Iran J Public Health, Vol. 52, No.5, May 2023, pp.880-891

Review Article

Effect of Baduanjin Exercise on Metabolic Syndrome Risk: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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(Received 15 Nov 2022; accepted 21 Jan 2023)

Abstract

Background: While people's living standards are improving, the incidence of chronic diseases due to a lack of exercise is increasing. Complex health conditions (e.g., metabolic syndrome) are becoming common, and means to lower their incidence are essential.

Methods: This study systematically reviewed the literature and performed a meta-analysis on the effects of Baduanjin exercise on metabolic syndrome-related factors. Using four English databases and three Chinese databases, randomized controlled trials on the effects of Baduanjin exercise on metabolic syndrome were identified. We analyzed whether Baduanjin could alleviate various metabolic syndrome indicators according to our selection guidelines.

Results: We found that Baduanjin exercise had positive effects on blood pressure (systolic blood pressure: mean difference (MD)=-6.39; 95% confidence interval (CI): -9.86 to -2.92; I2=12%; diastolic blood pressure: MD=-2.86; 95% CI: -5.96 to -0.23; I2=35%; *P*=0.07) and total cholesterol (standardized mean (SMD)=-0.55; 95% CI: -1.11 to 0.02; I2=86%; *P*=0.06), triglyceride (SMD=-0.29; 95% CI: -1.13 to - 0.56; I2=94%; *P*<0.51), and low-density cholesterol (SMD =-0.33; 95% CI: -0.52 to -0.14; I2=0%; *P*<0.0007) levels.

Conclusion: This evidence shows that Baduanjin exercise provides beneficial effects by improving metabolic syndrome and cardiovascular disease in adults. This suggests that Baduanjin exercise could be an effective alternative or complementary approach to conventional treatments for adults with metabolic problems. Additionally, these findings suggest that more rigorous randomized control trials are needed in the future.

Keywords: Qigong; Baduanjin; Metabolic syndrome; Risk factor; Exercise; Meta-analysis

Introduction

Metabolic syndrome is an independent risk factor for cardiovascular diseases, type 2 diabetes, cancer, and all causes of death (1). Metabolic syndrome is estimated to have a prevalence of 25% in adults worldwide and has recently become a major public health problem (2). It approximately doubles the risk of developing cardiovascular diseases within 5–10 years and increases the risk of

type 2 diabetes by five times (1). In addition, patients with metabolic syndrome have a two to four times higher risk of stroke, a three to four times higher risk of myocardial infarction, and a two times higher mortality rate than patients without metabolic syndrome (3). Therefore, preventing metabolic syndrome's occurrence and progression is a global public health priority (4).

Metabolic syndrome is an important risk factor for cardiovascular diseases and obesity, which are further increased due to lack of physical activity (2,5,6). In this regard, several previous cohort and survey studies have consistently reported that people in modern times are less physically active than their counterparts in the past (7–9). Exercise is important to avoid a sedentary lifestyle and prevent and treat metabolic syndrome. Adequate exercise and achieving healthy ranges regarding weight, blood pressure, blood glucose, high-density lipoprotein (HDL), and triglyceride levels can help control metabolic syndrome and improve dyslipidemia (10–13).

Low- to moderate-intensity aerobic exercise or exercise combining aerobic and resistance training is recommended for improving metabolic syndrome (2,14). However, this type of exercise may not be feasible in the current coronavirus disease (COVID-19) pandemic situation as it must be performed at specific locations or outside. In addition, the exercise cost may interfere with intervention compliance, and as result indirectly deters metabolic syndrome regression/prevention among people with low socioeconomic status. Therefore, exercise interventions that can prevent and treat metabolic syndrome even in a pandemic situation are those which are inexpensive and not limited by location.

Baduanjin is home-friendly which is important in the currently re-emerging COVID-19 pandemic due to the newer variants. Baduanjin exercise involves slow movements, there are no special location requirements, and it can be performed just within the amount of space necessary for the limbs to stretch out. Baduanjin is one of China's traditional health promotion exercises and consists of eight simple postures and movements (15). In addition, Baduanjin is a type of low-intensity aerobic exercise (16), which is easier to master in a short time than other exercises and has less physical burden (17). The practice of Baduanjin is known to improve not only physical strength and neuromuscular function (18) but also psychological factors (17), hypertension (19,20), diabetes (21), and dyslipidemia (21).

