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The Impact of Different Exercise Intensities on Blood Lipid Levels in Overweight and Obese Female College Students: A Meta-Analysis

Yuying Ren

School of Physical Education, Southwest University Chongqing Beibei 400715, China

Abstract

Objective: To investigate the effects of different exercise intensities on body fat and blood lipid levels in overweight and obese female college students, using a meta-analysis to provide evidence for improving their health. Methods: Five authoritative domestic and international databases (PubMed, Web of Science, CNKI, Wanfang, and Weipu) were searched. Cochrane tools were used to evaluate the quality of the included studies regarding the impact of exercise on body fat and blood lipids in overweight and obese female college students. A statistical analysis was performed using Review Manager 5.4 software. Results: Nine studies involving 249 participants were included, comprising three high-intensity exercise studies and seven moderate-intensity exercise studies. Meta-analysis revealed that both high- and moderate-intensity exercise reduced body fat percentage, total cholesterol (TC), and triglycerides (TG) in obese female college students. Moderate-intensity exercise had significantly greater effects than high-intensity exercise($p = 0.09$) on lowering body mass index (BMI, $p < 0.001$) and low-density lipoprotein cholesterol (LDL-C, $p < 0.001$). Neither intensity significantly affected high-density lipoprotein cholesterol (HDL-C) levels. Conclusion: Moderate-intensity exercise improves body composition by reducing BMI and body fat percentage and improves blood lipid levels by lowering TC, TG and LDL-C in obese female college students. The overall benefits of moderate-intensity exercise are superior to those of high-intensity exercise.

Keywords

Exercise, Obesity, Female College Students, Blood Lipids.

1. Introduction

Since the launch of reform and opening-up, China's rapid economic development and the continuous advancement of building a moderately prosperous society in all respects have significantly improved residents' living standards, leading to increasingly diverse and refined dietary patterns. Concurrently, reduced physical activity has markedly decreased the body's efficiency in burning calories, resulting in growing concerns over overweight and obesity. Obesity serves as a primary risk factor for the onset and progression of multiple chronic diseases, emerging as a global public health issue threatening human health [1]. According to data released in the China Nutrition and Chronic Disease Report (2020), the prevalence rates of overweight and obesity among Chinese residents aged 18 and above were 34.3% and 16.4%, respectively [2]. Overweight and obesity pose serious health threats, leading to insulin resistance, type 2 diabetes, hypertension, dyslipidemia, coronary artery disease, non-alcoholic fatty liver disease, and certain malignant tumors [3]. College students are at a critical stage where lifestyle habits are formed. Due to academic pressure, sedentary behavior, and irregular schedules and diets, overweight and obesity rates continue to rise, posing serious threats to their physical and mental health as well as future quality of life. Female college students are

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particularly sensitive to changes in their body weight, which may trigger psychological issues such as anxiety and social difficulties. Therefore, overweight and obesity have become urgent public health issues requiring immediate attention among contemporary female college students.

Against the backdrop of rising obesity rates, extensive research indicates that exercise, as a scientifically guided intervention, has been proven to be one of the effective strategies for combating obesity. It helps improve the physical health of overweight and obese individuals, significantly enhancing cardiorespiratory fitness, improving blood glucose, blood pressure, and lipid levels, and reducing visceral fat [4]. Exercise also exerts positive effects on adolescents' mental health, self-perception, and social adaptation abilities. High-intensity exercise has garnered significant attention due to its time efficiency, high effectiveness in reducing body fat percentage, and improving body composition. Meanwhile, moderate-intensity exercise remains a widely applicable traditional approach. Although numerous independent studies have examined the effects of different exercise intensities on blood lipid levels in obese female college students, findings are inconsistent, and comprehensive comparative analyses or systematic evaluations of the benefits across intensity levels are lacking. Therefore, this study employs meta-analysis to synthesize existing randomized controlled trials (RCTs), comparing the effects of different exercise intensities on metabolic indicators such as body composition and blood lipids in obese female college students. This aims to provide evidence for developing scientific, efficient, and personalized exercise intervention programs, thereby contributing to improving the health status of overweight and obese female college students.

2. Research Methods

2.1. Data Sources and Retrieval Methods

Literature retrieval was conducted across five authoritative domestic and international databases: PubMed, Web of Science, CNKI, Wanfang, and Weipu. The search scope extended to July 2025. Relevant search terms in both Chinese and English encompassed key concepts related to physical activity, body composition, and metabolic health. These included, but were not limited to: exercise, training, college students, overweight, obesity, blood lipids, and lipid metabolism.

