

REVIEW ARTICLE

Combined Effects of Herbal Medicine and Lifestyle Intervention on Childhood Simple Obesity: A Systematic Review and Meta-Analysis

Young-Shin Shim, KMD; Ji-U Choi, KMD; Eun-Jin Kim, KMD, PhD; Sang-Yeon Min, KMD, PhD

ABSTRACT

Objective: Childhood simple obesity is a metabolic condition associated with an increased risk of complications, including impaired growth, psychological disorders, and cardiovascular disease. This study aimed to assess the therapeutic effectiveness of combined herbal medicine (HM) and lifestyle interventions (LI) in managing childhood simple obesity through a systematic review and meta-analysis of randomized controlled trials (RCTs).

Methods: A comprehensive search of 12 databases in English, Chinese, Korean, and Japanese was performed from June 24 to June 30, 2025. RCTs comparing HM combined with LI versus LI alone were included. Data were synthesized using RevMan version 5.4; standardized mean differences (SMDs), risk ratios (RRs), and 95% confidence intervals (CIs) were calculated. The certainty of evidence was appraised using the GRADE framework. Potential publication bias was evaluated using funnel plots, Egger's test, fail-safe N, and the trim-and-fill method using the meta package in R Studio version 4.5.1.

Results: Twenty-two RCTs involving 1694 participants met the inclusion criteria. Compared to LI alone, combined

HM and LI approach yielded significantly greater reductions in body mass index (SMD = -1.09 , 95% CI: -1.47 to -0.71 ; $P < .00001$), low-density lipoprotein cholesterol (SMD = -0.86 , 95% CI: -1.16 to -0.56 ; $P < .00001$), triglycerides (SMD = -0.73 , 95% CI: -0.87 to -0.60 ; $P < .00001$), and total cholesterol (SMD = -1.00 , 95% CI: -1.20 to -0.80 ; $P < .00001$). The total effective rate also improved significantly (RR = 1.25 , 95% CI: 1.19 to 1.31 ; $P < .00001$). Notably, the incidence of adverse events did not differ significantly between groups (RR = 1.20 , 95% CI: 0.58 to 2.49 ; $P = .62$).

Conclusion: The HM and LI combination may be a potentially safe and effective therapeutic option for childhood simple obesity. Nonetheless, rigorously designed RCTs with extended follow-up and standardized safety assessments are needed to validate these findings.

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Keywords: childhood, simple obesity, lifestyle intervention, herbal medicine, meta-analysis

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INTRODUCTION

Simple obesity is the most common form of childhood obesity, accounting for 95–99% of all cases.¹ It is characterized by excessive accumulation of body fat without other underlying diseases and adversely affects physical growth and health.² Clinically, childhood simple obesity is associated with an increased risk of various metabolic abnormalities, including insulin resistance, dyslipidemia, and hypertension, all of which elevate the risk of adult obesity and a range of related complications, such as cardiovascular diseases.³ Moreover, childhood simple obesity can negatively impact growth and development, particularly by contributing to premature pubertal onset.⁴ Additionally, psychological complications—including low self-esteem, depression, and anxiety—are important comorbidities that warrant attention.⁵

A recent study reported that the global prevalence of obesity among children and adolescents increased by 244% between 1990 and 2021. By 2050, approximately one-third of

the world's children and adolescents (about 746 million) are projected to be overweight or obese, with approximately half (about 360 million) classified as obese. Furthermore, the age of onset is gradually decreasing, and the disease is presenting in increasingly severe forms. Taken together, these trends urgently call for effective intervention strategies.⁶

To manage childhood simple obesity, lifestyle modifications such as dietary changes, physical activity, and behavioral interventions are recommended, which help reduce body mass index (BMI).⁷ Evidence suggests that these interventions are more effective when implemented for longer durations and at higher intensities, with multi-component approaches yielding the greatest benefits.⁸ However, long-term adherence to lifestyle changes remains difficult, and overall success is often limited, as lifestyle interventions (LI) to date have demonstrated only modest effects on weight loss.⁹