Many studies have attempted to investigate the effects of Baduanjin exercise on various risk factors related to metabolic syndrome, although none have examined the overall impact of metabolic syndrome-related risk factors. Therefore, a systematic review and meta-analysis were performed to objectively evaluate the literature on the effects of Baduanjin on risk factors related to metabolic syndrome. Through this study, researchers, clinicians, and exercise therapists can design and develop efficient and effective exercise programs for the intervention of metabolic syndrome.

Methods

Search Strategy

PubMed, Embase, and Cochrane Library databases were used for the literature search. The searching period was from 2000 to 2022. Considering that the Baduanjin exercise was started in China, we searched papers in China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (VIP), and WanFang Data databases in China. The publication date was not limited. The search query was designed as follow: ("Baduanjin" OR "Baduanjin exercise") AND ("metabolic syndrome" OR "blood lipid" OR "blood cholesterol," OR "triglyceride" OR "high-density lipoprotein cholesterol" OR "low-density lipoprotein cholesterol" OR "high blood pressure" OR "blood glucose".

Inclusion and Exclusion Criteria

The inclusion criteria for the selected studies were as follows:

- Study type: a randomized controlled trial study published in a peer-

reviewed English or Chinese journal.

- Participants: adults, middle-aged, and older people.
- Intervention group: groups in which Baduanjin training was performed individually.
- Exercise intervention period: at least 4 weeks.
- Control group: groups in which any other interventions such as health education or daily life aspects were not involved.
- Results: assessment of blood glucose, blood lipid, triglyceride, high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), and total cholesterol levels and blood pressure.

In addition, the following studies were excluded by two authors (YJ and CB) who read the titles and abstracts of the studies and removed those that were (i) redundant or (ii) irrelevant to the topic. In addition, studies suitable for this analysis were identified and selected according to the predefined literature selection and exclusion criteria, and the finally selected literature was continuously cross-checked. All disagreements were resolved through discussion with the third reviewer (LD).

Quality Assessment

The methodological quality of the eligible studies was checked using the Physiotherapy Evidence Database scale. This scale ranges from 0 (high risk of bias) to 10 (low risk of bias) for each aspect considered to evaluate the effectiveness of each study, and a score of ≥6 indicates a low-bias risk study (22). When there was a disagreement between the two reviewers, an agreement was reached by discussion with the third reviewer (LD).

Data Extraction

Two reviewers (JY and BC) extracted data from selected studies. The extracted data included basic information about the study, demographic characteristics of participants, health status, exercise intervention plan, control group conditions, and measurement results. All disagreements were resolved through discussion with the third reviewer (DL).

Statistical Analyses

Meta-analysis of the extracted data was performed using Review Manager 5.3 Software. Each outcome was calculated using the mean difference (MD) or standardized mean (SMD) and 95% confidence interval (CI) between the intervention and control groups. I2 values (<25%, low; 25–75%, medium; >75%, high) and the chi-squared test were used to evaluate the heterogeneity of the data. If there was no heterogeneity between the studies, a fixed effect model was used, and if there was heterogeneity, a random effect model was used. The validity of all results was evaluated using the combined effect size (Z value).

Results

Study Selection

A total of 4,473 studies were identified in the initial database search. Finally, eight studies were selected according to the defined inclusion and exclusion criteria, each steps are presented in detail in Fig. 1.

