Intervention effects of four exercise modalities on nonalcoholic fatty liver disease: a systematic review and Bayesian network meta-analysis

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Abstract. – **OBJECTIVE:** This study aimed to evaluate the effect of four exercise modalities on patients with nonalcoholic fatty liver disease (NAFLD).

MATERIALS AND METHODS: Databases of CNKI, Wanfang, VIP, Web of Science, PubMed, Cochrane Library, Medline, and Embase were searched for relevant studies. The literature search was restricted to those published between January 2010 and June 2021. Randomized controlled trials of exercise interventions on NAFLD were collected. Data were presented as statistical graphics using ADDIS 1.16.5 and R-Studio 4.1.

RESULTS: Seventeen controlled studies analyzing 1627 patients with NAFLD were included. Patients were divided into the control group (n=688), aerobic training group (AT, n=554), resistance training group (RT, n=232), high-intensity interval training group (HIIT, n=53), and aerobic training with resistance training group (AT+RT, n=100). Results of the statistical analysis showed that the combined exercise intervention had the most significant effect on the total serum cholesterol of patients' mean difference [MD=0.47(0.23, 0.73), *p*<0.05]. Levels of alanine aminotransferase and aspartate aminotransferase were improved, but no significant difference was found in their levels in the four groups of exercise intervention. The intervention effect of the four exercises on blood lipid and liver enzymes in patients with NAFLD was in the order of AT+RT > HIIT > RT > AT > control.

CONCLUSIONS: Exercise interventions are recommended as stand-alone or adjunctive therapy. For patients with NAFLD who can tolerate various exercises, priority should be given to AT+RT exercise 4-5 times per week. The exercise intensity should be 50%-70% of the maximum heart rate and performed for >3 months to improve the effectiveness of the exercise supervision intervention.

Key Words:
Exercise intervention, Network meta-analysis, Nonalcoholic fatty liver disease, Recovery.

Abbreviations

ALT: alanine aminotransferase; AST: aspartate aminotransferase; AT: aerobic training; AT+RT: aerobic training and resistance training; ADDIS: aggregate data drug information system; C: control group; EPOC: excess post-exercise oxygen consumption; HIIT: high-intensity interval training; MD: mean difference; MCMC: Markov Chain Monte Carlo; NAFLD: nonalcoholic fatty liver disease; NASH: nonalcoholic steatohepatitis; ONC: orexigenic neuropeptide concentrations; RCT: randomized controlled trial; RT: resistance training; TC: total cholesterol; TG: triglyceride.

Introduction

Nonalcoholic fatty liver disease (NAFLD) is the most common liver disease worldwide and is an independent predictor of type 2 diabetes mellitus. A recent study showed that the overall prevalence of NAFLD was 29.62% in Asia. Its rate was the lowest in Japan (22.28%) compared with those in the general population in mainland China (29.81%) and Indonesia (51.04%). Overweight/obese people are at a high risk of NAFLD. In Asia, the prevalence rate of NAFLD in overweight/obese people is 52.3% and that in non-obese people is 11.8%[1]. However, its pathogenesis is still unclear. The main clinical manifestations of NAFLD are the excessive accumulation of triglycerides (TG) in the hepatocytes, hepatic steatosis, and intrahepatic lobular inflammation[2].

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NAFLD is a multisystem disease related to genetics, environment, and metabolic stress, including simple fatty liver, and progresses to nonalcoholic steatohepatitis (NASH) and liver cirrhosis (LC)[3]. NAFLD is the leading cause of chronic liver disease in Europe, America, Japan, and other countries. The disease occurs frequently between age 40 and 60 years, and the incidence is higher in women than in men after age of 50 years. In recent years, NAFLD, one of the most common liver diseases among obese children and overweight young people, tended to have a younger onset age in China. The main causes are an overweight status; consumption of high-calorie food, high sugary drinks, and processed foods, diet changes; and decreased physical activity. Based on the available evidence, no specific drug has been developed for the treatment of NAFLD, except for exercise and dietary intervention[4].

In recent years, basic therapies, such as exercise, diet, and behavioral therapies have been adopted internationally. Early-stage NAFLD can be well controlled with regular exercise. Regular exercise combined with a scientific diet can often reverse fatty liver without medication[4,5]. However, previous systematic studies[6-8] have included different exercise interventions and performed indirect comparisons, which failed to determine the best exercise mode. For example, Wang et al[6] did not provide the best exercise intervention recommendations, Liu et al[7] only included resistance training, and Sargeant et al's participants[8] have various diseases and have received drug therapy in addition to exercise intervention. To some extent, alterations in other factors may disrupt the effect of interventions.

This study was based on a Bayesian collection of publicly published randomized controlled trials (RCTs) of exercise intervention in NAFLD. This study aimed to investigate the effects of aerobic exercise intervention (AT), resistance training (RT), high-intensity interval training exercise (HIIT), and aerobic training and resistance training (AT+RT) on NAFLD and to provide evidence-based data for the follow-up exercise recovery of patients.