Due to these limitations, herbal medicine (HM) has gained increasing attention as a culturally acceptable, noninvasive adjunctive therapy, particularly in East Asian clinical practice.¹⁰ Commonly used prescriptions for simple obesity include Erchen decoction, Fangfeng Tongsheng pills, and Wendan decoction,¹⁰ while frequently used individual herbs include Ephedrae Herba, which supports metabolic regulation and circulation.¹¹ Recent studies report that HM can significantly improve BMI, weight percentiles, height z-scores, and metabolic markers with minimal adverse effects.¹¹ Moreover, preliminary studies including community-based programs have suggested that integrating HM with LI may result in additional BMI reduction and improved body composition compared with lifestyle changes alone, although current clinical data are limited with variation in methodological quality.¹²

Despite growing interest in this area, robust evidence from large, well-designed randomized clinical trials (RCTs) remains limited. To the best of our knowledge, no systematic review or meta-analysis has specifically evaluated the combined effects of HM and LI on childhood simple obesity. Accordingly, this systematic review and meta-analysis aimed to rigorously evaluate the efficacy and safety of HM combined with LI in managing childhood simple obesity, drawing on the most current and high-quality clinical data.

METHODS

Protocol and Registration

This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (see Supplementary file S1).¹³ The study protocol was prospectively registered on INPLASY (Registration No. INPLASY202560096) on June 24, 2025, and is publicly available at: <https://inplasy.com/inplasy-2025-6-0096/>.

Data Sources and Search Strategy

A comprehensive literature search was conducted across twelve electronic databases from June 24 to June 30, 2025,

without restriction on language or year of publication. These included three English language databases (MEDLINE via PubMed, Excerpta Medica Database [EMBASE], and the Cochrane Central Register of Controlled Trials [CENTRAL]), three Chinese databases (China National Knowledge Infrastructure [CNKI], Chinese Scientific Journal Database [VIP], and WanFang Data), five Korean medical databases (Korean Studies Information Service System [KISS], Korea Citation Index [KCI], Research Information Sharing Service [RISS], the Korean Medical Database [KMBase], and Oriental Medicine Advanced Searching Integrated System [OASIS]), and one Japanese database (Citation Information by the National Institute of Informatics [CINII]). Main search terms included “child”, “simple obesity”, and “herbal medicine”, which were adapted to meet each database's linguistic and indexing conventions. Detailed search strategies and results are provided in Supplementary File S2.

Eligibility Criteria

Types of Studies. This review included RCTs evaluating the efficacy of HM combined with LI in treating childhood simple obesity. Non-RCTs, animal studies, case reports, review articles, surveys, theses, and study protocols were excluded.

Types of Participants. Participants included children and adolescents aged 2–18 years diagnosed with childhood simple obesity based on the diagnostic criteria outlined in Pediatrics or other relevant clinical guidelines.^{7,14} Participants were excluded if they had secondary obesity due to genetic metabolic disorders, endocrine diseases (e.g., hypothyroidism or Cushing's syndrome), or other related conditions; had severe cardiac, hepatic, pulmonary, renal, hematologic, infectious, or psychiatric disorders, or other serious systemic conditions; or had used any weight loss medications within the previous three months.

Types of Interventions. The intervention group received oral HM in addition to the LI provided to the control group. The composition, formulation type (e.g., decoctions, granules, powders, pills), dosage, and treatment duration of HM were not restricted.

Types of Comparisons. The control group received LI comprising dietary and exercise management. Additional LI components, such as behavioral therapy or information provision, were allowed.

Types of Outcome Measures. The primary outcomes were BMI and lipid profile indicators in peripheral blood, including low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and total cholesterol (TC). Additional outcomes comprised the total effective rate (TER) and the incidence of adverse events.

Study Selection and Data Extraction

Study Selection. Two authors (Y.-S.S. and J.-U.C.) independently evaluated titles and abstracts, followed by full-text assessments based on predefined eligibility criteria. Two authors (Y.-S.S. and J.-U.C.) also independently screened

reference lists to identify additional eligible studies. Discrepancies were resolved through discussion, and unresolved issues were adjudicated by a third author (E.-J.K.).

Data Extraction. Two authors (Y.-S.S. and J.-U.C.) independently extracted data from the included studies. Discrepancies were resolved through discussion among all authors. In cases of missing or unclear information, the corresponding authors were contacted via email. Extracted data included the first author's name, year of publication, sample size, participants' characteristics, treatment interventions and comparisons, total treatment duration, HM composition, outcome measurements, adverse events, and information relevant to risk of bias (RoB).

