

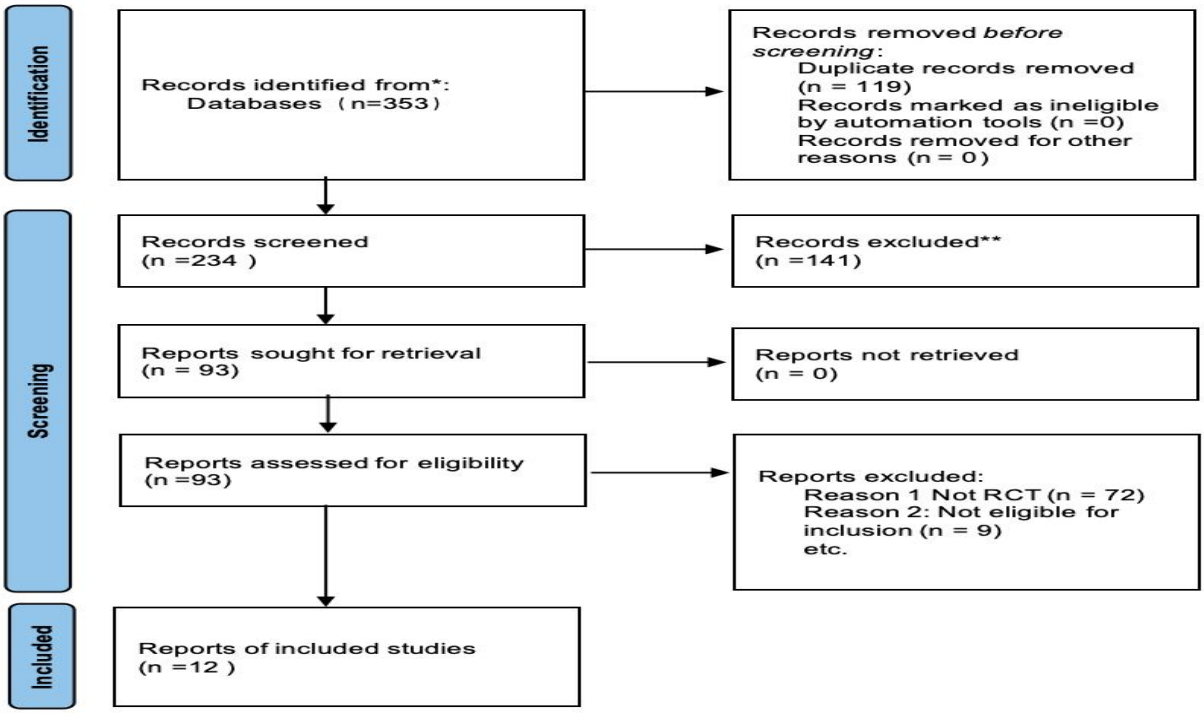

Fig. 1 PERSiST flow diagram detailing inclusion and exclusion of manuscripts

3.2 Study Characteristics

As shown in Table 1, a total of 12 studies were incorporated into this investigation for systematic literature review and statistical analysis. These studies were published within the last decade (2015–2025) and collectively encompassed a sample size of 840 participants. Of these, 7 studies had seniors with sleep problems. Two studies focused only on female participants, namely breast cancer survivors and elderly women with knee OA at higher sleep risk than men (Babaei Bonab & Parvaneh, 2022; Lü et al., 2017). In the present study, we included only studies whose outcome metrics included the Pittsburgh Sleep Quality Inventory, 4 studies analyzed sleep quality, sleep latency, sleep efficiency, sleep disorders, hypnotic medications, and daytime dysfunction using the PSQI index, and 5 studies assessed sleep duration utilizing the Pittsburgh Sleep Quality Index (PSQI). All of the study protocols incorporated training intervention periods ranging from 8 to 24 weeks. In addition, the tai chi exercise

intervention protocols used in these studies were not uniform. They included 24-pattern taijiquan, Chen's taijiquan, taijiquan sleep-assisting gong, created taijiquan, Yang's 24-pattern taijiquan, and 8-pattern taijiquan. In addition, 2 studies have specifically compared the effects of taijiquan exercise with cognitive behavioral therapy (Ding, 2020; Irwin et al., 2017).

Table 1 Basic Characteristics of Included Studies

study (Year)	Disease	Age		Sample size (T/C)	Types of Tai Chi Chuan	Intervening measure		Period (week)
		T	C			T（Frequency/Duration）	C	
Ding et al. 2020(Ding, 2020)	Individuals with insomnia symptoms	65.24±4.57	65.83±4.08	29/36	The 24-form Tai Chi and Chen-style Tai Chi	3 sessions/week, 80 min/session	Cognitive Behavioral Therapy	24
Fan et al. 2020(樊国栋, 2025)	Individuals with insomnia symptoms	83.6±3.98	81.6±5.41	10/10	Tai Chi Sleep Aid Exercises	5 ± 1 sessions/week, 30 min/session	Maintain the original lifestyle	12
Fang et al. 2021(方炎炎, 2025)	Individuals with insomnia symptoms	86.14±3.84	87.0±0.745	29/34	Adapted Seated Tai Chi	3 sessions/week, 60 min/session	Maintain the original lifestyle	12
Iwrin et al. 2017(Irwin et sl., 2017)	Breast cancer survivors with insomnia symptoms.	59.6±7.9	60.0±9.3	33/40	Tai Chi	120 minutes per week	Cognitive Behavioral Therapy	12
Li et al. 2020(Li, 2021)	Individuals with no diseases significantly affecting their activities	79.13±5.88	77.33±6.05	30/30	8-Form Tai Chi	4 sessions/week, 40 min/session	Maintain the original lifestyle	12

Li et al. 2024(L.-Y. Li et al., 2024)	Individuals with no diseases significantly affecting their activities	66.13±4.29	68.92±4.64	23/25	Yang-style 24-form Tai Chi	3 sessions/week, 60 min/session	Maintain the original lifestyle	8
Lv et al. 2017(Lü et al., 2017)	Individuals with knee osteoarthritis (OA) and stable medication use.	64.61±3.40	65.43±3.43	21/19	Knee-friendly Yang-style 8-form Tai Chi	3 sessions/week, 60 min/session	Health Education	24
Siu et al. 2021(Siu et al., 2021)	Individuals with insomnia symptoms	66.5 ± 6.4	68.0 ± 8.2	105/110	Yang-style 24-form Tai Chi	3 sessions/week, 60 min/session	Maintain the original lifestyle	12
Solmaz et al. 2022(Babaei Bonab & Parvaneh, 2022)	Elderly women with no diseases significantly affecting their activities.	-	-	35/35	The 24-form Simplified Tai Chi	3 sessions/week, 60 min/session	Maintain the original lifestyle	12
Wang et al 2024(Wange t al., 2024)	Individuals with no diseases significantly affecting their activities	66.0±4.97	69.1±4.56	30/25	The 24-form Simplified Tai Chi	3 sessions/week, 60 min/session	Maintain the original lifestyle	8
Xie et al. 2023(Xie, 2023)	Individuals with no diseases significantly affecting their activities	66.00±5.05	69.12±4.65	30/26	24-Form Tai Chi	3 sessions/week, 45 min/session	Maintain the original lifestyle	8
Yang 2019(Yang, 2019)	Individuals with elderly primary hypertension and insomnia symptoms.	66.59±4.53	67.47±5.12	37/38	The 24-form Simplified Tai Chi	3 sessions/week, 60 min/session	Equivalent energy expenditure through walking exercise	16