Materials and Methods

Based on the evidence-based medicine research methods, the PICOS (Population, Intervention, Comparison, Outcome, and Study Design) framework of the PRISMA statement ***(Supplementary Figure 1)*** was used as the basis for article inclusion in this review[9]. This systematic review has been registered in the International Platform of Registered Systematic Review and Meta-Analysis Protocols (Unique Identification No. INPLASY202180062, DOI: 10.37766/inplasy2021.8.0062).

Retrieval Strategy

Figure 1 presents a flowchart of the literature search and study selection processes. Databases of CNKI, Wanfang, VIP, Web of Science, PubMed, Cochrane Library, Medline, Embase, etc., were searched for relevant studies. The search was restricted to articles published between January 2010 and June 2021. RCTs of exercise interventions in NAFLD were collected. Subject terms were obtained from PubMed Medical Subject Headings. In the retrieval strategy, a combination of subject terms and free words was used, and language was restricted to Chinese and English. For example, in the Cochrane Library, the retrieval strategy can be as follows: "(Non-alcoholic Fatty Liver Disease):ti, ab, kw OR (NAFLD):ti, ab, kw OR (Nonalcoholic Fatty Liver Disease):ti, ab, kw OR (Nonalcoholic Fatty Liver):ti, ab, kw OR (Nonalcoholic Fatty Livers):ti, ab, kw OR (Nonalcoholic Steatohepatitis):ti, ab, kw OR (Nonalcoholic Steatohepatitides):ti, ab, kw "AND" (Exercises):ti, ab, kw OR (Physical Activity):ti, ab, kw OR (Physical Activities):ti, ab, kw OR (Physical Exercise):ti, ab, kw OR (Physical Exercises):ti, ab, kw OR (Isometric Exercises):ti, ab, kw OR (Isometric Exercise):ti, ab, kw OR (Aerobic Exercise):ti, ab, kw OR (Aerobic Exercises):ti, ab, kw OR (Exercise Training):ti, ab, kw OR (Exercise Trainings):ti, ab, kw OR (High intensity interval training):ti, ab, kw OR (HIIT):ti, ab, kw OR (TABATA):ti, ab, kw OR (Resistance training):ti, ab, kw OR (Strength Training):ti, ab, kw."

Selection Criteria

Inclusion criteria

This review included RCTs published in China and abroad, written in Chinese and English, and published between January 2010 and June 2021. Participants were patients with NAFLD. Before the experiment, no significant difference was found between the experimental group and the control group. The outcome indicators of the included studies were the same or similar. The exercise intervention time of the experimental group was not less than 4 weeks. Each exercise session was >30 min and performed not less than 3 times per week. Outcome indicators included total serum cholesterol (TC), TG, alanine aminotransferase (ALT), and aspartate aminotransferase (AST).