Assessment of Risk of Bias

Two authors (Y.-S.S. and J.-U.C.) independently evaluated RoB using the Cochrane Risk of Bias 2 (RoB 2) tool, following the guidance of the Cochrane Handbook for Systematic Reviews of Interventions.¹⁵ Each study was rated as low, some concerns, or high risk of bias, based on five domains: the randomization process, deviations from the intended interventions, missing outcome data, measurement of outcomes, and selection of reported results. Any discrepancies between authors were resolved through discussion and consensus in consultation with all authors.

Statistical Analysis

Meta-analyses were performed using Review Manager (RevMan) version 5.4 (Cochrane Collaboration, London, UK). For dichotomous outcomes, risk ratios (RRs) with 95% confidence intervals (CIs) were calculated. Continuous outcomes were analyzed using mean differences (MDs) or standardized mean differences (SMDs) with 95% CIs, depending on the consistency of measurement scales and methodological approaches across the included studies.

Assessment of Heterogeneity. Heterogeneity was assessed by using the Higgins I^2 index,¹⁶ with $I^2 \geq 50\%$ indicating substantial heterogeneity, and $I^2 \geq 75\%$ indicating significant heterogeneity. A random-effects model was used for substantial heterogeneity ($I^2 \geq 50\%$), and a fixed-effects model was used for low heterogeneity ($I^2 < 50\%$).

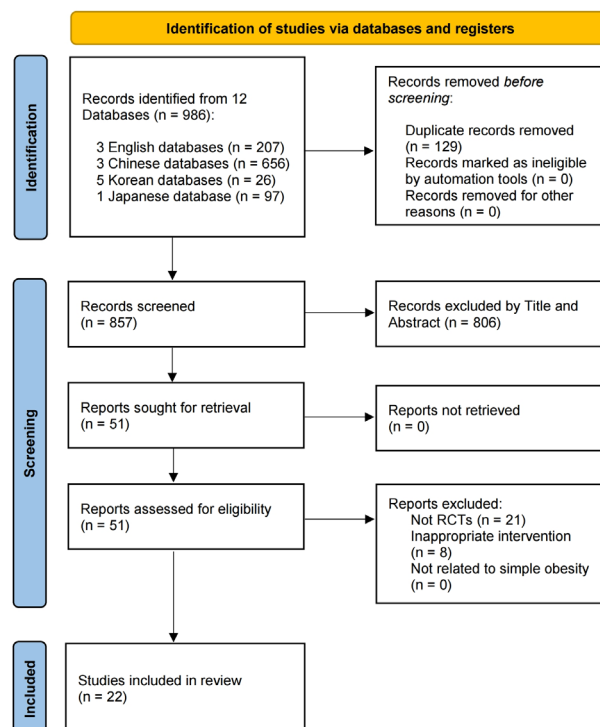
Assessment of Reporting Bias. For outcomes with ≥ 10 studies, publication bias was assessed via funnel plots. Where asymmetry was observed, further analyses included Egger's regression test, the trim-and-fill method, and Rosenthal's fail-safe N to quantify and explore reporting bias.

Subgroup and Sensitivity Analysis. If significant heterogeneity was observed in the meta-analysis, subgroup analyses were performed to explore potential sources of variability based on HM type. Leave-one-out sensitivity analyses were performed for outcomes that were included in ≥ 10 studies to assess robustness.

Quality of Evidence

The quality of evidence was evaluated using the Grading of Recommendations, Assessment, Development, and

Figure 1. PRISMA Flow Diagram



Abbreviations: EMBASE, Excerpta Medica database; CENTRAL, Cochrane Central Register of Controlled Trials; CNKI, China National Knowledge Infrastructure; VIP, Chinese Scientific Journal Database; OASIS, Oriental Medicine Advanced Searching Integrated System; KISS, Korean studies Information Service System; KCI, Korea Citation Index; RISS, Research Information Sharing Service; KMBASE, Korean Medical Database; CINII, Citation Information by the National Institute of Informatics

Evaluation (GRADE) framework (<http://gradepro.org> (accessed on 24 July 2025)). This framework considers five domains: risk of bias, inconsistency, indirection, imprecision, and publication bias. Evidence quality for each outcome was classified as very low, low, moderate, or high.