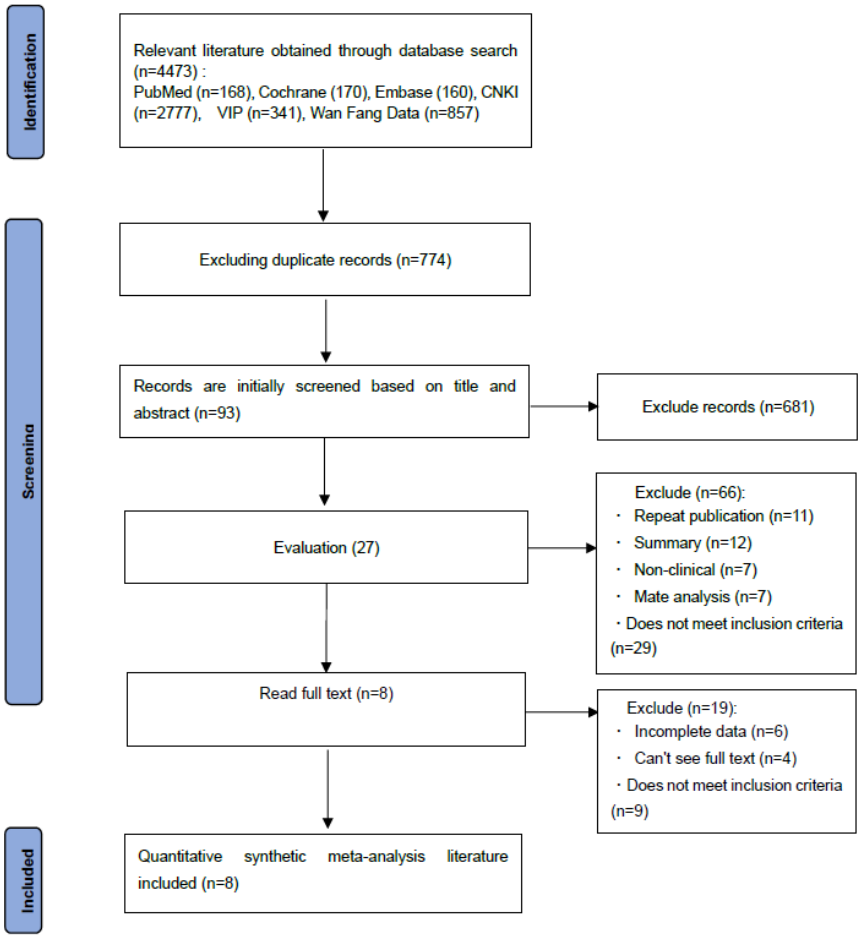

Fig. 1: Flow chart of the literature selection process

Study Characteristics

The characteristics of the selected studies are summarized in Table 1. This review included 646 participants (322 in the experimental and 324 in the control groups) with various health conditions. The age of the study subjects varied from 18 to 70 years. Ten studies used only Baduanjin as an exercise intervention. The exercise intervention period was 3–18 months. The exercise frequency was 3–7 times a week, and the exercise time was 30–90 min. There were no studies reporting side effects during the Baduanjin exercise.

Assessment of Study Quality

Table 2 shows the results of evaluating the quality of the study. Accordingly, one study with a score of 10/10, one with a score of 8/10, two with a score of 7/10, and four with a score of 6/10 were evaluated.

Table 1: Summary of included studies

Reference	*Location (language)*	*Participant characteristics*		*Intervention program*	*Baduanjin training*			*Outcome measured*	*Adverse event; follow-up*
		Sample size (attrition rate)	Mean age or age range		Frequency (weekly)	Time (min)	Duration (months)		
27	China (Chinese)	104	40–70	EG: Baduanjin/CG: Provide education on basic knowledge of hypertension	3	20	12	BP↓, BMI↓, WHR↓	No
30	China (Chinese)	116	53.27±10.67	EG: Baduanjin/CG: no intervention	N	N	6	FPG↓	No
26	China (Chinese)	39	60–69	EG: Baduanjin/CG: no intervention	5	40–50	3	Lipid parameters: TG↓, LDL↓, HDL↑	No
23	China (Chinese)	23	41±5.61	EG: Baduanjin/CG: no intervention	5	50–60	3	WC↓, HDL↑, LDL↓	No
24	China (Chinese)	49	63±6.35	EG: Baduanjin/CG: no intervention	5–7	50	18	Lipid parameters: TG↓, TC↓, HDL↓, LDL↓	No
25	China (English)	170	50–57	EG: Baduanjin/CG: no intervention	3	30	6	FGB↓, TG↓, WHR↓,	No
28	China (Chinese)	35	57.2±5.4	EG: Baduanjin/CG: no intervention	6	90	6	Lipid parameters: FPG↓, TG↓, HbA1c↓, HDL↑, WHR↓	No
29	China (English)	110	20–59	EG: Baduanjin/CG: no intervention	3	30–60	4	Lipid parameters: TC↓, TG↓, HDL↑, LDL↓	No