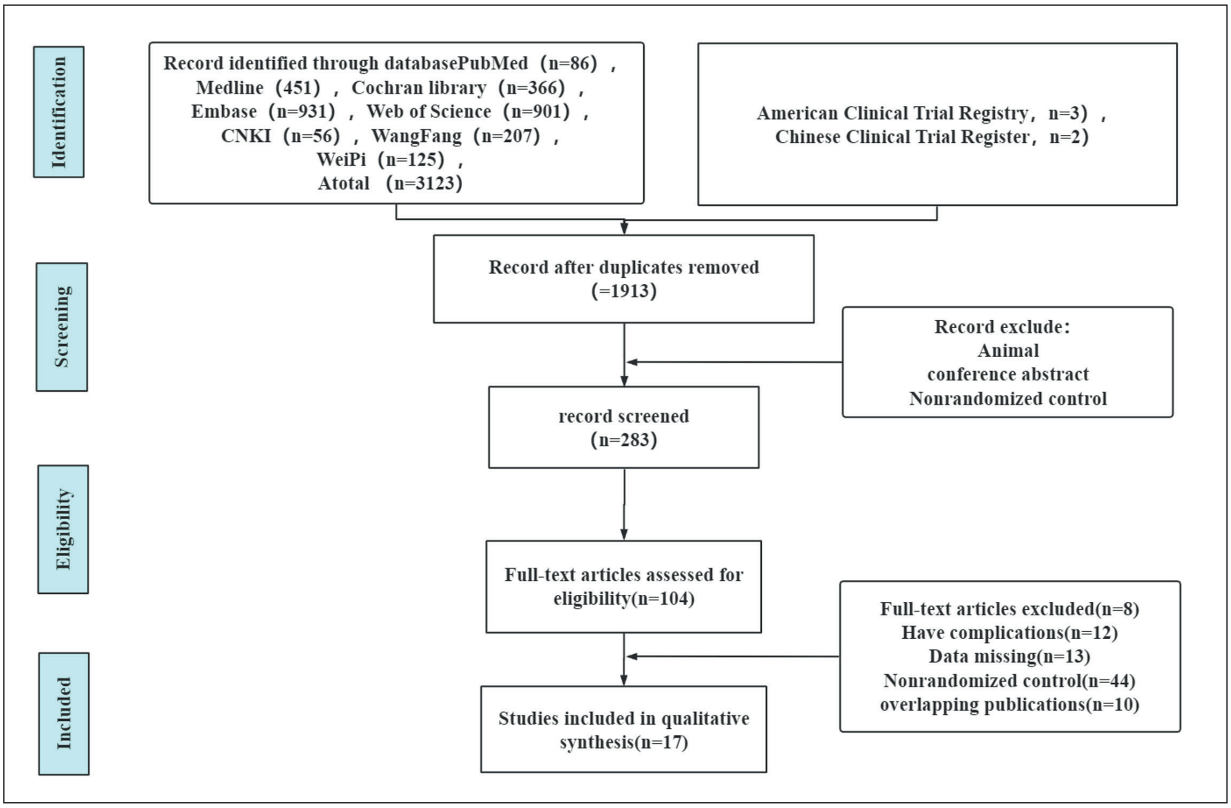

Figure 1. Study flow diagram.

Exclusion criteria

Studies were excluded if they meet any of the following: (1) the outcome indicators did not meet the requirements of this review and animal experiments were performed, (2) patients had other diseases or complications, (3) exercises were performed <2 times a week and <30 min each time, (4) non-RCTs, (5) lack of a control group, and (6) republished articles.

Literature Screening and Data Extraction

Literature screening and data extraction were performed independently by two researchers (Bojun Zhou and Gang Huang). Basic information of the retrieved literature was extracted and imported into NoteExpress for deduplication. First, the titles and abstracts were screened. Then, for studies that cannot be confirmed in the primary screening, the full text was downloaded and screened again. The following data were extracted from the included studies: authors, publication year, basic information of the participants (age and nationality), intervention measures, treatment plan, outcome indicators, project risk assessment, etc. In case of disagreement in literature selection and data extraction and no consensus reached after cross-checking, a third researcher conducts an extraction evaluation.

Bias Risk Assessment

The methodology of a single RCT was independently evaluated by two researchers following the Cochrane Collaboration tool (Figure 2)[10]. The evaluation results were as follows:

1) Randomized allocation: six studies were randomized using a controlled randomized number method. Three studies used a security envelope distribution method. Eight studies were RCTs but did not indicate the randomized allocation method.
2) Allocation concealment: of 17 studies, 9 rigorously followed the results of a randomized number method or security envelope distribution method.
3) Blinding: only two studies were double-blinded, and all participants in 12 studies signed informed consent.
4) Integrity of reported results: none of the 17 studies showed case shedding.
5) Reporting bias: all 17 studies had trial protocols.
6) Other bias: no other influencing factors caused bias in the 17 studies.