3.3 Meta-analysis results

Twelve papers were included in this study for statistical analysis, and all employed the PSQI index to assess the sleep quality of older adults. Following the tai chi intervention, elderly participants exhibited significantly reduced PSQI scores, indicating improved sleep quality. The findings indicated that tai chi significantly influenced PSQI scores in elderly participants (WMD = -1.8; 95% CI: [-2.40, -1.20]; $p < 0.00001$). Inter-study heterogeneity was evaluated using the Q-test, which yielded Q = 33.04, df = 11, and $I^2 = 67\%$ ($p < 0.001$), indicating substantial variability among the studies. Funnel plot analysis (Fig. 3) suggested symmetry among the included studies, implying no significant publication bias and confirming the reliability and stability of the overall findings. To explore the source of heterogeneity, we conducted a sensitivity analysis by systematically omitting one study at a time and evaluating its influence on the pooled PSQI score. The findings demonstrated (Fig. 3) that the included studies exhibited minimal heterogeneity, and the effect size of excluding any single study on the total PSQI score was negligible. Consequently, the results of the meta-analysis in this investigation are reasonably robust.

The meta-analysis examining the impact of tai chi on PSQI dimensions in the elderly showed that the intervention effect sizes of tai chi exercise on the subjective sleep quality among older adults were (WMD=-0.23, 95% CI: [-0.43,-0.04], p=0.02), and the intervention effect sizes on daytime dysfunction were (WMD=-0.38, 95% CI: [-0.55,-0.21], p<0.001). There were no significant differences in sleep latency, sleep medication use, habitual sleep efficiency, sleep duration, and sleep disturbance in the seniors (p>0.05). This suggests that tai chi exercise can improve the quality of sleep in seniors from the dimensions of sleep quality and daytime dysfunction.

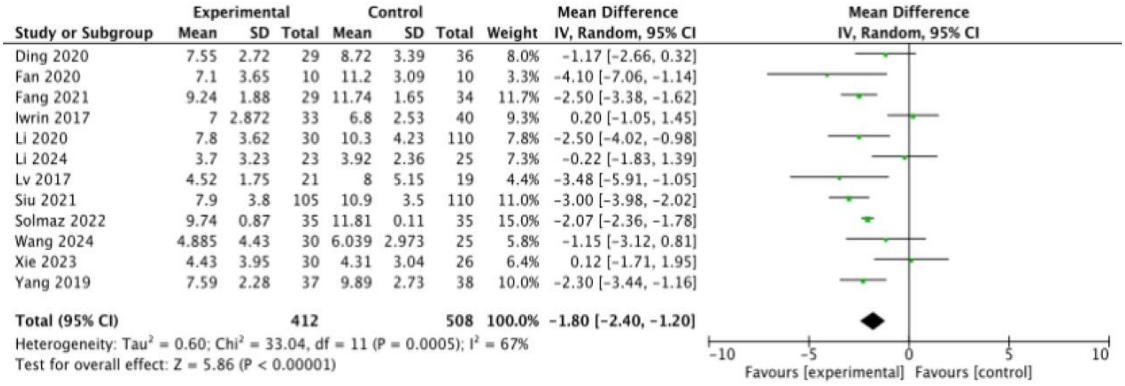

Fig. 2. Forest plot of meta-analysis of the effect of tai chi on PSQI index in senior citizens