EG, experimental group; CG, control group; BP, blood pressure; BMI, body mass index; WHR, waist-to-hip ratio; FPG, fasting plasma glucose; TG, triglycerides; LDL, low-density lipoprotein; HDL, high-density lipoprotein; WC, white cells; TC, total cholesterol; HbA1c, hemoglobin A1c

Measurement of the Effects

Systolic and diastolic blood pressure

Figure 2 shows the results of the meta-analysis of Baduanjin exercise for systolic blood pressure. The combined results of 166 subjects in three studies (84 in the experimental group and 82 in the control group) showed that the Baduanjin exercise had a large effect size on systolic blood pressure improvement (MD=- 6.39; 95% CI: -9.86 to -2.92; I2=12%).

Table 2: Physiotherapy evidence database scale ratings

Reference	*Eligibility specification*	*Random allocation*	*Concealed allocation*	*Similarity at baseline*	*Subject blinding*	*Therapist blinding*	*Assessor blinding*	*85% follow up*	*Intention-to-treat analysis*	*Between-group statistical comparison*	*Point and variability measures*	*Total (1–10)*
27	1	1	0	0	0	0	0	1	1	1	1	6
30	1	1	0	1	0	0	0	1	1	1	0	6
26	1	1	0	1	0	0	0	1	1	1	1	7
23	1	1	0	1	0	0	0	1	1	1	1	7
24	1	1	0	1	0	0	0	1	0	1	1	6
25	1	1	0	1	0	0	1	1	1	1	1	8
28	1	0	0	1	0	0	0	1	1	1	1	6
29	1	1	1	1	1	1	0	1	1	1	1	10

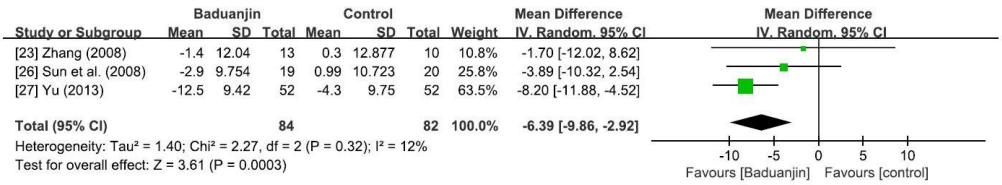

Fig. 2: Forest plot depicting differences in the change-from-baseline systolic blood pressure between the Baduanjin and control groups

Figure 3 shows the results of the meta-analysis of Baduanjin exercise for diastolic blood pressure. The combined effects of 166 subjects (84 subjects in the experimental group and 82 in the control group) from three studies showed that the Baduanjin exercise had a large effect size on the reduction of diastolic blood pressure (MD=-2.86; 95% CI: -5.96 to -0.23; I^2=35%; *P*=0.07). To evaluate the sensitivity of the meta-analysis results of Baduanjin's effects on diastolic blood pressure, the meta-analysis was repeatedly performed while excluding each study one by one. After sensitivity analysis, data from Zhang's study (23) were speculated to be the main cause of heterogeneity. The statistical significance of the meta-analysis changed to MD=-4.24, 95% CI -6.73 to -1.7 (*P*=0.0009) when the other two studies and Zhang's study (23) were excluded.

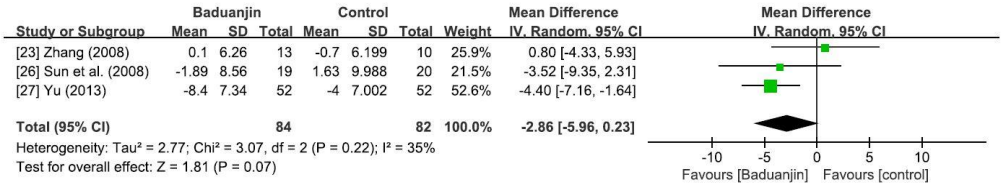

Fig. 3: Forest plot depicting differences in the change-from-baseline diastolic blood pressure between the Baduanjin and control groups