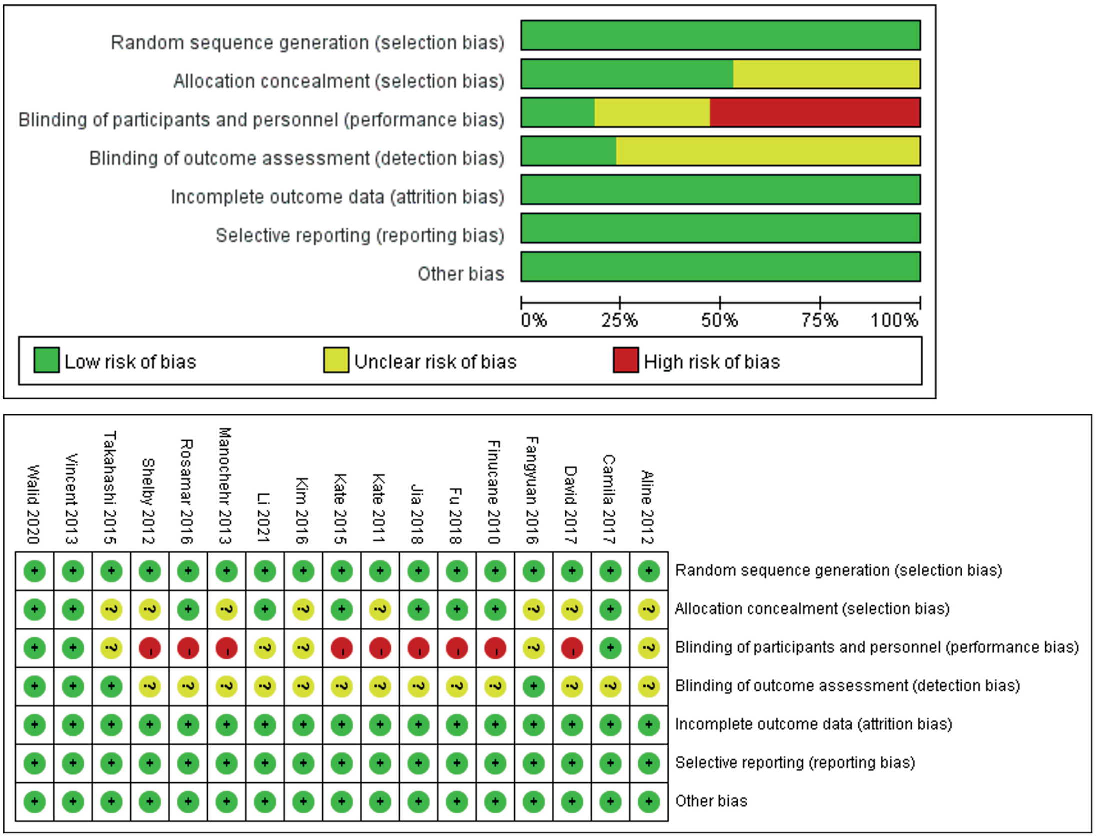

Figure 2. Schematic of Cochrane bias risk assessment.

The quality of the included studies was evaluated based on the methodology: 12 included studies scored >5 points (high quality), and five studies scored 3-4 points (medium quality). Therefore, the overall quality of the included studies was high.

Basic Characteristics of the Included Studies

All studies included patients with NAFLD without other complications. The exercise intervention measures were AT, RT, HIIT, and AT+RT. The control group was further divided into routine control, diet intervention, or routine drug treatment. Eight studies employed exercise intervention >12 weeks, and nine studies had intervention <12 weeks. In total, 1627 patients with NAFLD were analyzed, including 688 patients in the control group, 554 in the AT group, 232 in the RT group, 53 in the HIIT group, and 100 in the AT+RT group. Details are shown in Table I.

Statistical Analysis

The effects of the four interventions were statistically analyzed using R-Studio 4.1 and ADDIS 1.16.5 software, and the network diagram and sequence diagram of various interventions were plotted[36,37]. Netmeta was started by R language programming, and Bayesian Markov Chain Monte Carlo (MCMC) algorithm was invoked by relevant instructions to analyze and map the results of random-effects model data. Results of the random-effects model data were previously evaluated and processed by the Bayesian MCMC algorithm invoked by relevant instructions of ADDIS statistical software; $p < 0.05$ and 95% confidence intervals (95% CI) were used as criteria for a significant difference.

Results

Network Diagram of the Four Intervention Methods

TC and TG generally presented a star structure of five intervention nodes centered on the control group, forming two triangular closed loops: control–AT–RT and control–AT–AT+RT. AST and ALT presented the star structure with no closed-loop centered on the control group (Figure 3).

Table I. Basic characteristics of the included studies.

First author (year of publication)	Country	Age (C/T)	Sample size (C/T)	Control/ treatment	Intervention time	Outcome indicator
Finucane 2010[11]	England	67.4–76.3/67.4–76.3	50/50	C/AT	12 weeks	①②
Hallsworth 2011[12]	England	62 ± 7.4/52 ± 13.3	8/11	C/RT	8 weeks	①②④
Shelby 2012[13]	America	47.5 ± 3.1/48.6 ± 2.2	6/12	C/AT	16 weeks	①②④
Aline 2012[14]	Iran	16.48 ± 1.42/16.48 ± 1.42	14/14	AT/AT+RT	12 months	①②
Khaoshbaten 2013[15]	Iran	39.5 ± 6.9/35.6 ± 9.2	45/45	C/AT	12 months	①②③④
Vincent 2013[16]	China	51 ± 9/51 ± 9	77/77	C/AT	12 months	①②③④
Hallsworth 2015[17]	England	54 ± 12/54 ± 10	12/11	C/HIIT	12 weeks	①②③④
Kim 2015[18]	Korea	25.8 ± 5.5/25.7 ± 4.1/ 26.4 ± 2.9	8/10/10	C/AT/RT	8 weeks	①②
Takahashi 2015[19]	Japan	51.4 ± 14.8/55.5 ± 13.2	22/31	C/RT	12 weeks	①③④
Rosamar 2016[20]	Brazil	54.5 ± 8.9/56.2 ± 7.8	21/19	C/AT	24 weeks	①②③④
Fangyuan 2016[21]	China	57.94 ± 5.71/56.68 ± 5.33	130/130	C/AT	24 months	①②③④
Camila 2017[22]	Brazil	14.72 ± 1.35/14.95 ± 1.35	33/26	C/HIIT	12 weeks	①②③④
Houghton 2017[23]	England	51 ± 16/54 ± 12	12/12	C/AT+RT	12 weeks	①②③④
Fu 2018[24]	China	61.18 ± 7.53/55.90 ± 12.3	30/28/27	C/AT/RT	4 months	①②
Jia 2018[25]	China	54.24 ± 7.51/54.62 ± 7.54/ 55.18 ± 7.48	154/154/153	C/AT/RT	6 months	①②③④
Walid 2019[26]	Egypt	55.2 ± 4.3/54.9 ± 4.7/ 54.4 ± 5.8	16/15/16	C/AT/HIIT	8 weeks	①②④
Li 2021[27]	China	53.1 ± 8.2/53.5 ± 8.3	64/64	C/AT+RT	3 months	①②

Notes: C, control group; AT, aerobic training; RT, resistance training; AT+RT, aerobic training and resistance training; HIIT, high-intensity interval training; ① total serum cholesterol (TC), ② triglycerides (TG), ③ alanine aminotransferase (ALT), ④ aspartate aminotransferase (AST).