2.2. Inclusion and Exclusion Criteria

Inclusion Criteria: ① Self-controlled trials or randomized controlled trials (RCTs); ② Female college students clinically diagnosed as overweight/obese based on Asian criteria: BMI ≥ 24 kg/m^2 (overweight) or BMI ≥ 28 kg/m^2 (obese); participants with no history of substance abuse within 12 months prior to study entry; ③ Experimental group engaged in any form of exercise-only intervention lasting >4 weeks; ④ Outcome measures: Body Mass Index (BMI), body fat percentage(BF%), total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C). ⑤ Exercise intensity classification typically uses percentages of maximal oxygen uptake (VO_2max) or maximal heart rate (HRmax) as objective benchmarks. Specifically: - High-intensity exercise corresponds to 70%–80% of VO_2max, approximately 80%–90% of HRmax, with a heart rate range of roughly 170–180 beats per minute; Moderate-intensity exercise corresponds to 50%–60% of VO_2max, equivalent to approximately 65%–75% of HRmax, with a heart rate range of about 140–150 beats per minute;Low-intensity exercise corresponds to approximately 40% of VO_2max, equivalent to about 60% of HRmax, with a heart rate range typically falling between 110–120 beats per minute [5].

Exclusion Criteria: ① Studies involving subjects with metabolic disorders (diabetes, fatty liver disease) in addition to overweight/obesity; ② Comprehensive studies incorporating concurrent nutritional interventions; ③ Studies with incomplete or missing analytical data; ④ Duplicate publications, review articles, and conference proceedings.

2.3. Data Extraction and Quality Assessment

Researchers independently conducted literature screening and data extraction in strict accordance with predefined inclusion and exclusion criteria. Standardized forms were used for data extraction, covering: ① basic study characteristics (first author, publication year); ② participant characteristics (including sample size and age), along with comprehensive intervention protocols and implementation details; ③ Key elements for assessing risk of bias; ④ Outcome measure data. Research quality was evaluated using the Cochrane Risk of Bias Assessment Tool. Each randomized controlled trial (RCT) was rigorously assessed across seven domains, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other potential sources of bias. Each domain was judged to be at high, low, or unclear risk of bias, thereby ensuring the scientific rigor and reliability of the systematic review and meta-analysis.

2.4. 1.4 Statistical Analysis

This study employed Review Manager 5.4 software to conduct meta-analysis on the included outcome measures, drawing inferences through heterogeneity testing and statistical pooling of effect sizes. Heterogeneity was assessed using the I^2 statistic, while effect sizes were expressed as weighted mean differences (WMD) with 95% confidence intervals (95% CI). Results were presented via forest plots. If $P > 0.10$, heterogeneity was considered negligible. If $P \leq 0.10$, further assessment was based on the I^2 value: $I^2 \leq 50\%$ indicated mild heterogeneity (fixed-effect model); $50\% < I^2 \leq 70\%$ indicated moderate heterogeneity; $I^2 > 70\%$ indicated high heterogeneity (random-effects model). The meta-analysis was conducted at a significance level of $\alpha=0.05$, and 95% confidence intervals (CI) for effect size measures were provided.

3. Research Findings

3.1. Literature Search Results

Using the search strategy, a total of 368 articles were retrieved from systematic databases. Through tiered screening, review of titles, abstracts, and full texts, and exclusion of non-compliant studies, nine articles [6][7][8][9][10] [11][12][13][14], encompassing 249 subjects. The literature screening process and results are illustrated in Figure 1.

3.2. Basic Characteristics of Included Studies and Risk of Bias Assessment Results

A total of 9 studies were included in this review, with interventions including aerobic exercise, high-intensity interval training, and others. Intervention durations ranged from 8 to 36 weeks. Using the Cochrane risk of bias assessment tool, the included studies were evaluated across seven dimensions: random sequence generation, allocation concealment, blinding, completeness of data, and selective reporting. All nine articles exhibited varying degrees of bias. Detailed results are presented in Table 1 and Figure 2.

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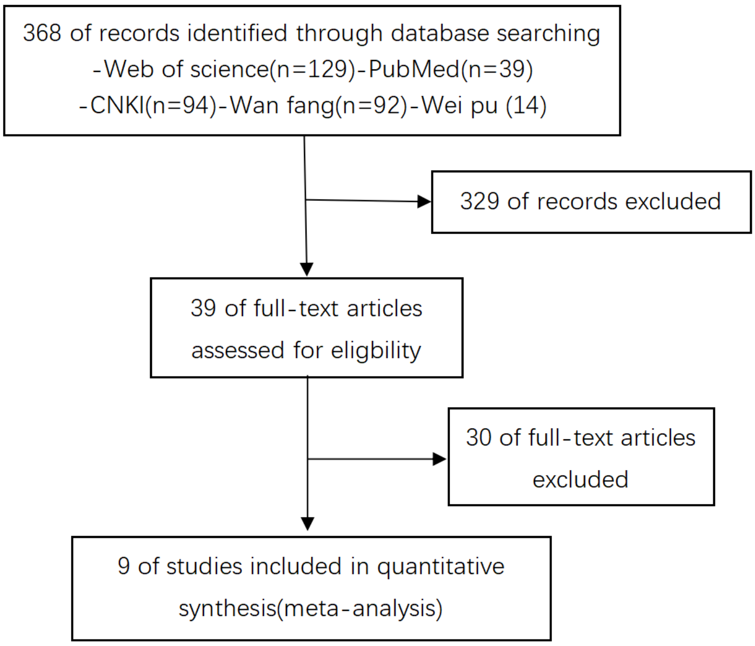