Total cholesterol

Figure 4 shows the results of the meta-analysis of Baduanjin exercise for total cholesterol levels. The combined results of 426 subjects (214 in the experimental group and 212 in the control group) from a total of six studies showed that Baduanjin exercise had a moderate effect size on the improvement of total cholesterol levels (SMD=-0.55; 95% CI: –1.11 to –0.02; I^2=86%; *P*=0.06). After sensitivity analysis, data from Miao et al. study (24) and Zhang's (23) studies were speculated to be the main cause of heterogeneity. In the case of using the remaining four studies except for the two studies, the statistical significance of the meta-analysis changed to SMD=–0.19, 95% CI=-0.46~0.09 (*P*=0.19).

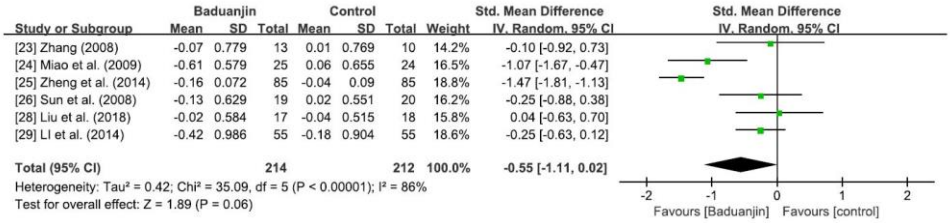

Fig. 4: Forest plot depicting differences in the change-from-baseline total cholesterol between the Baduanjin and control groups

Triglycerides

Figure 5 shows the results of the meta-analysis of Baduanjin exercise for triglyceride levels. The combined results of 426 subjects (214 subjects in the experimental group and 212 in the control group) from a total of six studies showed that Baduanjin exercise had a small effect size on improving triglyceride levels (SMD=-0.29; 95% CI: -1.13 to -0.56; I^2=94%; *P*<0.51). After sensitivity analysis, data from other studies (24-26), were speculated to be the main cause of heterogeneity. The statistical significance of the meta-analysis changed to SMD=–0.29, 95% CI=-1.13–0.56, I^2=0% (*P*=0.82) when these three studies were excluded and only the remaining three were included.

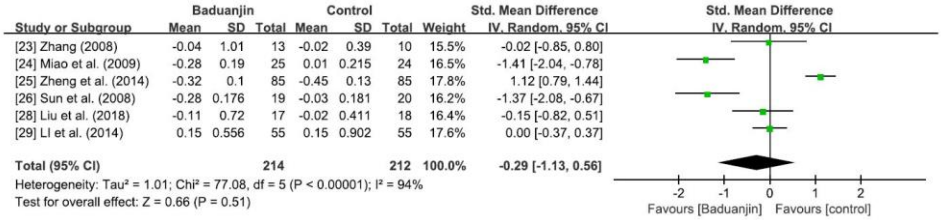

Fig. 5: Forest plot depicting differences in the change-from-baseline triglycerides between the Baduanjin and control groups

High-density lipoprotein cholesterol

Figure 6 shows the results of the meta-analysis of Baduanjin exercise for HDL-C levels. The combined results of 426 subjects (214 subjects in the experimental group and 212 in the control group) in a total of six studies showed that Baduanjin exercise did not significantly affect the HDL-C improvement (SMD=-0.19; 95% CI: -1.55 to -1.16; I^2=97%; *P*<0.78). After sensitivity analysis, data from studies by Zheng et al (25), Miao et al (24), and Sun et al (26) studies were speculated to be the main cause of heterogeneity. The statistical significance changed to SMD=–0.25, 95% CI: –0.55 to –0.06, I^2=0% (*P*=0.11) when using the remaining five studies, except for three studies.