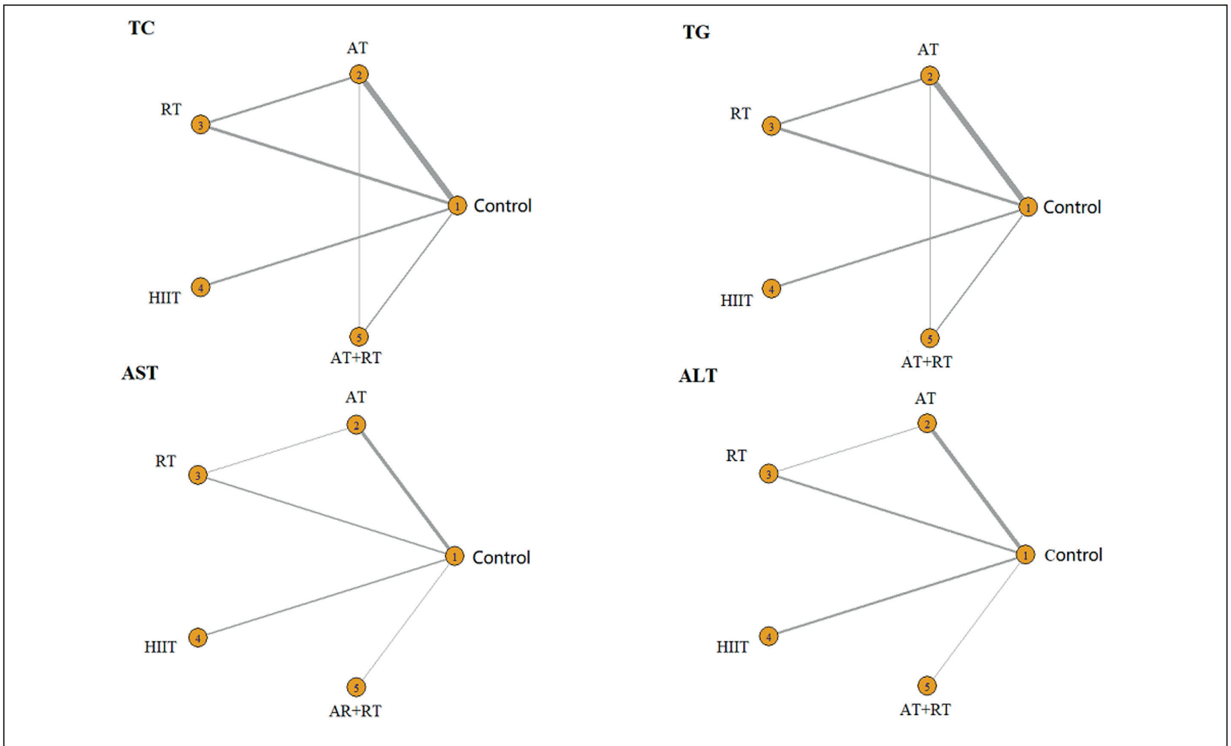

Figure 3. Four exercise modalities in the reticulation of lipids and liver enzymes in patients with nonalcoholic fatty liver disease. ALT, alanine aminotransferase; AST, aspartate aminotransferase; AT, aerobic training; AT+RT, aerobic training and resistance training; HIIT, high-intensity interval training; RT, resistance training; TC, total cholesterol; TG, triglyceride.

Table II. Node analysis of the consistency between the direct and indirect comparisons [log OR(95% CI)].

Interventions	Direct effect	Indirect effect	Overall	*p*-value
AT, AT+RT	−0.30(−0.97, 0.41)	−0.42(−0.80, −0.14)	−0.37(−0.65, −0.17)	0.75
AT, control	0.09(−0.06, 0.20)	0.00(−0.64, 0.64)	0.06(−0.05, 0.17)	0.84
AT, RT	−0.06(−0.35, 0.09)	0.57(−0.66, 1.50)	−0.09(−0.26, 0.09)	0.33
AT+RT, control	0.48(0.21, 0.80)	0.33(−0.38, 1.02)	0.44(0.24, 0.70)	0.70

Notes: AT, aerobic training; RT, resistance training; AT+RT, aerobic training and resistance training; HIIT, high-intensity interval training.
*Significant difference baseline *vs.* post-intervention ($p<0.05$)

The node analysis showed that the *p*-value was > 0.05, indicating the lack of evident inconsistency between the results of the direct and indirect comparisons, as shown in Table II. Therefore, the consistency test results were used in this study.