Figure 1: Literature Screening Flowchart

Table 1 Characteristics of included studies

Study	Sample	Intervention method	Frequency(days/week)	Intervention duration（week）	Intensity	Outcome
Guijun Chi2023	T32 C32	HICT	3	8	85%HRmax	①②③④⑤⑥
Jian Lin2016	T18 C18	HIIT	2	12	90% HRmax	①②③④⑤⑥
Shan Chen2022	T110 T210 C7	T1HIIT T2COP	3	10	T185%HRmax T260%HRmax	①②③④⑤⑥
Huijun Li2015	T15	AT	3	36	HR:130-150bpm	①②③④⑤⑥
Xiaoli Huang2005	T12 C12	AT	4	16	60-70%HRmax	①②③④⑤⑥
Yingxue Chi2015	T15	AT	3	36	HR:130-140bpm	①②③④⑤⑥
Xuehui Li2017	T12 C12	AT	3	16	60-70%HRmax	①②③④⑤⑥
Haili Zhang2011	T10 C10	AT	7	20	HR:130-150bpm	①②③④⑤⑥
Cheng Yan2009	T12 C12	AT	4	16	60-75%HRmax	①②③④⑤⑥

Note: ① Body Mass Index; ② Body Fat Percentage; ③ Total Cholesterol; ④ Triglycerides; ⑤ High-Density Lipoprotein Cholesterol; ⑥ Low-Density Lipoprotein Cholesterol

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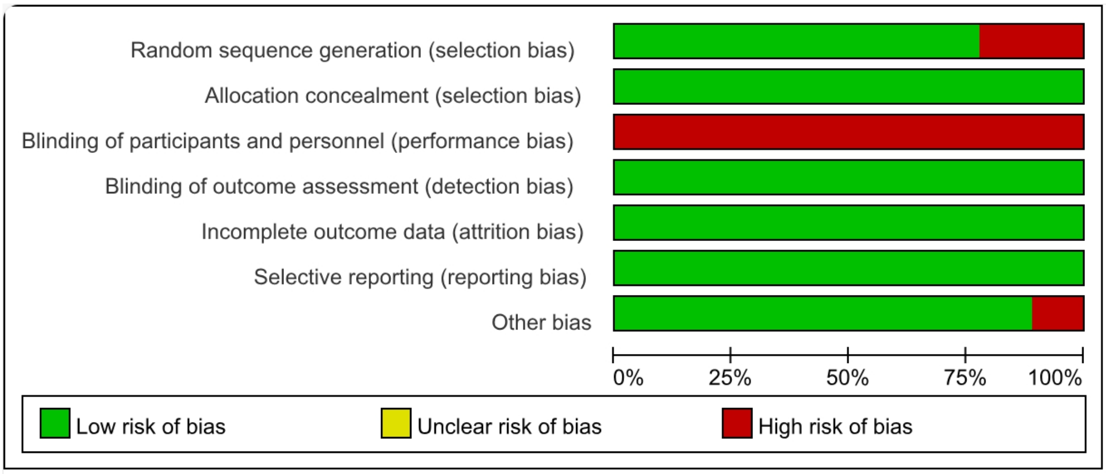

Figure2 Risk of Bias for Included Studies

3.3. Meta-analysis Results

3.3.1. Effects of Different Exercise Intensities on BMI

This investigation conducted a systematic review and pooled analysis of nine randomized controlled trials (RCTs) involving a total of 249 overweight or obese female collegiate participants. The meta-analysis aimed to determine the efficacy of differing exercise intensity regimens on alterations in body mass index (BMI). The forest plot (Figure 3) and a high statistical heterogeneity (I^2 = 81%, P < 0.00001) indicated significant variation across studies, justifying the use of a random-effects model for data pooling. The between-group comparison evidenced a significant advantage in BMI reduction for the exercise intervention group over the control group (MD = -2.12, 95% CI = -3.20 , -1.05), indicating that exercise training effectively reduces BMI in obese university students (P < 0.001).

Subgroup analysis revealed persistent high heterogeneity in both the High subgroup (I^2 = 92%, P < 0.001) and Moderate subgroup (I^2 = 73%, P = 0.001). The Moderate subgroup effectively reduced BMI in obese female university students (MD = -2.14, 95% CI = -3.37, -0.90; P < 0.001), P<0.001), whereas the High subgroup showed no statistically significant effect on BMI (MD=-2.03, 95% CI=-4.39, 0.32, P=0.09), no statistically discernible difference was found among the intervention groups(P=0.94).