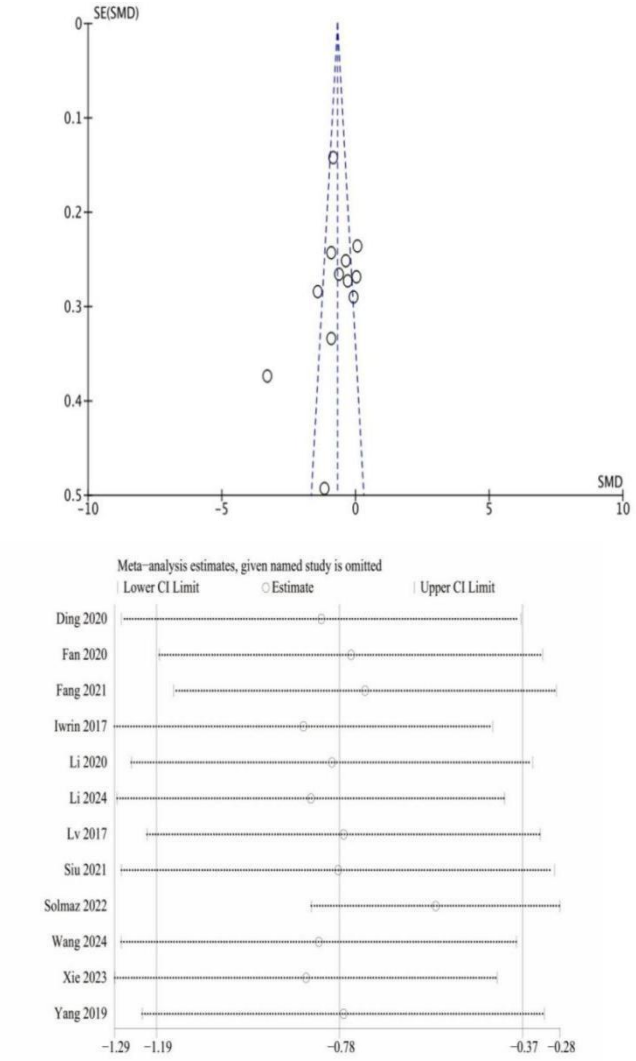

Fig. 3. Sensitivity analysis

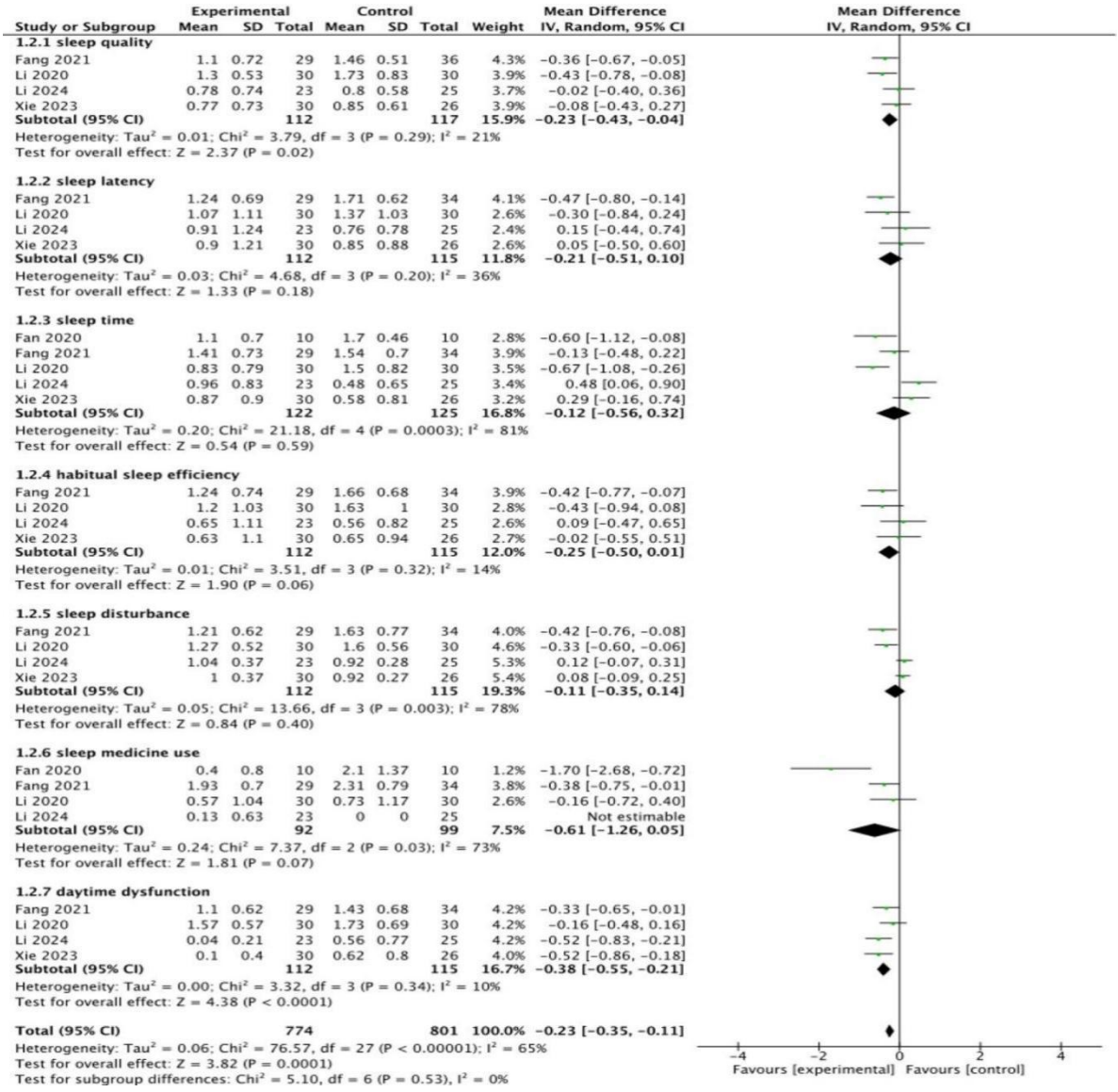

Fig. 4. Meta-forest plot of the effect of tai chi on each dimension of PSQI

3.4 Subgroup analysis

In order to better understand the origins of heterogeneity, subgroup analysis was conducted to analyze the factors that may affect the results, such as the presence of insomnia in the group of seniors, the intervention period, the length of a single intervention, and the type of taijiquan.

The studies included in the analysis were divided into two categories according to the presence or absence of insomnia symptoms among participants. Among seniors with insomnia symptoms, the

amount of intervention effect of tai chi exercise on PSQI scores was (WMD=-2.47，95%CI：[-3.09,-1.84], p<0.001), with low within-group heterogeneity (I^2=25%). Among seniors without insomnia symptoms, the intervention effect size for tai chi exercise was (WMD=-1.36，95%CI：[-2.70,-1.27], p<0.05) with moderate within-group heterogeneity (I^2=58%). Statistical significance was not reached between subgroups (Chi^2=2.36, p=0.12, I^2=57.6%).

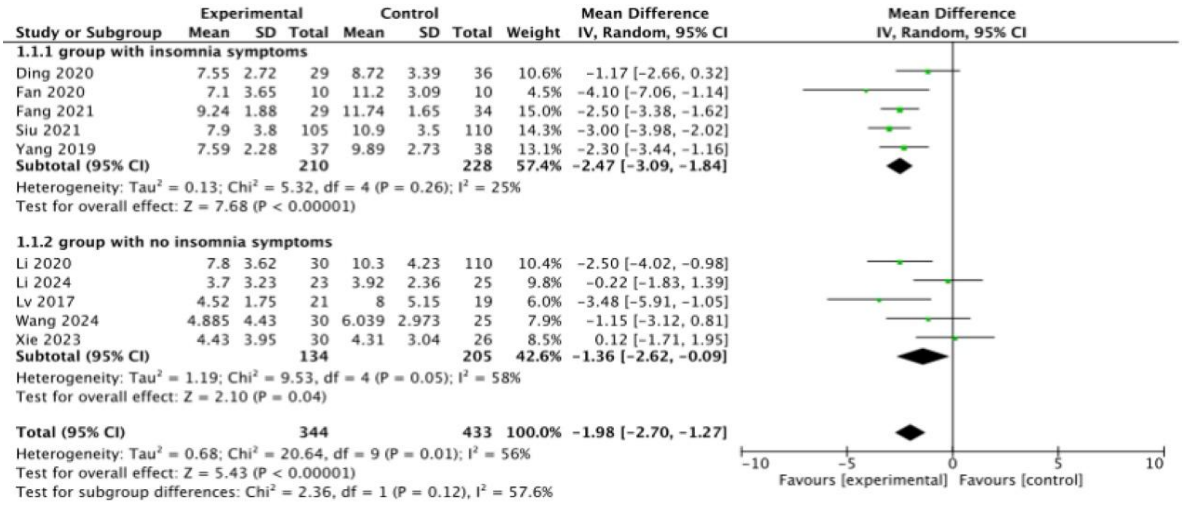

Fig. 5. Forest plot of the effect of tai chi on the presence or absence of insomnia symptoms in seniors

The included studies were divided into two groups according to whether the duration of the intervention exceeded 8 weeks. The results of subgroup analysis showed that the intervention cycle was an important factor affecting heterogeneity. Based on the PSQI total score index, in terms of intervention cycle, the 8-week tai chi exercise intervention cycle was not statistically significant (p>0.05) on the amount of sleep intervention effect on the seniors, and there was no heterogeneity within the group (I^2=0%, p=0.48). The amount of sleep intervention effect on the group sleep effect on the seniors in the intervention cycle with more than 8 weeks was (WMD=-2.53，95%CI：[-3.01,-2.04], p<0.00001), with no within-group heterogeneity (I^2=0%, P=0.43). The difference between subgroups was highly significant (Q^2=13.79, df=1, p=0.0002, I^2=92.7%). The intervention cycle emerged as the key factor underlying the overall heterogeneity.

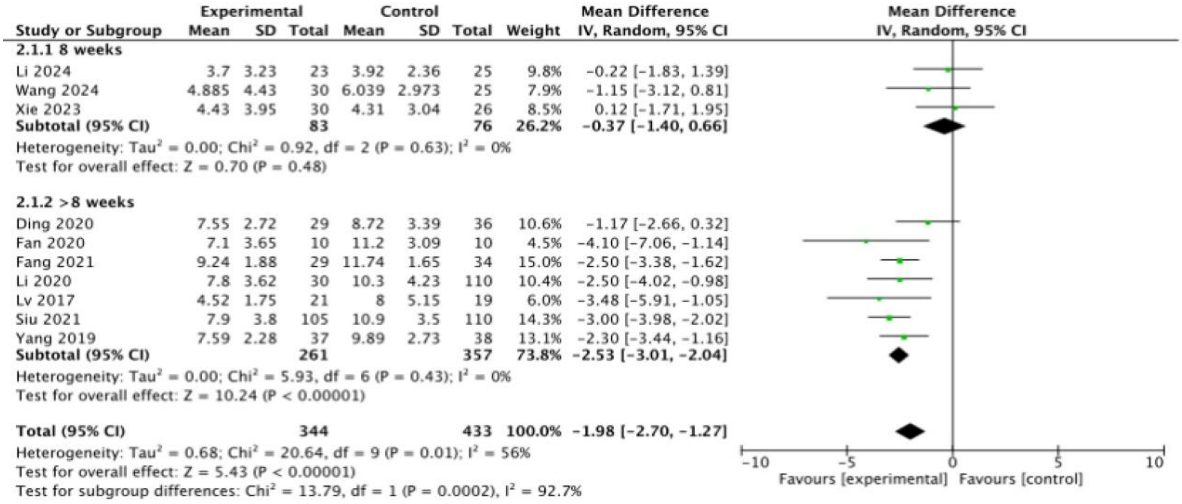

Fig. 6. Forest plot of the effect of different intervention cycles of tai chi on the quality of sleep in senior citizens

The included literature was divided into two subgroups according to different single intervention durations. The results showed that the amount of sleep intervention effect on seniors' sleep was not statistically significant for a single tai chi intervention of less than 60 minutes (p>0.05), and for a single tai chi intervention of greater than 60-80 minutes (WMD=-2.11, 95% CI: [-2.77,-1.45], p<0.00001), with moderate heterogeneity within the group (I^2 =46%). The difference between subgroups was not statistically significant (Chi^2=0.02, p=0.89, I^2=0%).