RESULTS

Study Selection

After applying the search strategy across all databases, a total of 986 records were identified: 207 from English-language databases, 656 from Chinese databases, 26 from Korean databases, and 97 from Japanese databases. After removing duplicates, 857 records remained. Based on title and abstract screening, 51 studies were selected for full-text review. Of these, 21 were excluded as they were not RCTs, and 8 were excluded for inappropriate interventions. Ultimately, 22 RCTs^{17–38} were included in this systematic review and meta-analysis (Figure 1).

Study Characteristics

The 22 included studies were RCTs conducted in China, published between 2007 and 2025. Sample sizes varied from 45 to 138 participants, and treatment durations ranged from 2 weeks to 6 months. The mean age of participants across the studies ranged from 6.6 ± 1.1 to 12.93 ± 2.61 years, and the

Table 1. Basic Characteristics of the Included Studies

First author (year)	Sample size (E/C)	Age distribution (yr, mean ± SD)	Gender (M/F)	Experimental intervention (E)	Duration of disease (mean ± SD)	Total treatment periods	Outcome measurement	Adverse events (n/N)
				Control intervention (C)				
Duan (2007) ¹⁶	45 (23/22)	NR	45 (28/17)	(C) + HM	NR	3 m 2 wk	(1)	NR
Huang (2021) ¹⁷	120 (60/60)	E: (7.98 ± 1.03) C: (7.95 ± 1.12)	E: 60 (35/25) C: 60 (36/24)	Diet, Exercise	NR	12 wk	(1),(2),(3)	NR
				(C) + HM				
				Diet, Exercise				
Li(2024) ¹⁸	62 (31/31)	E: (12.81 ± 2.59) C: (12.93 ± 2.61)	E: 31 (16/15) C: 31 (18/13)	(C) + HM	E: (17.93 ± 3.09) m C: (18.14 ± 3.10) m	3 m	(1),(4),(5)	NR
Ling (2023) ¹⁹	60 (30/30)	E: (8.24 ± 1.25) C: (8.38 ± 1.19)	E: 30 (17/13) C: 30 (16/14)	Diet, Exercise	E: (3.21 ± 0.54) yr C: (3.17 ± 0.48) yr	2 wk	(1),(3),(4),(5),(6)	NR
				(C) + HM				
Liu (2018) ²⁰	68 (35/33)	E: (6.9 ± 1.5) C: (6.6 ± 1.1)	E: 35 (16/17) C: 33 (17/18)	(C) + HM	NR	12 wk	(1),(3),(4),(7),(8),(9),(10),(11)	NR
Liu (2022) ²¹	86 (43/43)	E: (11.45 ± 2.56) C: (11.83 ± 2.49)	E: 43 (27/16) C: 43 (25/18)	Diet, Exercise	NR	12 wk	(1),(12),(13)	E: (4/43) C: (2/43)
				(C) + HM				
Luan (2023) ²²	60 (30/30)	E: (10.47 ± 2.03) C: (10.70 ± 2.14)	E: 30 (9/21) C: 30 (14/16)	(C) + HM	NR	3 m	(1),(2),(3),(4),(5),(13)	E: (3/30) C: (5/30)
				Diet, Exercise, Behavior				
Mei (2014) ²³	122 (60/62)	E: (11.2 ± 1.7) C: (10.6 ± 1.5)	E: 60 (31/29) C: 62 (34/28)	(C) + HM	NR	6 m	(14)	NR
				Diet, Exercise, Behavior				
Wang (2017) ²⁴	80 (40/40)	E: (8.9 ± 3.10) C: (9.5 ± 4.69)	E: 40 (17/23) C: 40 (19/21)	(C) + HM	NR	16 wk	(1),(3),(4)	NR
				Diet, Exercise, Psychological				
Wang (2021) ²⁵	74 (37/37)	E: (7.61 ± 2.47) C: (7.54 ± 2.39)	E: 37 (20/17) C: 37 (19/18)	(C) + HM	NR	1 m	(1),(3)	NR