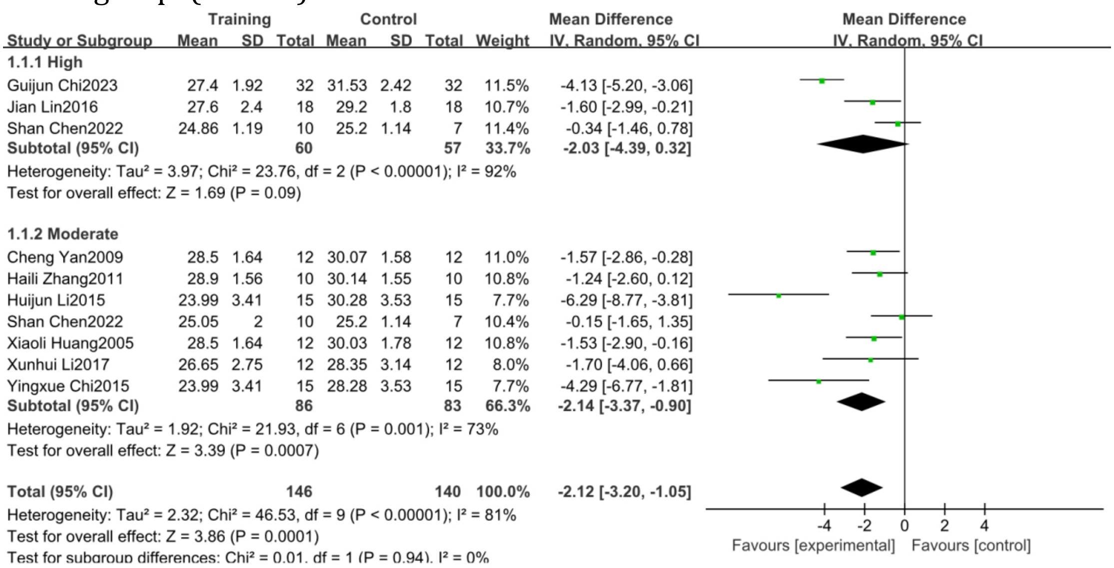

Figure3 Meta-analysis of the effects of different exercise Intensities on BMI

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3.3.2. Effects of Different Exercise Intensities on BF%

This investigation conducted a systematic review and pooled analysis of nine randomized controlled trials (RCTs) involving a total of 249 overweight or obese female collegiate participants. The meta-analysis aimed to determine the efficacy of differing exercise intensity regimens on alterations in body fat percentage (BF%) . The forest plot (Figure 4) and a moderate statistical heterogeneity (I^2 = 58%, P = 0.01) indicated considerable variation across studies, justifying the use of a random-effects model for data synthesis. The between-group comparison evidenced a significant advantage in BF% reduction for the exercise intervention group over the control group (MD = -3.11, 95% CI = -4.29, -1.93), indicating that exercise training effectively reduces BF% in obese university students (P < 0.001).

Subgroup analysis revealed reduced heterogeneity among studies in the High subgroup (I^2 = 92%, P < 0.001), while the Moderate subgroup (I^2 = 73%, P = 0.001) still exhibited high heterogeneity, suggesting exercise intensity may be a contributing factor to heterogeneity. Both the High subgroup (MD = -2.20, 95% CI = -3.94, -0.46, P = 0.01) and the Moderate subgroup (MD = -3.57, 95% CI = -5.09 , -2.05, P<0.001) both effectively reduced body fat levels in obese female college students, no statistically discernible difference was found among the intervention groups (P=0.25).