Network Meta-Analysis

Total TC score

Total TC scores were reported by 16 included studies[10-18,20-27], with a total of 1,549 patients. Using MD as the effect size and 95% CI for the statistical analysis, each intervention was compared with the control. The results showed that AT+RT was superior to the control [MD = 0.47(0.23, 0.73), $p < 0.05$].

Pairwise comparison of the four interventions showed that AT+RT was superior to RT [MD = 0.35(0.01, 0.64), $p < 0.05$] and AT [MD = −0.40(−0.69, (−0.13), $p < 0.05$], and the difference was significant. The results of the pairwise comparison of other interventions were not significantly different ($p > 0.05$, Table III).

Total TG score

Fifteen studies reported total TG scores, with a total of 1,584 patients[10-17,20-27]. Using MD as the effect size and 95% CI for the statistical analysis, each intervention was compared with the control. The results showed that AT+RT was superior to the control [MD = 0.41(0.12, 0.73), $p < 0.05$], and the difference was significant. The pairwise comparison of other interventions did not show a significant difference ($p > 0.05$, Table III).

Total AST score

Twelve studies[11-12,14-16,18-22,24-25] reported the total ALT scores, and a total of 1,233 patients were analyzed. Using MD as the effect size and 95% CI for the statistical analysis, each intervention was compared with the control, and the difference was significant. Results of the pairwise comparison of other interventions were not significantly different ($p > 0.05$, Table III).

Table III. Results of the network meta-analysis.

Treatment		TC	TG	AST	ALT
Method ①	Method ②				
AT	RT	0.06(−0.11, 0.30)	0.07(−0.18, 0.30)	0.04(−0.28, 0.52)	0.13(−0.37, 0.71)
	HIIT	0.11(−0.19, 0.37)	−0.04(−0.39, 0.26)	0.12(−0.33, 0.67)	0.18(−0.35, 0.73)
	AT+RT	0.42(0.14, 0.70)*	0.25(−0.08, 0.57)	0.78(−0.39, 2.01)	1.26(−0.72, 3.30)
	Control	−0.07(−0.19, 0.07)	−0.17(−0.34, −0.00)	−0.01(−0.21, 0.30)	−0.11(−0.41, 0.18)
RT	HIIT	0.05(−0.32, 0.32)	−0.11(−0.51, 0.25)	0.08(−0.52, 0.64)	0.04(−0.65, 0.73)
	AT+RT	0.36(0.01, 0.65)*	0.18(−0.19, 0.56)	0.72(−0.52, 1.97)	1.12(−0.89, 3.18)
	Control	−0.13(−0.36, 0.05)	−0.24(−0.49, 0.01)	−0.06(−0.45, 0.30)	−0.25(−0.79, 0.24)
HIIT	AT+RT	0.30(−0.03, 0.69)	0.29(−0.09, 0.73)	0.66(−0.61, 1.92)	1.08(−0.88, 3.13)
	Control	−0.18(−0.40, 0.11)	−0.13(−0.39, 0.18)	−0.13(−0.55, 0.30)	−0.29(−0.76, 0.15)
AT+RT	Control	−0.48(−0.73, −0.21)*	−0.42(−0.72, −0.13)*	−0.78(−1.98, 0.39)	−1.38(−3.38, 0.57)

Notes: C, control group; AT, aerobic training; RT, resistance training; AT+RT, aerobic training and resistance training; HIIT, high-intensity interval training.
*Significant difference baseline *vs.* post-intervention ($p<0.05$)