Xu (2024) ²⁶	70 (35/35)	E: (9.03 ± 2.09) C: (9.25 ± 2.13)	E: 35 (23/12) C: 35 (21/14)	Diet, Exercise	E: (4.72 ± 1.58) yr C: (4.69 ± 1.54) yr	3 m	(2),(3),(4),(10),(15)	NR
				(C) + HM				
Yang (2003) ²⁷	55 (35/20)	E: (10.23) C: (10)	E: 35 (18/17) C: 20 (11/9)	Diet, Exercise, Behavior	E: (5.25 ± 3.76) yr C: (4.98 ± 3.28) yr	3 m	(1),(4),(5),(13),(16)	E: (NR/35) C: (NR/20)
				(C) + HM				
Yang (2018) ²⁸	108 (54/54)	E: NR C: (10.31)	E: 54 (30/24) C: 54 (32/22)	Diet, Exercise	NR	12 wk	(1),(3),(4),(5),(13),(17)	E: (1/54) C: (0/54)
Yang (2021) ²⁹	68 (34/34)	E: (11.08 ± 1.44) C: (10.36 ± 1.54)	NR	(C) + HM	NR	8 wk	(1),(3),(4),(5),(13)	E: (0/34) C: (0/34)
				Diet, Exercise, Behavior				
Yang (2025) ³⁰	61 (35/26)	E: (11.46 ± 1.46) C: (10.42 ± 1.84)	E: 35 (24/11) C: 26 (10/16)	(C) + HM	NR	12 wk	(1),(3),(4),(5),(13)	E: (2/35) C: (2/26)
Ye (2020) ³¹	76 (38/38)	E: (9.25 ± 0.54) C: (9.38 ± 0.56)	E: 38 (20/18) C: 38 (15/23)	Diet, Exercise	E: (2.02 ± 0.21) yr C: (2.35 ± 0.43) yr	8 wk	(1),(3),(4)	NR
				(C) + HM				
Ye (2024) ³²	60 (30/30)	E: (10.46 ± 1.77) C: (10.34 ± 1.83)	E: 30 (17/13) C: 30 (18/12)	Diet, Exercise, Psychological, Health education	NR	2 m	(1),(2),(3),(18),(19)	NR
				(C) + HM				
Zhang (2021) ³³	80 (40/40)	(8.14 ± 1.97)	80 (48/32)	Diet, Exercise, Behavior	NR	3 m	(3),(20)	NR
				(C) + HM				
Zhang (2023) ³⁴	70 (35/35)	E: (8.97 ± 2.26) C: (8.20 ± 2.87)	E: 35 (22/13) C: 35 (20/15)	Diet, Exercise	NR	8 wk	(1),(4),(5)	NR
				(C) + HM				
Zhao (2023) ³⁵	138 (69/69)	E: (10.16 ± 2.05) C: (9.88 ± 1.96)	E: 69 (32/37) C: 69 (36/33)	(C) + HM	NR	12 wk	(1),(3),(4),(5),(9)	NR
Zheng (2024) ³⁶	71 (36/35)	E: (112.69 ± 19.55)m C: (118.60 ± 22.91)m	E: 36 (16/20) C: 35 (15/20)	Diet, Exercise	E: (2.72 ± 1.23) yr C: (2.77 ± 1.09) yr	2 m	(1),(4),(5),(13),(20),(21)	E: (0/36) C: (0/35)
				(C) + HM				
Zhou (2016) ³⁷	60 (31/29)	(12.75 ± 1.45)	E: 31 (19/12) C: 29 (21/8)	Diet, Exercise	NR	3 m	(1),(2),(4),(10)	NR

Abbreviations: E, experimental; C, control; SD, standard deviation; NR, not reported; wk, week; m, month; yr, year; HM, herbal medicine; (1), Total effective rate; (2), Insulin resistance indicator; (3), Lipid profile indicator; (4), Body composition; (5), Traditional Chinese Medicine syndrome score; (6), Gut microbiota; (7), Acanthosis nigricans; (8), Blood pressure; (9), Blood test indicator; (10), Fasting Blood Glucose; (11), Fatty liver disease; (12), Adipokine level; (13), Adverse events; (14), Endothelin; (15), Growth hormone; (16), Traditional Chinese Medicine symptom rate; (17), Recurrence rate; (18), Free fatty acid; (19), Inflammation indicator; (20), Obesity levels; (21), Visual analogue scale appetite scale scores

duration of disease ranged from 17.93 ± 3.09 months to 5.25 ± 3.76 years. Most studies used identical treatment durations in both experimental and control groups (Table 1).