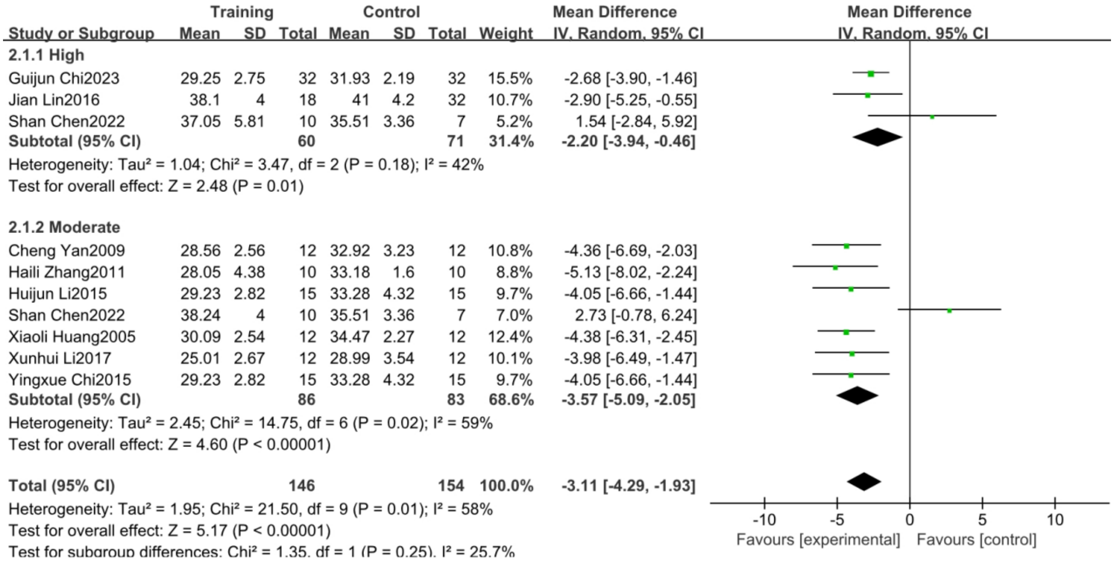

Figure4 Meta-analysis of the effects of different exercise Intensities on BF%

3.3.3. Effects of Different Exercise Intensities on TC

This investigation conducted a systematic review and pooled analysis of nine randomized controlled trials (RCTs) involving a total of 249 overweight or obese female collegiate participants. The meta-analysis aimed to determine the efficacy of differing exercise intensity regimens on alterations in TC. The forest plot (Figure 5) and a mild statistical heterogeneity (I^2 = 42%, P = 0.08) indicated acceptable consistency across studies, supporting the use of a fixed-effects model for data synthesis. Analysis revealed significantly lower TC levels in the exercise intervention group compared to the control group (MD = -0.34, 95% CI = -0.43 , -0.25), indicating exercise training effectively reduces TC levels in obese female college students (P < 0.001).

Subgroup analysis revealed persistent mild heterogeneity in both the High subgroup (I^2 = 37%, P = 0.20) and Moderate subgroup (I^2 = 41%, P = 0.12). The High subgroup (MD = -0.28, 95% CI = -0.40, -0.16, P<0.001) and Moderate subgroup (MD=-0.41, 95% CI=-0.55, -0.28, P<0.001) both effectively reduced TC levels in obese female college students, no statistically discernible difference was found among the intervention groups (P=0.15).

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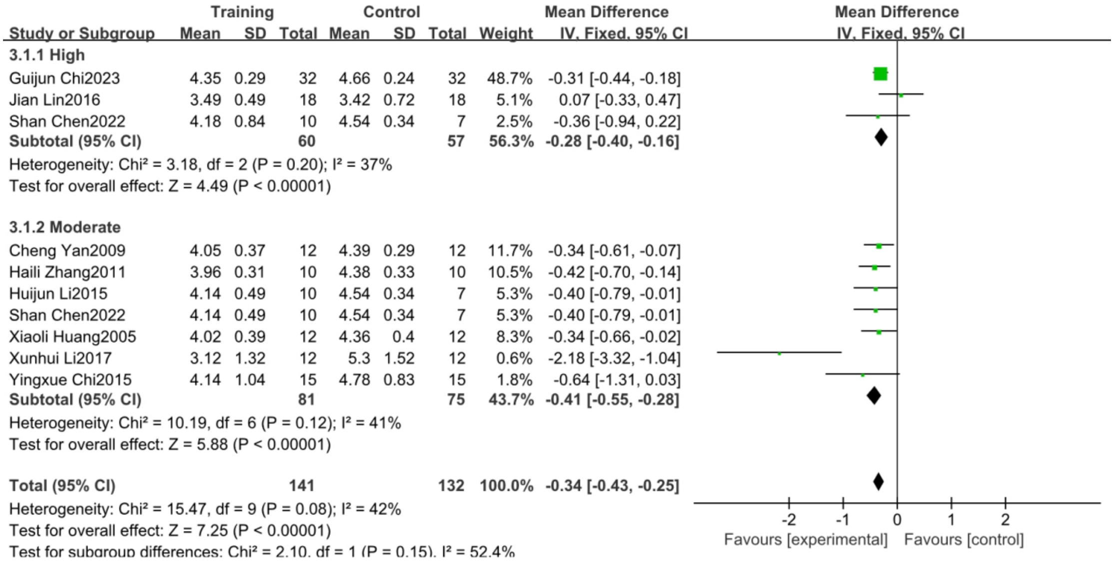

Figure5 Meta-analysis of the effects of different exercise Intensities on TC

3.3.4. Effects of Different Exercise Intensities on TG

This study included 9 randomized controlled trials examining the effects of varying exercise intensities on TG levels in 249 overweight and obese female college students. The meta-analysis forest plot (Figure 6) and heterogeneity test indicated negligible between-study heterogeneity (I^2 = 2%, P = 0.42), thus permitting data pooling using a fixed-effects model. Analysis revealed significantly lower TG levels in the exercise intervention group compared to the control group (MD = -0.14, 95% CI = -0.19 , -0.10), indicating exercise training effectively reduces TG levels in obese female college students (P < 0.001).