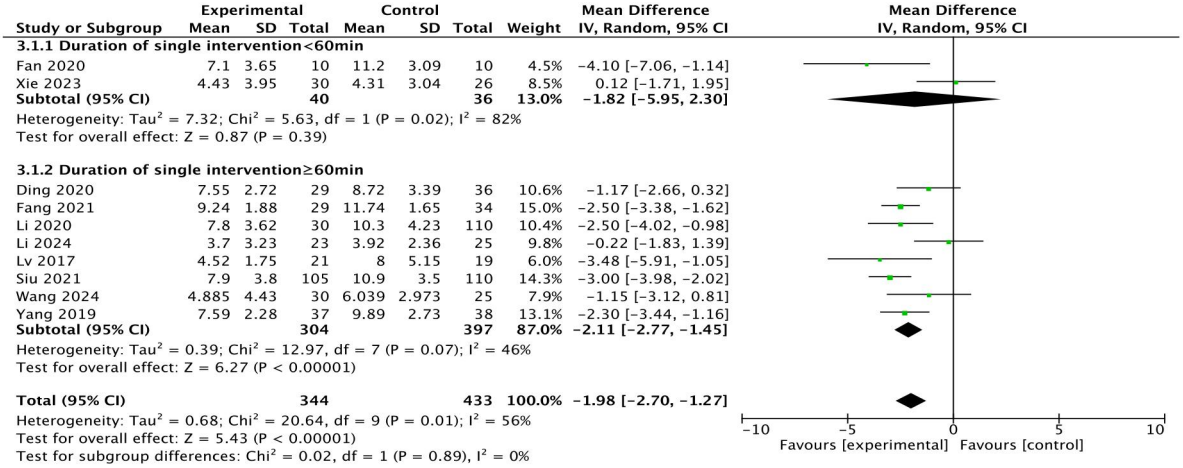

Fig. 7. Forest plot of the effect of tai chi of different intervention durations on the sleep quality of seniors

The included literature was analyzed in subgroups according to traditional taijiquan and created taijiquan. The results showed that the amount of sleep intervention effect of traditional tai chi chuan intervention on seniors was (WMD=-1.60, 95% CI: [-2.50,-0.71], p=0.0005), and the amount of sleep intervention effect of created tai chi chuan intervention on seniors was (WMD=-2.72, 95% CI: [-3.52,-1.92], p<0.00001). There was moderate heterogeneity of differences between subgroups (Chi^2=3.33, p=0.07, I^2=69.9%). It can be concluded that the type of taijiquan may be a candidate factor underlying the overall heterogeneity. The intervention effect of the created type of taijiquan was significantly better than that of the traditional type of taijiquan.

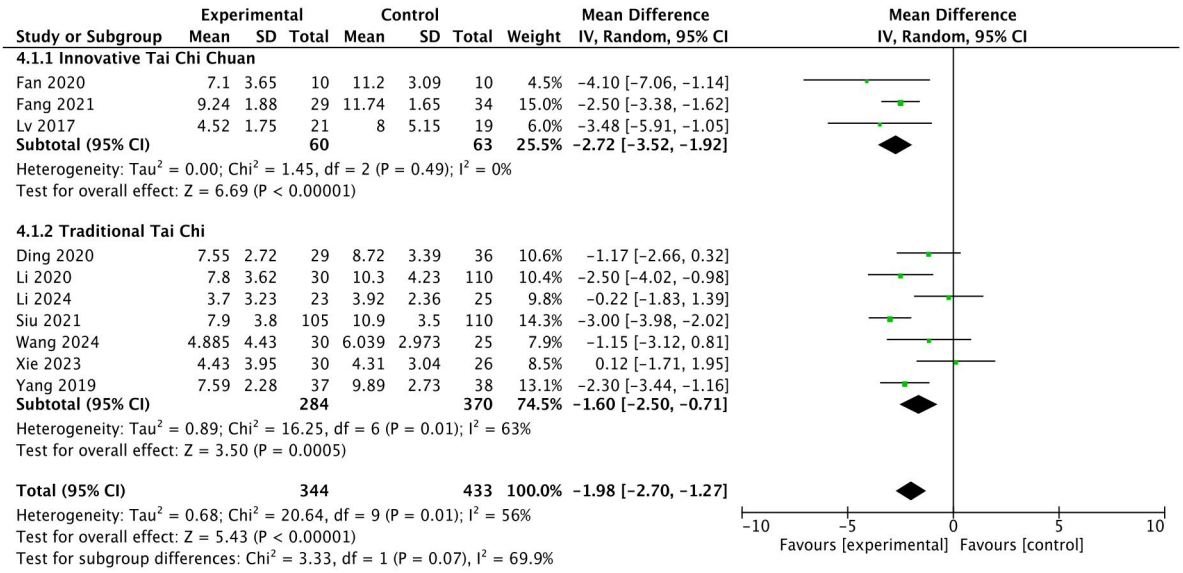

Fig. 8. Forest plot of the effect of different types of tai chi on the sleep quality of senior citizens

3.5 Quality assessment

This study used the Cochrane Risk Assessment Tool to assess the risk of bias of the included articles (Fig. 9). Of the 12 included studies, 11 studies (92%) all showed a low risk rating for randomized sequence generation. 10 studies (83%) showed a low risk rating for allocation

concealment. Due to the specific nature of randomized controlled trials, several studies used blank controls, and there was a risk of uncertainty throughout the blinding process. 11 studies (92%) showed low risk ratings for incomplete outcome data. A total of 8 studies (67%) did not provide information on possible conflicts of interest, and there was an unclear risk of bias.1 study did not describe the allocation scheme in detail. One study reported incomplete outcome data at high risk of bias. The overall quality of the included studies was good.