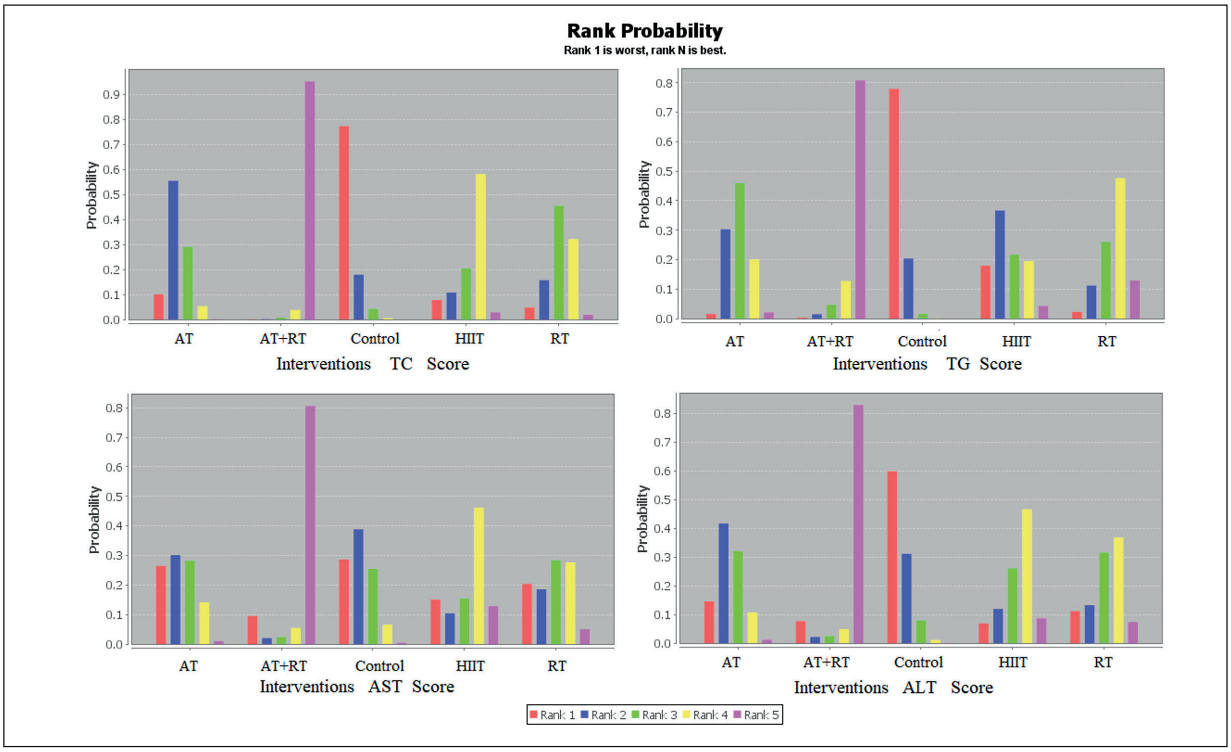

Figure 4. Ranking diagram of different outcome indicators for each intervention ALT, alanine aminotransferase; AST, aspartate aminotransferase; AT, aerobic training; AT+RT, aerobic training and resistance training; HIIT, high-intensity interval training; RT, resistance training; TC, total cholesterol; TG, triglyceride

Total ALT score

Nine studies reported the total AST scores, and a total of 1,164 patients were analyzed[14-16,18-24]. Using MD as the effect size and 95% CI for the statistical analysis, each intervention was compared with the control, and the results were significantly different. The results of the pairwise comparison of other interventions were not significantly different ($p > 0.05$, Table III).

Rank Probability

In the rank probability of the four interventions, the highest score of Rank 5 was the best for the total scores of TC, TG, AST, and ALT, and the larger the Rank 5 value, the better (Figure 4, Table IV).

Publication Bias or Small-Sample Effect Tests

The publication bias test of blood lipid and liver enzyme indexes showed that the analyzed studies were symmetrical. This suggests the small possibility of a publication bias or a small-sample effect on this study.

Table IV. Ranking list of the interventions.

Interventions	TC score	TG score	AST score	ALT score
AT	0.00	0.02	0.01	0.01
AT+RT	0.95	0.81	0.81	0.83
Control	0.00	0.00	0.00	0.00
HIIT	0.03	0.05	0.13	0.09
RT	0.02	0.12	0.05	0.07

Notes: C, control group; AT, aerobic training; RT, resistance training; AT+RT, aerobic training and resistance training; HIIT, high-intensity interval training; ALT, alanine aminotransferase; AST, aspartate aminotransferase; TC, total serum cholesterol; TG, triglycerides

Discussion

This study has some notable findings. First, AT, RT, or HIIT is not the best exercise intervention. According to the statistical evidence as well as results of previous studies, AT+RT is superior to the abovementioned exercises because AT+RT not only can regulate the secretion of adipocytes, improve lipid metabolism, and promote weight loss but can also increase the muscle mass of the patients. Secondly and more importantly, performing the AT+RT longer than 12 weeks can significantly reduce the level of melanin-enriched hormone (MCH) and increase the expression of adiponectin, consequently reducing food intake, which has not been observed in the three exercise interventions.