Interventions

Oral HMs were reported in all 22 studies. Twenty different formulations were used, including Modified Wendan Decoction (WD),^{18,29,32} Modified Siling Powder,¹⁹ Qiwei Baizhu Powder,²⁰ Xiaoe Xiaozhi Prescription,²¹ Hezhong Jianpi Decoction,²² Modified Cangfu Daotan Decoction,²³ Liu Wei Di Huang Wan,²⁴ Heling Shouer decoction,²⁵ Liqi Jianpi Decoction,²⁶ Jianpi Huashi Qutan Decoction,²⁷ Jianfei Jiao granule,²⁸ Huatan Xingzhi Sanjie Decoction,³⁰ Modified Fangji Huangqi Decoction,³¹ Modified Ljin Decociton,³³ Heze granule,³⁴ Modified Huangya Decoction,³⁵ Spleen-Fortifying and Phlegm-Resolving Decoction,³⁶ Modified Banxia Xiexin Decoction,³⁷ Fangfeng Tongsheng Powder,³⁸ and an unnamed decoction.¹⁷ Details on composition, dosage, and administration frequency are provided in Table 2.

Among the herbal components, Poria Sclerotium was most frequently prescribed (16 studies), followed by Atractylodes Rhizome (13 studies). Aurantii Nobilis Pericarpium appeared

in 11 studies, while Glycyrrhizae Radix et Rhizoma and Pinelliae Rhizoma were each included in 10 studies (Table 3).

All studies^{17–38} included conventional treatments in both experimental and control groups. Diet and exercise interventions were conducted in every study,^{17–38} while behavioral interventions,^{23,24,27,28,30,33} psychological interventions,^{25,32} and health education³² were included in specific trials (Supplementary File S3). In all included RCTs, the experimental groups received HM in addition to the same conventional treatments provided to the control groups, allowing the additive therapeutic effect of HM to be evaluated.

Outcome Measures

Main outcome measures included BMI,^{19–21,23,25,27,29–32,35–38} LDL-C,^{18,20,21,23,25–27,29–34,36} TG,^{18,20,21,23,25,27,29–34,36} and TC.^{18,20,21,23,25,27,29–34,36}

BMI was reported in 14 studies.^{19–21,23,25,27,29–32,35–38} Three lipid profile indicators—LDL-C, TG, and TC—were selected as main outcomes, as lipid metabolic abnormalities frequently accompany simple obesity. LDL-C was reported in 14 studies,^{18,20,21,23,25–27,29–34,36} TG in 13 studies,^{18,20,21,23,25,27,29–34,36} and TC in 13 studies.^{18,20,21,23,25,27,29–34,36} The authors of this