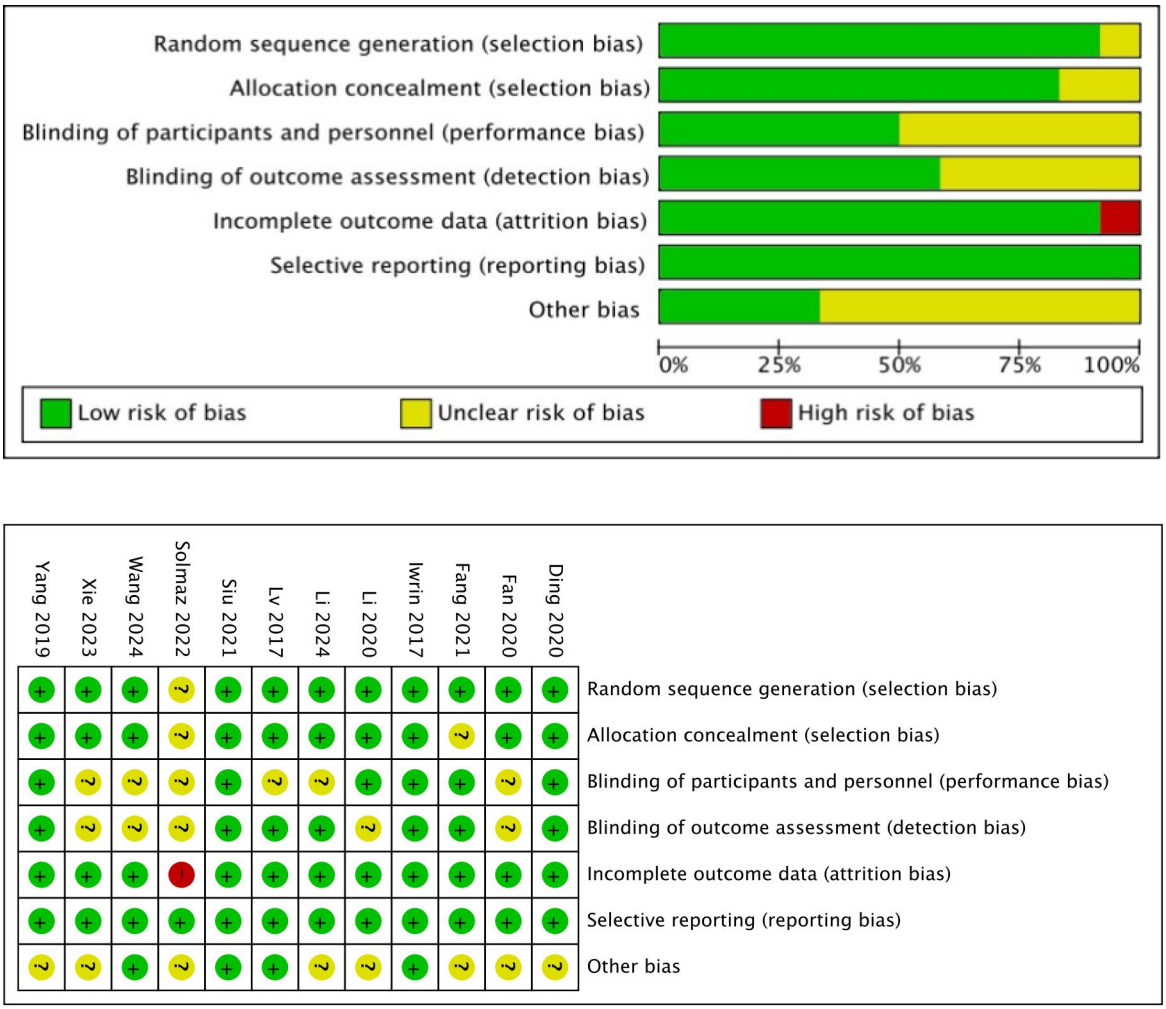

Fig. 9. Summary of risk of bias and risk of bias assessment charts

4. Discussion

This systematic review and Meta-analysis synthesized evidence from 12 randomized controlled trials and showed that tai chi has a significant and consistent positive effect in improving sleep quality in the elderly (WMD=-1.80; 95% CI: [-2.40, -1.20]; $p<0.001$). This was mainly reflected in the improvement of both subjective sleep quality and daytime dysfunction dimensions in senior citizens. It suggests that tai chi, as a physical and mental exercise, is beneficial for enhancing sleep quality among older adults. The current results mirror those of previous studies (Du et al., 2015; Irwin et al., 2008; Wang et al., 2024). Taijiquan may improve sleep through multiple pathways such as autonomic regulation, neuroendocrine adjustment, brain plasticity enhancement, inflammation suppression, and biological clock optimization (Leung, 2009; Stein & Pu, 2012; Yeh et al., 2008). Taijiquan, as a mind-body exercise that incorporates gentle body movements, deep breathing, positive meditation, and mind-body coordination, has been shown to have benefits associated with increased prefrontal activation(Z. Liu et al., 2025). Tai chi requires focus and coordination, which can enhance the brain's executive function and reduce sleep disruption. Taijiquan can effectively reduce sympathetic excitability and enhance parasympathetic tone through slow, gentle, and consistent movements with deep and long abdominal breathing, inducing the body to enter a state of relaxation and improving difficulty in falling asleep (Tseng et al., 2020).

Regular Tai Chi practice has been shown to modulate hypothalamic–pituitary–adrenal (HPA) axis function, reduce cortisol secretion, and alleviate psychological stress, anxiety, and tension—factors commonly associated with insomnia(Lavretsky et al., 2011). As a low-intensity physical and mental exercise, taijiquan can moderately enhance body fatigue and thermoregulation, which is in line with the physiological needs of sleep, while avoiding the over-excitement that may be brought about by strenuous exercise(F. Li et al., 2003). In summary, taijiquan can comprehensively enhance sleep quality through multi-target effects such as neuromodulation, stress hormone down-regulation, psychological relaxation, moderate physiological fatigue induction, and mood improvement.

Subgroup analysis results indicated that the intervention duration was the primary contributor to heterogeneity. In the present study, after grouping by intervention cycles of less than 8 weeks and more than 8 weeks: heterogeneity within subgroups disappeared completely (I^2=0%), and the findings were highly consistent for the same intervention duration; the difference in effect sizes between subgroups was significant (I^2=92.7%, p=0.0002), and intervention cycles of more than 8 weeks presented a significant efficacy (MD=-2.53), whereas intervention cycles of less than 8 weeks showed no statistically significant effect on the sleep quality improvement benefit was not statistically significant (MD=-0.37, p>0.05). Combined with the dose-effect relationship, sufficient exercise duration may reinforce sleep improvement by prolonging physical and mental relaxation time and enhancing metabolic regulation (e.g., promoting melatonin secretion) (Banno et al., 2018). Long-term regular practice accumulates neuromuscular adaptations and psychological regulation, whereas short-term interventions may not be sufficient to trigger deep physiological changes. Longer-term taijiquan practice may lead to fuller physical exercise and enhancement of physical functions, such as improved cardiorespiratory fitness, flexibility, and coordination, which in turn may have a positive effect on sleep in the senior population. Prolonged tai chi interventions may provide more adequate relaxation and meditation time for seniors, which may help to alleviate anxiety, stress, and other emotions, and thus improve sleep quality. In contrast, short interventions may not allow seniors to fully enter this state of relaxation. Taijiquan type may also be a potential source of influence on overall heterogeneity. The subgroup results showed that both traditional and created taijiquan styles were effective, but the created style was more effective, possibly because its movement design focused more on the coordination of breathing and intention, or was optimized for the physical characteristics of seniors (e.g., seated taijiquan to reduce the load on the lower limbs), which enhanced adherence and intervention effectiveness. Meanwhile, taijiquan was not only effective for seniors with insomnia symptoms, but also showed preventive effects for those without insomnia symptoms, suggesting that it can be used as a generalized health promotion tool with both therapeutic and preventive functions.