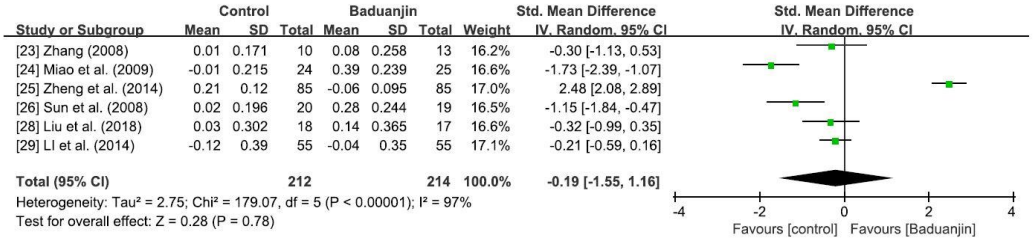

Fig. 6: Forest plot depicting differences in the change-from-baseline HDL cholesterol between the Baduanjin and control groups. HDL, high-density lipoprotein

Low-density lipoprotein cholesterol

Figure 7 shows the results of the meta-analysis of Baduanjin exercise LDL-C levels. The combined results of 426 subjects (214 subjects in the experimental group and 212 in the control group) from a total of six studies showed that the Baduanjin exercise had a small effect on LDL-C improvement (SMD=-0.33; 95% CI: -0.52 to –0.14; I^2=0%; P<0.0007).

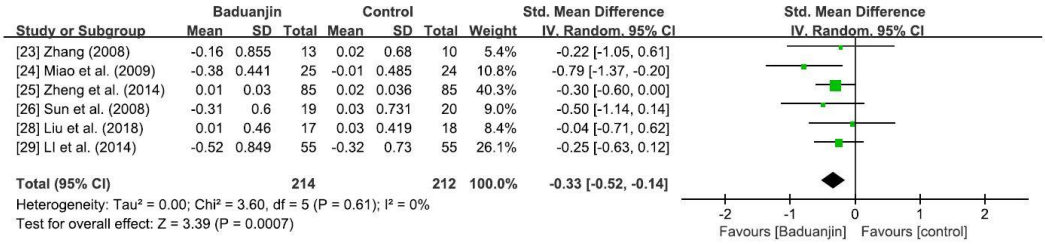

Fig. 7: Forest plot depicting differences in the change-from-baseline LDL cholesterol between the Baduanjin and control groups. LDL, low-density lipoprotein

Discussion

Metabolic syndrome is on the rise in many countries around the world and is associated with the risk of cardiovascular diseases and type 2 diabetes. This systematic review of the impact of Baduanjin exercise on metabolic syndrome-related biomarkers was critically evaluated and statistically integrated. To the best of our knowledge, this study was the first to investigate the effect of Baduanjin exercise on metabolic syndrome-related factors in middle-aged and older adults using a systematic review and meta-analysis. Our review and analysis results showed that traditional Baduanjin exercise could effectively improve the metabolic syndrome's hallmarks: systolic blood pressure, diastolic blood pressure, total cholesterol, triglycerides, and LDL-C. The Baduanjin exercise intervention was an important adjuvant in treating risk factors for metabolic syndrome. Although further research is needed, Baduanjin may improve cardiovascular risk factors and the physical benefits of such form of exercise. Baduanjin can be used as a safe and useful intervention for preventing and treating metabolic syndrome in adults. In addition, the results may provide a reference basis for applying Baduanjin exercise to middle-aged people, which is considered significant for public health.

This meta-analysis showed that Baduanjin training effectively improved systolic and diastolic blood pressure. Baduanjin was found to have a great effect on improving systolic and diastolic blood pressure. Compared with the control group (non-intervention), systolic blood pressure significantly improved in the intervention group in two of the three studies (26,27). The study by Zhang (23), which was the only study that did not achieve statistical significance, reported that systolic blood pressure at 121.2±10.75 mmHg

before the experiment decreased to 119.8±13.01 mmHg after the experiment and the diastolic blood pressure also showed a lowering trend to some extent. The insignificant improvement may be because the study subjects' systolic blood pressure was within the normal range; thus, the improvement effect was unclear. However, it was suggested that a 10-week intervention period may not have been sufficient, and that the duration of the training program may be important for inducing a beneficial effect on systolic blood pressure. Compared with the control group (non-intervention or education on basic knowledge about hypertension), Baduanjin showed positive results on diastolic blood pressure for the shortest period. As mentioned, Zhang (23) found no difference between groups, where the diastolic blood pressure of the subjects was within the normal range and, simultaneously, the frequency of the 10-week Baduanjin training was 5 days a week; nevertheless, the diastolic blood pressure tended to improve. Therefore, this suggested that 50–60 min of Baduanjin exercise, 3–5 days per week for at least 3 months can significantly reduce systolic and diastolic blood pressure.