Subgroup analysis revealed no heterogeneity among studies in the High subgroup (I^2 = 0%, P = 0.71), whereas heterogeneity increased in the Moderate subgroup (I^2 = 29%, P = 0.21), suggesting exercise intensity may be a contributing factor to heterogeneity. Both the High subgroup (MD = -0.14, 95% CI = -0.20, -0.07, P < 0.001) and the Moderate subgroup (MD = -0.14, 95% CI = -0.21, -0.08, P<0.001) both effectively reduced TC levels in obese female college students, no statistically discernible difference was found among the intervention groups (P=0.87).

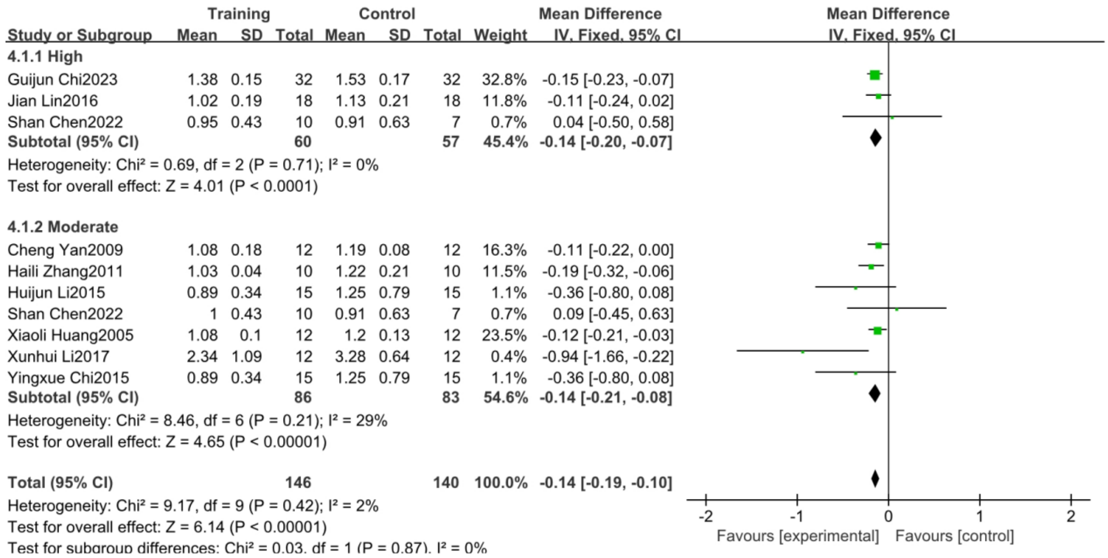

Figure6 Meta-analysis of the effects of different exercise Intensities on TG

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3.3.5. Effects of Different Exercise Intensities on HDL-C

Nine randomized controlled trials comprising 249 overweight or obese female university students were analyzed in this investigation to assess the influence of different exercise intensity regimens on high-density lipoprotein cholesterol (HDL-C) parameters. Based on the forest plot (Figure 7) and quantitative heterogeneity assessment (I^2 = 62%, P = 0.005), which demonstrated moderate variation across studies, a random-effects model was employed for data synthesis. Subsequent analysis revealed no statistically significant intervention effect on HDL-C concentrations between experimental and control conditions (P = 0.21).

Subgroup analysis revealed increased heterogeneity in the High subgroup (I^2 = 81%, P = 0.005), suggesting exercise intensity may be a contributing factor to heterogeneity. Neither the High subgroup (P = 0.40) nor the Moderate subgroup (P = 0.42) demonstrated statistically significant effects on HDL-C levels in obese female college students.