After analyzing the subgroups of intervention period, single intervention duration, taijiquan type, and intervention frequency, the findings indicated that interventions lasting fewer than 8 weeks and

individual sessions shorter than 60 minutes did not lead to significant improvements in sleep quality. It was suggested that the effectiveness of taijiquan in enhancing sleep may diminish when an adequate exercise dose is not met. Based on the findings of this study, it is concluded that taijiquan interventions with a single intervention duration of more than 60 minutes or an intervention period of more than 8 weeks may achieve better results in improving sleep in the elderly. The results of the literature included in this study showed that tai chi and rTMS have complementary effects(Z. Liu et al., 2025). Tai chi, as a physical and mental exercise, extensively activates the brain and improves receptivity to subsequent inputs. Low frequency rTMS can modulate neural activity in distal regions, alter neuronal excitability and connectivity, enhance neuroplasticity, and ameliorate dysfunctional brain states by focusing on the DLPFC. This process facilitates neural reorganization, ultimately contributing to improved sleep quality(Z. Liu et al., 2025). Meanwhile, taijiquan can regulate excitatory neurotransmitters, and low-frequency rTMS can increase inhibitory neurotransmitter levels, and the combined interventions can collaboratively modulate the balance between excitation and inhibition, thereby helping to alleviate sleep disorders(Z. Liu et al., 2025).

The causes of sleep disorders in the senior population are complex, involving altered biological rhythms, co-morbid somatic diseases, psychosocial factors, poor sleep hygiene practices, and environmental disturbances (Yang et al., 2007). Current clinical interventions for the treatment of patients with sleep disorders include melatonin receptor agonists, benzodiazepines, non-benzodiazepines, and antidepressants(Sateia et al., 2017), which are mainly aimed at improving sleep quality by modulating the neurotransmitter system. Benzodiazepines are the most common sedative-hypnotic medications, but are prone to dependence and tolerance, as well as day-after residual impact (e.g., somnolence, cognitive deficits), and extended use may heighten the risk of falls in elderly individuals Research indicates that numerous individuals rely on pharmacological therapies that either lack efficacy in managing sleep disorders or carry substantial risks of adverse effects(Kassam & Patten, 2006). Alterations in metabolism among older adults may result in heightened drug sensitivity and a greater likelihood of polypharmacy-related interactions(Shan et al., 2015). Managing sleep disorders in older adults presents challenges such as drug safety, limited effectiveness, and complex co-

morbidities. With the global in-depth research on sleep disorders, non-pharmacological treatments are becoming more and more significant in the treatment of sleep disorders. Compared with pharmacological treatments, non-pharmacological approaches (e.g., CBT-I, exercise, light therapy, relaxation training, sleep hygiene education) do not have drug-related systemic side effects (e.g., risk of addiction, falls, and cognitive impairments) (Edinger et al., 2001; Montgomery & Dennis, 2003) and are more suitable for the elderly population with declining physical function and co-morbidities.

As an important component of non-pharmacological therapies, exercise intervention has great potential and value for implementation and is an inevitable choice for achieving healthy aging. Extensive research evidence supports the conclusion that regular exercise not only effectively improves core sleep indicators and regulates circadian rhythms, but also brings multiple synergistic health benefits simultaneously: including significantly reducing the risk of anxiety and depression, relieving chronic pain, enhancing cardiorespiratory and metabolic health, enhancing cognitive function and reducing the risk of dementia, and improving physical functioning and reducing the risk of falls(Gardner et al., 2000; Guo, 2022; Hou et al., 2024; Otones et al., 2020). These multidimensional health-promoting effects are far beyond those of pharmacological interventions alone and avoid the systemic risks associated with medications. Given this, adopting an evidence-based and well-structured exercise intervention is of particular importance for improving sleep quality in the elderly population. It can enhance the quality of life of the elderly, prevent chronic diseases, delay cognitive decline, promote mental health, and reduce healthcare costs, which plays an important role in maintaining the overall health and independent living ability of the elderly.

In conclusion, Tai chi serves as a secure and efficacious non-pharmacological complementary or alternative therapy that can enhance sleep quality among older adults. Adaptive tai chi programs can be provided for senior citizens with different health conditions.

5. Study limitations

1) The scales used in the literature included in this study are mainly subjective scales, which may have some heterogeneity. Future studies could combine objective outcome indicators such as polysomnography (PSG) and body movement recorder to enable a more comprehensive evaluation of tai chi's effects on sleep quality enhancement.

2) Among the studies included in this review, only two implemented follow-up evaluations with the participants, making it difficult to accurately determine the sustained intervention effects of tai chi exercise. Future studies should increase the follow-up evaluation and thoroughly investigate the long-term improvement effect of taijiquan exercise on sleep quality in elderly people.

3) This study only classified the types of taijiquan into traditional taijiquan and created taijiquan types, and failed to analyze the differential effects of different schools of taijiquan in depth. The differences in effects among various tai chi schools could be explored in future studies.

6. Conclusion

1) Tai chi intervention exerts a multidimensional positive influence on sleep quality among elderly individuals.

2) The improvement effect of tai chi exercise on sleep quality was influenced by the duration of the exercise. A taijiquan exercise intervention program with an intervention period of more than 8 weeks and a single intervention duration of 60-80 minutes was significantly more effective in improving sleep quality in the elderly population.

(3) Compared to traditional tai chi, adapted tai chi styles show greater effectiveness in enhancing sleep quality in the elderly. Creation of traditional taijiquan moves to adapt to the different health conditions of the elderly can achieve better results.

Disclossure

Author Contributions

Chenyu Wang: Writing - original draft. **Xuemei Wu**: Validation. **Chuanqiushui Wang**: Investigation. **Jiong Luo**: Writing – reviw&editing.

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References

FAN, G. D. (2020). An Experimental Study on the improvement of Sleep Disordersin the Elderly by Tai Chi Chuan Sleep Aid [Master's thesis]. Beijing Sport University, Beijing, China https://doi.org/10.26961/d.cnki.gbjtu.2020.000245

FANG, Y. Y. (2021). Effects of Sitting Taijiquan on Sleep Quality、Anxiety andFatigue in Elderly Patients with Sleep Disorders [Master's thesis]. Shanghai University of Sport, Shanghai, China. https://doi.org/10.27315/d.cnki.gstyx.2021.000225

Li，Y.Q. (2021). A Randomized Controlled Experimental Study on the Influence of Eight-style Taijiquan Exercise on Mental Health Level of Elderly in Nursing Homes [Master's thesis]. Shandong Sport University, Jinan, China.. https://doi.org/10.27725/d.cnki.gsdty.2020.000032

XIE, X. (2023). The effects of Tai Chi exercise on sleep and sleep-related cognitive function in older adults [Master's thesis]. Southwest University, Chongqing, China.. https://doi.org/10.27684/d.cnki.gxndx.2022.000252

YANG,X.W. (2019). The effects of Tai Chi on sleep quality in elderly patients with essential hypertension [Master's thesis]. Chengdu University of Traditional Chinese Medicine, Chengdu, China. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD201901&filename=1018890067.nh

Ardern, C. L., Büttner, F., Andrade, R., Weir, A., Ashe, M. C., Holden, S., Impellizzeri, F. M., Delahunt, E., Dijkstra, H. P., Mathieson, S., Rathleff, M. S., Reurink, G., Sherrington, C., Stamatakis, E., Vicenzino, B., Whittaker, J. L., Wright, A. A., Clarke, M., Moher, D., … Winters, M. (2022). Implementing the 27 PRISMA 2020 statement items for systematic reviews in the sport and exercise medicine, musculoskeletal rehabilitation and sports science fields: The PERSiST (implementing prisma in exercise, rehabilitation, sport medicine and SporTs science) guidance. British Journal of Sports Medicine, 56 (4), 175～195. https://doi.org/10.1136/bjsports-2021-103987