Searching on the improvement of total cholesterol levels by Baduanjin training confirmed that Baduanjin positively affected total cholesterol in all six included studies (23–26,28,29). Miao et al (24) had the best intervention effect and longest intervention time. The duration of the intervention was 18 months, whereas the other studies ranged 3–6 months. The sample size of the survey showing statistical significance was 23–170, mainly targeting middle-aged and older patients. The training frequency was 5–7 days per week, and the training time was 50–90 min. The only study without a statistically significant change was a study with 35 participants aged 57.2±5.4 years (29). Nonetheless, total cholesterol levels improved from 4.95±0.65 mmol/L before the experiment to 4.93±0.48 mmol/L after the experiment and showed a decreasing tendency. These results suggested that Baduanjin training for at least 60 min a day and five times a week for at least 3 months can reduce total cholesterol levels in the blood.

The result of the meta-analysis regarding the influence of Baduanjin on triglyceride level improvements showed a certain effect. The analyzed study included 23–170 subjects, most of whom were of middle and older age. After analyzing the data and carefully reading the full text, we found that the only not statistically significant study was the one by Zheng et al (25), which included a control group that performed moderate-to-low intensity daily physical activity (brisk walking and square dancing). In this study (25), the triglycerides index decreased in both the control (pre, 5.67±0.14 vs. post, 5.22±0.1) and intervention groups (pre, 5.67±0.14 vs. post, 5.22±0.12). These results showed that performing Baduanjin exercise for 60 min a day and 5–7 days a week for at least 10 weeks can positively affect triglyceride levels.

A meta-analysis of the effects of Baduanjin exercise on LDL-C levels reported that five of six studies showed significant improvement in LDL-C levels (23,24,26,28,29). The study by Zheng et al (25) showed a tendency of LDL-C levels to decrease in the experimental group compared with the control group. The reasons may be related to the intervention timing and control group members' lifestyle. According to the full article, some members of the control group performed moderate daily physical activity (brisk walking and square dancing); as a result, there was no significant change in LDL-C indices between the groups. However, it was also shown that Baduanjin exercise was effective in reducing LDL-C levels, and when performed 5–7 days a week, 60–90 min/time, for at least 3 months, it can promote LDL-C decrease. However, our analysis also suggests that Baduanjin exercise did not significantly affect HDL-C improvement. Nevertheless, the effects of the interventions in the studies by Miao et al (24) and Sun et al (26) were clearly shown. The reason may be that the intervention period was long, and the average age of the intervention group was high. The study of Miao et al (24) had the longest intervention period (18 months) and showed the best effect among all studies; the average age of the participants undergoing intervention was 63±6.3 years.

In the study of Sun et al (26), the average age of the intervention group was 60–69 years, because of which the effect was the second best. Because the study showed that the members of the control group engaged in moderate daily physical activity (brisk walking and square dancing), the HDL-C index did not show statistically significant differences between groups. Yet, in the case of HDL-C levels, many studies reported effective improvement when regular aerobic exercise exceeding the threshold was performed (31). Based on these results, follow-up studies should be conducted to set the intervention period and intensity such that the HDL-C improvement effect becomes obvious.

Conclusion

We suggest that Baduanjin exercise can be an effective and safe exercise intervention to improve the risk factors of metabolic syndrome. Future randomized controlled trials with a rigorous study design is needed to evaluate the therapeutic and preventive effects of Baduanjin exercise on metabolic syndrome risk factors and the treatment potential of metabolic syndrome-related factors. All studies were conducted in China (mainland China or Hong Kong), and the subjects were mainly Chinese. In the future, studies can be conducted to confirm the effect of the Baduanjin exercise targeting non-Chinese individuals.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

This paper was supported by the KU Research Program of Konkuk University, Seoul, South Korea.

Conflict of Interest

The authors declare that there is no conflict of interests.

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