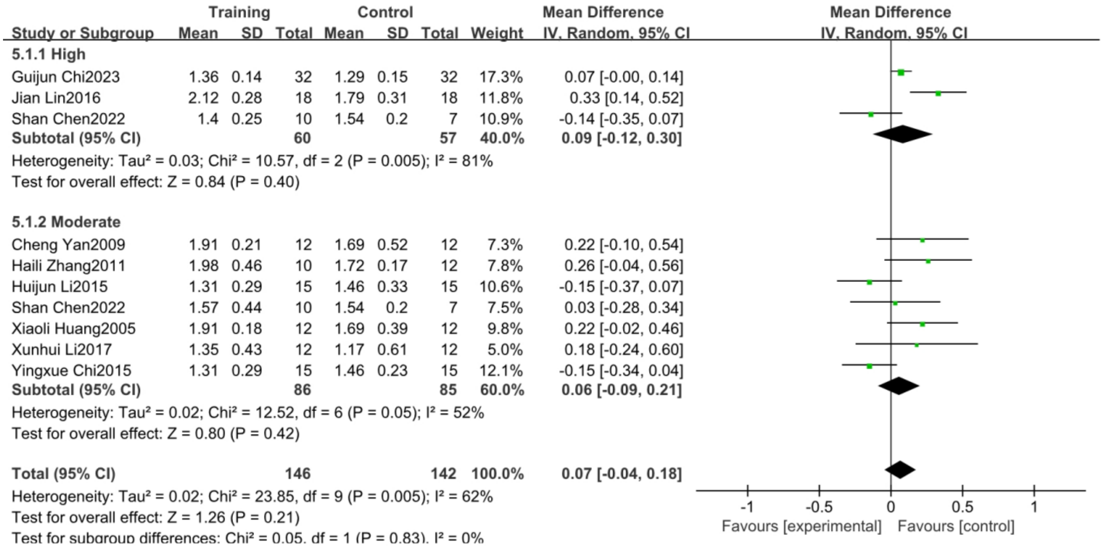

Figure7 Meta-analysis of the effects of different exercise Intensities on HDL-C

3.3.6. Effects of Different Exercise Intensities on LDL-C

This systematic review and meta-analysis synthesized data from nine randomized controlled trials comprising a total of 249 overweight or obese female collegiate participants. The investigation specifically evaluated the efficacy of differential exercise intensity regimens on low-density lipoprotein cholesterol (LDL-C) profile modifications. The meta-analysis forest plot (Figure 8) and heterogeneity test indicated low inter-study heterogeneity (I^2 = 28%, P = 0.21), thus allowing data pooling using a fixed-effects model. Results indicated that the exercise intervention group exhibited significantly lower LDL-C levels than the control group (MD = -0.14, 95% CI = -0.21, -0.07), demonstrating that exercise training effectively reduces LDL-C levels in obese female college students (P < 0.001).

Subgroup analysis revealed no heterogeneity among studies in the High subgroup (I^2 = 0%, P = 0.45), whereas the Moderate subgroup (I^2 = 28%, P = 0.21) exhibited mild heterogeneity. The Moderate subgroup effectively reduced LDL-C levels in obese female college students (MD = -0.18, 95% CI = -0.27, -0.08) P<0.001), whereas the High subgroup showed no statistically significant effect on LDL-C levels in obese female college students (MD=-0.09, 95% CI=-0.20, 0.02, P=0.09). However, the difference between subgroups was not statistically significant (P=0.24).

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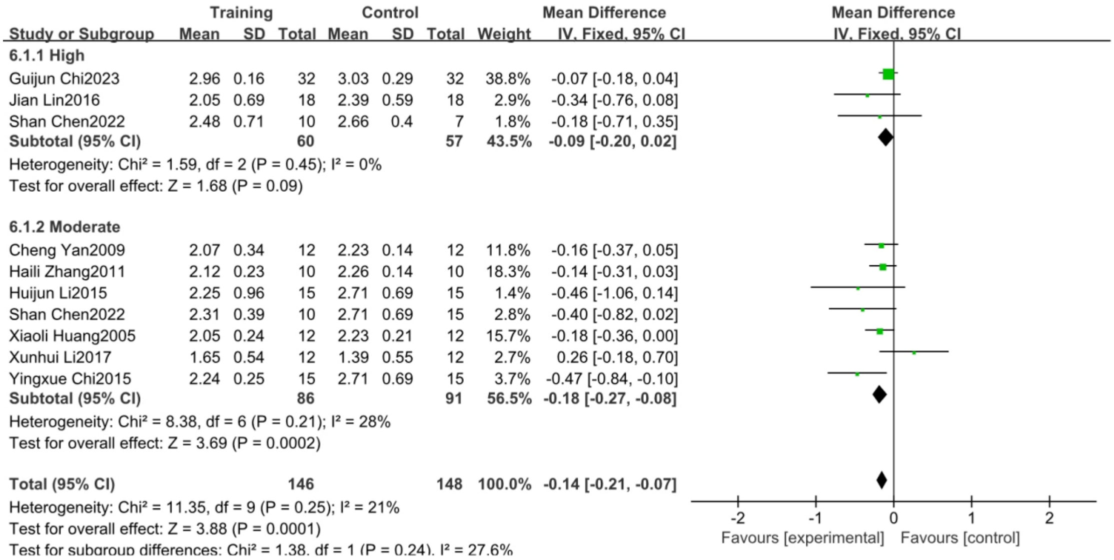

Figure8 Meta-analysis of the effects of different exercise Intensities on LDL-C

4. Discussion

Adolescent obesity has emerged as a public health challenge of widespread societal concern. Employing scientifically sound exercise strategies to assist adolescents in weight reduction and management represents a critical direction for current research and practice. Body Mass Index (BMI) and body fat percentage serve as two core indicators in clinical practice for assessing obesity severity, formulating intervention plans, and evaluating treatment efficacy. This study observed a significant differential effect: both exercise regimens significantly reduced participants' body fat percentage. However, only the moderate-intensity group exhibited a statistically significant decrease in BMI, while the high-intensity group showed no statistically significant change in BMI. This finding aligns with the research of Lu Yining [15] and Macpherson [16], both of which indicate that exercise significantly improves body fat percentage and body composition, but has a relatively limited impact on weight and BMI.