Babaei Bonab, S., & Parvaneh, M. (2022). The effect of twelve weeks of tai chi exercises on sleep quality, pain perception, and death anxiety in elderly women. Annales Médico-Psychologiques, Revue Psychiatrique, 180(9), 9. https://doi.org/10.1016/j.amp.2022.01.019

Banno, M., Harada, Y., Taniguchi, M., Tobita, R., Tsujimoto, H., Tsujimoto, Y., Kataoka, Y., & Noda, A. (2018). Exercise can improve sleep quality: A systematic review and meta-analysis. PeerJ. https://doi.org/10.7717/peerj.5172

Buysse, D., Reynolds, C., Monk, T., Berman, S., & Kupfer, D. (1989). The pittsburgh sleep quality index—A new instrument for psychiatric practice and research. Psychiatry Research, 28(2), 193～213. https://doi.org/10.1016/0165-1781(89)90047-4

Cao, X.-L., Wang, S.-B., Zhong, B.-L., Zhang, L., Ungvari, G. S., Ng, C. H., Li, L., Chiu, H. F. K., Lok, G. K. I., Lu, J.-P., Jia, F.-J., & Xiang, Y.-T. (2017). The prevalence of insomnia in the general population in China: A meta-analysis. PLOS One, 12(2), e0170772. https://doi.org/10.1371/journal.pone.0170772

Carvalho, D. Z., St Louis, E. K., Knopman, D. S., Boeve, B. F., Lowe, V. J., Roberts, R. O., Mielke, M. M., Przybelski, S. A., Machulda, M. M., Petersen, R. C., Jack, C. R., & Vemuri, P. (2018). Association of excessive daytime sleepiness with longitudinal β-amyloid accumulation in elderly persons without dementia. JAMA Neurology, 75(6), 672～680. https://doi.org/10.1001/jamaneurol.2018.0049

Cumpston, M., Li, T., Page, M. J., Chandler, J., Welch, V. A., Higgins, J. P. T., & Thomas, J. (2019). Updated guidance for trusted systematic reviews: A new edition of the cochran e handbook for systematic reviews of interventions. Cochrane Database of Systematic Reviews, 10, ED000142. https://doi.org/10.1002/14651858.ED000142

Ding Y. (2020). Research on the intervention effect of Taijiquan exercise on insomnia in the e lderly [Master's thesis].Anhui University of Chinese Medicine. Anhui， China. https:// doi.org/10.26922/d.cnki.ganzc.2020.000306

Du, S., Dong, J., Zhang, H., Jin, S., Xu, G., Liu, Z., Chen, L., Yin, H., & Sun, Z. (2015). Taic hi exercise for self-rated sleep quality in older people: A systematic review and meta-a nalysis. International Journal of Nursing Studies, 52(1), 368～379. https://doi.org/10.1 016/j.ijnurstu.2014.05.009

Edinger, J. D., Wohlgemuth, W. K., Radtke, R. A., Marsh, G. R., & Quillian, R. E. (2001). Co gnitive behavioral therapy for treatment of chronic primary insomnia: A randomized c ontrolled trial. JAMA, the Journal of the American Medical Association, 285(14), 185 6～1864. https://doi.org/10.1001/jama.285.14.1856

Effects of drugs on sleep. (1996). Neurologic Clinics, 14(4), 827～840. https://doi.org/10.101 6/S0733-8619(05)70287-5

Gardner, M. M., Robertson, M. G., & Campbell, A. J. (2000). Exercise in preventing falls and fall related injuries in older people: A review of randomised controlled trials. British J ournal of Sports Medicine, 34(1), 7～17. https://doi.org/10.1136/bjsm.34.1.7

Gong M., Tang Q., Tan S., & Hu X. (2024). Research Progress in the Effect of Exercise Inter vention on Sleep Disorders and the Mechanisms Involved. Journal of Sichuan Univers ity(Medical Sciences), 55(1), 236～242.

Guo, L. (2022). Effects of 24-form tai chi on cardio-pulmonary functions, exercise performan ces, and cognitive functions of the aged. Iranian Journal of Public HEALTH, 51(10), 2 253～2261.

Himali, J. J., Baril, A.-A., Cavuoto, M. G., Yiallourou, S., Wiedner, C. D., Himali, D., Decarli, C., Redline, S., Beiser, A. S., Seshadri, S., & Pase, M. P. (2023). Association between slow-wave sleep loss and incident dementia. JAMA Neurology, 80(12), 1326～1333. https://doi.org/10.1001/jamaneurol.2023.3889

Hou, B., Wu, Y., & Huang, Y. (2024). Physical exercise and mental health among older adult s: The mediating role of social competence. Frontiers in Public Health, 12, 1385166. h ttps://doi.org/10.3389/fpubh.2024.1385166

International, B. R. (2023). Retracted: Correlation between sleep time, sleep quality, and emot ional and cognitive function in the elderly. Biomed Research International, 2023, 9843 104. https://doi.org/10.1155/2023/9843104

Irwin, M. R., Olmstead, R., Carrillo, C., Sadeghi, N., Nicassio, P., Ganz, P. A., & Bower, J. E. (2017). Tai chi chih compared with cognitive behavioral therapy for the treatment of i nsomnia in survivors of breast cancer: A randomized, partially blinded, noninferiority trial. Journal of Clinical Oncology, 35(23), 2656. https://doi.org/10.1200/JCO.2016.71. 0285

Irwin, M. R., Olmstead, R., & Motivala, S. J. (2008). Improving sleep quality in older adults with moderate sleep complaints: A randomized controlled trial of tai chi chih. Sleep, 3 1(7), 1001～1008.

Kassam, A., & Patten, S. B. (2006). Hypnotic use in a population-based sample of over thirty-five thousand interviewed canadians. Population Health Metrics, 4(1), 15. https://doi.o rg/10.1186/1478-7954-4-15

Lavretsky, H., Alstein, L. L., Olmstead, R. E., Ercoli, L. M., Riparetti-Brown, M., St. Cyr, N., & Irwin, M. R. (2011). Complementary use of tai chi chih augments escitalopram trea