The current classic research hypothesis suggests that a certain correlation exists between the pathogenesis of NAFLD and the "second blow" theory. Lipid metabolism disorder caused by overweight or obesity leads to the deposition of large amounts of lipids in the liver and insulin resistance, which results in the fatty degeneration of liver cells and secretion of large amounts of adipocytes, and subsequently into steatohepatitis or cirrhosis[29]. Therefore, improving lipid metabolism and regulating the secretion of adipocytes is important to improve the intervention effect. TC is an independent factor correlated with the development of cirrhosis[30], and TG is an independent predictor of cardiovascular disease[31]. High levels of AST and ALT increase the risk of liver cells to damage. These two liver enzymes are also key parameters for the determination of the incidence of NAFLD and hepatitis. Existing evidence shows that when patients with NAFLD lose 5%-10% of their body weight, the levels of liver enzymes *in vivo* will normalize[32]. Moreover, a direct benefit of exercise therapy on the improvement of serum transaminase in patients with NAFLD is the reversal of hepatic steatosis[32]. Accumulating clinical evidence shows that exercise as a non-drug intervention to NAFLD is scientific and effective and has been widely used in the prevention and treatment of NAFLD-related chronic metabolic diseases[12]. Exercise intervention is beneficial in regulating the secretion of adipocytes and improving lipid metabolism and body shape. The possible mechanism is that a certain intensity of physical activity can increase the intake and release of free fatty acids, promote fat consumption, and reduce body weight. It can also improve glucose disposal rate, reduce the conversion of excess sugar to fats, and lessen fat formation. Other convincing studies[34] have shown that aerobic exercise affects the neurohumoral system, which can increase the activity of lipoprotein lipase, facilitate fat decomposition, and reduce the expression of lipids (TC, TG, etc.) and their deposition in the liver. Resistance exercise can improve the balance of the sympathetic and parasympathetic nerves in the heart system and can enhance the adiponectin and reduce MCH expression[35]. According to Schleppenbach[35] and Saris[36], HIIT can increase post-exercise oxygen consumption (EPOC) in the body, and the energy metabolism of EPOC is mainly derived from fat. The intervention effect on patients with NAFLD is also significant, and the possible reason is that HIIT has a better effect on fat oxidation rate than AT. The essential reason for AT+RT intervention on patients with NAFLD has not been reviewed yet, and the possible reason is that the combined exercise effect of AT and RT is better than that of a single exercise intervention. In addition, AT+RT plays a role in improving inflammatory biomarkers of NAFLD and reducing orexigenic neuropeptide concentrations in overweight patients with NAFLD[14].

Although physical activity has good effects on NAFLD, the effects of different exercise patterns and exercise intensities are significantly different. For example, Sechang[38] believed that moderate-intensity aerobic exercise can effectively improve the degree of fatty liver in NAFLD, but the effect of low-intensity aerobic exercise is not noticeable. After RT, fat-free body weight and muscle mass were significantly increased, while hepatic steatosis grading, mean insulin and ferritin levels, and insulin resistance index were significantly decreased[19]. HIIT ameliorates the effects of reverse cholesterol transport on peripheral tissues and the liver, as well as enhances lipid oxidation in hepatocytes. However, in the present study, the results of the statistical analysis revealed that AT, RT, and HIIT are not the best intervention methods, and the scores of AT+RT on the four biomarkers are much higher than those of the first three types of exercise. Therefore, AT+RT should be given priority in the formulation of exercise prescriptions for patients with NAFLD.

Limitations of this study

This study is a research update, so only studies indexed in Chinese and English databases in the recent 11 years are retrieved. Moreover, we cannot rule out the possibility that high-quality RCTs have been published previously or published in other languages. Inconsistencies in exercise intensity, not a rigorous study design, different ethnicities, inconsistencies in outcome indexes, disease severity, and blinded trials of the evaluators in the analyzed studies may contribute to biases in conclusions.

Conclusions

This study conducted a network meta-analysis of intervention methods based on the Bayesian theory, which can provide a reference for exercise prescription in patients with NAFLD, help improve the status of blood lipid and liver enzymes in patients with NAFLD and avoid further pathological changes of symptoms or other complications. According to the results of the network meta-analysis, compared with the control group, the four exercise interventions showed different degrees of effectiveness in NAFLD. The results of the analysis of 1,627 patients with NAFLD showed that AT+RT > HIIT > RT > AT > control (in this order) were the exercises with the best effect on the overall blood lipid and liver enzymes of the patients. AT+RT included brisk walking, jogging, and cycling combined with sitting posture rowing, deep squatting, and plank support. The target exercise intensity is 50%-70% of the maximum heart rate. AT+RT should last 30 min each and be performed four or five times a week, and the entire training period should exceed 3 months. During this period, AT+RT combined with a dietary intervention was found to achieve better effects. For patients with NAFLD who can tolerate various exercises, a combination of aerobic and resistance exercises is ideal. Exercise intervention as a stand-alone or adjunctive therapy is suggested in patients in whom traditional treatment is not effective, those who are waiting for treatment, or those who do not want to receive medication for personal reasons. Special attention should be paid to the individual exercise preferences of patients regarding intervention methods to avoid resistance to exercise therapy and to improve the effectiveness of exercise supervision intervention.

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Not applicable.

Declaration of Funding Interests

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Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' Declaration of Personal Interests

Study concept and design: MFH and ZBJ; Collection and assembly of data: ZBJ, HG, WW, DYX and HYY; Data analysis and interpretation: WW and ZLH; Manuscript writing and review: ZBJ, HG and MFH. All authors read and approved the final manuscript.

Ethical Approval

Not applicable.

Conflict of Interests

The authors declare that they have no conflict of interest.

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