The reason for this discrepancy may lie in the fact that BMI is not an absolute standard for measuring overweight and obesity. Its primary limitation is its inability to directly reflect body fat content and body composition. In contrast, body fat percentage—the percentage of body fat weight relative to total body weight—can more accurately reflect the actual accumulation of fat in the body. In this study, the high-intensity group demonstrated significant improvements in body fat percentage without noticeable changes in BMI. This suggests that the exercise regimen may have triggered a more favorable body composition shift: while effectively reducing fat mass, fat-free mass (particularly muscle mass) may have increased or been well-maintained, thereby counteracting potential weight loss due to fat reduction. Furthermore, increased energy expenditure from high-intensity or excessive exercise often leads to corresponding increases in food intake. Conversely, moderate-intensity, prolonged exercise regimens—due to their higher feasibility, greater sustainability over time, and lesser acute stimulation of appetite—may more effectively achieve sustained energy deficit, thereby promoting significant BMI reduction [17].

Epidemiological studies indicate that dyslipidemia affects approximately 30% to 40% of the general population [18], with prevalence rates reaching as high as 20% among children and adolescents [19]. Obesity during childhood and adolescence constitutes a major risk factor for diabetes, dyslipidemia, and cardiovascular disease, significantly increasing the likelihood of developing hypertension and dying from chronic cardiovascular conditions in adulthood. Mechanistically, obese individuals often experience increased intestinal lipid absorption due to

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excessive food intake. This is accompanied by alterations in the activity of lipid transport carriers such as lipoproteins, disrupting normal lipid metabolism. This leads to abnormal accumulation of lipids in the liver and bloodstream, ultimately causing dyslipidemia and elevating the overall risk of metabolic disorders [20]. Dyslipidemia is a major contributor to atherosclerosis, where excessive fat deposits in arterial walls form atherosclerotic plaques. These plaques narrow the vessel lumen, causing ischemic damage to supplied tissues and ultimately leading to organ dysfunction [21]. Interventions for dyslipidemia aim to maintain lipid levels within normal ranges, thereby reducing cardiovascular disease risk [22]. Exercise training serves as a vital method for enhancing physical fitness and promoting health. Studies have examined the acute effects of exercise on lipids. Górecka[23] measured lipid profiles in 10 healthy males after completing a marathon. Results showed a significant post-exercise increase in plasma HDL-C concentration. At 90 minutes post-exercise, TG, LDL-C, and TC/HDL-C ratios were lower than pre-exercise levels. Additionally, both the immediate post-exercise and 90-minute post-exercise TG/HDL-C ratios were significantly lower than pre-exercise levels.

The results of this study indicate that long-term exercise training significantly reduces TC, TG, and LDL-C levels in overweight and obese female college students, while showing no significant difference in increasing HDL-C levels. This finding is consistent with the results reported by Sun Lei [24]. Her study suggests exercise may elevate lipoprotein lipase activity, gradually increasing free fatty acid concentrations in the blood and thereby promoting muscle utilization of these fats. This mechanism may contribute to the reduction in triglyceride (TG) levels. The synthesis of HDL-C occurs primarily in the liver and the intestines. In obese individuals, although HDL-C promotes monocyte chemotaxis during the acute phase response, its anti-inflammatory effects are diminished. Furthermore, HDL-C in obese patients exhibits reduced antioxidant capacity and weakened endothelial protective effects. These factors may collectively explain why exercise intervention did not significantly affect HDL-C levels.

Limitations of this study include: (1) a limited number of included articles, restricted to publicly available Chinese and English literature; (2) variations in intervention protocols and outcome measurement methods, potentially introducing bias; (3) generally small sample sizes across included studies, with a lack of large-scale randomized controlled trials; (4) differences in study designs—such as exercise frequency and intervention duration—that may generate heterogeneity.

5. Conclusion

This meta-analysis indicates that while both high-intensity and moderate-intensity exercise effectively reduce body fat percentage (BF%) and improve certain lipid parameters (TC, TG) in overweight and obese women, significant differences exist in their specific benefits: moderate-intensity exercise demonstrates more comprehensive effects, significantly lowering BMI while also effectively improving LDL-C levels; while high-intensity exercise failed to achieve statistically significant improvement in LDL-C and did not demonstrate significant effects on reducing BMI. Therefore, for overweight and obese women requiring simultaneous improvement in body composition (fat loss and weight reduction) and comprehensive lipid regulation (including LDL-C), moderate-intensity exercise represents a more comprehensive exercise intervention strategy. It is recommended as the preferred option when developing exercise prescriptions.

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