tment of geriatric depression: A randomized controlled trial. American Journal of Geri atric Psychiatry, 19(10), 839～850. https://doi.org/10.1097/JGP.0b013e31820ee9ef
Leblanc, M.-F., Desjardins ,Sophie, & and Desgagné, A. (2015). The relationship between sle ep habits, anxiety, and depression in the elderly. Nature and Science of Sleep, 7, 33～ 42. https://doi.org/10.2147/NSS.S77045
Leung, R. S. T. (2009). Sleep-disordered breathing: Autonomic mechanisms and arrhythmias. Progress in Cardiovascular Diseases, 51(4), 324～338. https://doi.org/10.1016/j.pcad. 2008.06.002
Li, F., Fisher, K. J., Harmer, P., & Shirai, M. (2003). A simpler eight-form easy tai chi for eld erly adults. https://doi.org/10.1123/japa.11.2.206
Li, L.-Y., Xie, X., Jiang, H.-X., & Yu, J. (2024). Improving memory through better sleep in c ommunity-dwelling older adults: A tai chi intervention study. The Journals of Geronto logy, Series B: Psychological Sciences and Social Sciences, 79(11), 条 11. https://doi. org/10.1093/geronb/gbae156
LIU na, & WANG J. (2024). The Relationship Between Quality of Life and Quality of Sleep: The Chain Mediation Effects of Perceived Stress and Sleep Anxiety. Journal of South China Normal University(Social Science Edition), 4, 74～93, 206.
Liu H., Li F., & Wang Y. (2017). Association between sleep and leukocyte telomere length in middle-aged and older adults. Chinese journal of Epidemiology, 38(7). https://kns.cnk i.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=CJFDTEMP&filename=ZHL X201707008
Liu Y., Dong Y., Li X., & Mao X. (2014). Meta-analysis of the prevalence of sleep disorder a mong Chinese elderly aged 60 years and over. Modern Preventive Medicine, 41(8), 14 42～1445, 1449.
Liu, Z., Zhang, L., Bai, L., Guo, Z., Gao, J., Lin, Y., Zhou, Y., Lai, J., Tao, J., & Chen, L. (20 25). Repetitive transcranial magnetic stimulation and tai chi chuan for older adults wit h sleep disorders and mild cognitive impairment: A randomized clinical trial. JAMA N etwork Open, 8(1), 1. https://doi.org/10.1001/jamanetworkopen.2024.54307
Lü, J., Huang, L., Wu, X., Fu, W., & Liu, Y. (2017). Effect of tai ji quan training on self-repor ted sleep quality in elderly chinese women with knee osteoarthritis: A randomized con trolled trail. Sleep Medicine, 33, 70～75. https://doi.org/10.1016/j.sleep.2016.12.024
Lu, W.-A., & Kuo, C.-D. (2003). The effect of tai chi chuan on the autonomic nervous modul ation in older persons. Medicine & Science in Sports & Exercise, 35(12), 1972. https:// doi.org/10.1249/01.MSS.0000099242.10669.F7
Montgomery, P., & Dennis, J. (2003). Cognitive behavioural interventions for sleep problems in adults aged 60+. The Cochrane Database of Systematic Reviews, 1, CD003161.
Otones, P., Garcia, E., Sanz, T., & Pedraz, A. (2020). A physical activity program versus usua l care in the management of quality of life for pre-frail older adults with chronic pain: Randomized controlled trial. BMC Geriatrics, 20(1), 396. https://doi.org/10.1186/s128 77-020-01805-3
Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Sh amseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimsha w, J. M., Hrobjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDo nald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ: British Medical Journal, 372, n71. https://doi.org/ 10.1136/bmj.n71
Sabia, S., Fayosse, A., Dumurgier, J., van Hees, V. T., Paquet, C., Sommerlad, A., Kivimaeki, M., Dugravot, A., & Singh-Manoux, A. (2021). Association of sleep duration in midd le and old age with incidence of dementia. Nature Communications, 12(1), 2289. https:

//doi.org/10.1038/s41467-021-22354-2
Sateia, M. J., Buysse, D. J., Krystal, A. D., Neubauer, D. N., & Heald, J. L. (2017). Clinical practice guideline for the pharmacologic treatment of chronic insomnia in adults: An american academy of sleep medicine clinical practice guideline. Journal of Clinical Sleep Medicine, 13(2), 307～349. https://doi.org/10.5664/jcsm.6470
Shan H., Liu A., & He Y. (2015). Rational Drug Use and Safety of the Elderly. Chinese General Practice, 18(35), 4362. https://doi.org/10.3969/j.issn.1007-9572.2015.35.022
Siu, P. M., Yu, A. P., Tam, B. T., Chin, E. C., Yu, D. S., Chung, K.-F., Hui, S. S., Woo, J., Fong, D. Y., Lee, P. H., Wei, G. X., & Irwin, M. R. (2021). Effects of tai chi or exercise on sleep in older adults with insomnia: A randomized clinical trial. JAMA Network Open, 4(2), 2. https://doi.org/10.1001/jamanetworkopen.2020.37199
Siu, P. M., Yu, A. P., Tam, B. T., Chin, E. C., Yu, D. S., Chung, K.-F., Hui, S. S., Woo, J., Fong, D. Y., Lee, P. H., Wei, G. X., & Irwin, M. R. (2021). Effects of tai chi or exercise on sleep in older adults with insomnia: A randomized clinical trial. JAMA Network Open, 4(2), 2. https://doi.org/10.1001/jamanetworkopen.2020.37199
Stein, P. K., & Pu, Y. (2012). Heart rate variability, sleep and sleep disorders. Sleep Medicine Reviews, 16(1), 47～66. https://doi.org/10.1016/j.smrv.2011.02.005
Tian, L., Pan, D., Kuang, X., Ai, W., & Shi, H. (2024). The association between sleep duration trajectories and successful aging: A population-based cohort study. BMC Public Health, 24, 1～12. https://doi.org/10.1186/s12889-024-20524-7
Tian, Y., & Li, L. M. (2017). [Epidemiological study of sleep disorder in the elderly]. Zhonghua Liu Xing Bing Xue Za Zhi = Zhonghua Liuxingbingxue Zazhi, 38(7), 988～992. https://doi.org/10.3760/cma.j.issn.0254-6450.2017.07.028
Tseng, T.-H., Chen, H.-C., Wang, L.-Y., & Chien, M.-Y. (2020). Effects of exercise training on sleep quality and heart rate variability in middle-aged and older adults with poor sleep quality: A randomized controlled trial. Journal of Clinical Sleep Medicine, 16(9), 1483～1492. https://doi.org/10.5664/jcsm.8560
Wang, C., Jiang, T., Li, H., Cao, G., & Zhang, G. (2024). The effects of tai chi exercise on sleep quality among the elderly: A study based on polysomnographic monitoring. Frontiers in Neurology, 15. https://doi.org/10.3389/fneur.2024.1304463
Wang, C., Jiang, T., Li, H., Cao, G., & Zhang, G. (2024). The effects of tai chi exercise on sleep quality among the elderly: A study based on polysomnographic monitoring. Frontiers in Neurology, 15. https://doi.org/10.3389/fneur.2024.1304463
Wayne, P. M., Berkowitz, D. L., Litrownik, D. E., Buring, J. E., & Yeh, G. Y. (2014). What do we really know about the safety of tai chi?: A systematic review of adverse event reports in randomized trials. Archives of Physical Medicine and Rehabilitation, 95(12), 2470～2483. https://doi.org/10.1016/j.apmr.2014.05.005
Yang L., Jiang Z., & Zhao J. (2007). Causes of sleep disorders in elders and nursing care. Chinese Journal of Nursing, 1, 75～77.
Yeh, G. Y., Mietus, J. E., Peng, C.-K., Phillips, R. S., Davis, R. B., Wayne, P. M., Goldberger, A. L., & Thomas, R. J. (2008). Enhancement of sleep stability with tai chi exercise in chronic heart failure: Preliminary findings using an ECG-based spectrogram method. Sleep Medicine, 9(5), 527～536. https://doi.org/10.1016/j.sleep.2007.06.003
Zhang R., Zhang S., Qi H., Qiao W., & Zhao J. (2022). Influencing Factors of Sleep Disorders in the Elderly and Their Effects on Immune Status, Cognitive Function and Quality of Life. Progress in Modern Biomedicine, 22(21), 4071～4075. https://doi.org/10.13241/j.cnki.pmb.2022.21.012
Zhang Y., Fu Y., & Li D. (2024). Association of sleep duration and sleep quality with chronic disease and comorbidity among the elderly in China: An analysis of 2018 CLHLS sur

vey data. Chinese Journal of Public Health, 40(8), 954～958.
Zisapel, N. (2007). Sleep and sleep disturbances: Biological basis and clinical implications. C ellular and Molecular Life Sciences, 64(10), 1174～1186. https://doi.org/10.1007/s000 18-007-6529-9