Table 2. Intervention Details for the Experimental Group

First author (year)	Type of formulation /Composition	Dosage (time)	Frequency (day)
Duan (2007) ¹⁶	Decoction <i>Atractylodes Rhizome, Poria Sclerotium, Crataegi Fructus, Rhei Rhizome</i>	30 ml	3 times
Huang (2021) ¹⁷	Modified Wendan Decoction <i>Zizphi Fructus 3g, Zingiberis Rhizome 5 spices, Glycyrrhizae Radix et Rhizoma 6g, Alismatis Rhizoma 10g, Bambusae Calulis in Taeniam 10g, Pinelliae Rhizoma 10g, Polygalae Radix 10g, Aurantii Nobilis Pericarpium 10g, Acori Graminei Rhizoma 10g</i>	100 ml	2 times
Li (2024) ¹⁸	Modified Siling Powder <i>Atractylodes Rhizome 25g, Codonopsis Pilosulae Radix 9g, Astragali Radix 12g, Polyporus 12g, Poria Sclerotium 12g, Alismatis Rhizoma 10g, Saussureae Radix 9g, Glycyrrhizae Radix Praeparata 6g</i>	200 ml	2 times
Ling (2023) ¹⁹	Qiwei Baizhu Powder <i>Pseudostellariae Radix 10g, Poria Sclerotium 10g, Atractylodes Rhizome 10g, Glycyrrhizae Radix et Rhizoma 3g, Saussureae Radix 5g, Agastachis Herba 5g, Puerariae Radix 5g, Astragali Radix 10g, Stephaniae Tetrandrae Radix 3g</i>	150 ml	2 times
Liu (2018) ²⁰	Xiaoer Xiaozhi Prescription <i>Pseudostellariae Radix, Astragali Radix, Salviae Radix, Crataegi Fructus, Nelumbinis Folium, Maydis Stigma</i>	50 ml	2 times
Liu (2022) ²¹	Hezhong Jianpi Decoction <i>Atractylodes Rhizome 12g, Cocicis Semen 12g, Aurantii Nobilis Pericarpium 6g, Dolichoris Semen 6g, Poria Sclerotium 9g, Massa Medicata Fermentata 6g, Angelicae Gigantis Radix 12g, Paeoniae Radix 6g, Glycyrrhizae Radix et Rhizoma 3g</i>	NR	2 times
Luan (2023) ²²	Modified Cangfu Daotan Decoction <i>Atractylodes Rhizome 15g, Cyperi Rhizma 15g, Poria Sclerotium 15g, Pinelliae Rhizoma 10g, Cnidii Rhizoma 10g, Aurantii Nobilis Pericarpium 10g, Plantaginis Semen 10g, Aurantii Fructus 15g, Cocicis Semen 15g, Magnoliae Cortex 15g, Coptidis Rhizoma 10g, Achyranthis Radix 10g</i>	150 ml	2 times
Mei (2014) ²³	Liu Wei Di Huang Wan	3 pills	3 times
Wang (2017) ²⁴	Heling Shower decoction <i>Nelumbinis Folium 9g, Astragali Radix 9g, Atractylodes Rhizome 9g, Aurantii Nobilis Pericarpium 9g, Pinelliae Rhizoma 9g, Arecae Pericarpium 9g, Crataegi Fructus 9g, Poria Sclerotium 12g, Dioscoreae Radix 12g, Glycyrrhizae Radix et Rhizoma 3g</i>	NR	NR
Wang (2021) ²⁵	Liqi Jianpi Decoction <i>Astragali Radix 12g, Crataegi Fructus 12g, Aurantii Nobilis Pericarpium 6g, Salviae Radix Pinelliae Rhizoma 6g, Maydis Stigma 9g, Pseudostellariae Radix 9g</i>	NR	2 times
Xu (2024) ²⁶	Jianpi Huashi Qutan Decoction <i>Astragali Radix 10-15g, Poria Sclerotium 10-15g, Salviae Radix 6-12g, Aurantii Nobilis Pericarpium 6-12g, Pinelliae Rhizoma 6-12g, Atractylodes Rhizome 5-10g, Stephaniae Tetrandrae Radix 5-10g, Nelumbinis Folium 5-10g</i>	200 ml	2 times
Yang (2003) ²⁷	Jianfei Jiao granule <i>Pinelliae Rhizoma, Poria Sclerotium, Alismatis Rhizoma, Magnoliae Cortex</i>	5 pills	3 times
Yang (2018) ²⁸	Modified Wendan Decotion <i>Zizphi Fructus 3g, Poria Sclerotium 15g, Alismatis Rhizoma 10g, Bambusae Calulis in Taeniam 10g, Pinelliae Rhizoma 10 g, Glycyrrhizae Radix et Rhizoma 6g, Polygalae Radix 10g, Acori Graminei Rhizoma 10g, Aurantii Nobilis Pericarpium 10g, Zingiberis Rhizome 5 spices</i>	200 ml	2 times
Yang (2021) ²⁹	Huatan Xingzhi Sanjie Decoction <i>Bupleuri Radix 15g, Paeoniae Radix 15g, Fritillariae Bulbus 15g, Prunellae Herba 15g, Litchi Semen 15g, Cyperi Rhizma 15g, Moutan Radicis Cortex 10g, Meliae Fructus 10g, Scutellariae Radix 10g, Leonuri Herba 10g, Achyranthis Radix 10g, Bambusae Calulis in Taeniam 10g, Trichosanthis 10g, Aurantii Nobilis Pericarpium 10g</i>	5-8 yr: 150 ml 8-14 yr: 200 ml	2 times
Yang (2025) ³⁰	Modified Fangji Huangqi Decoction <i>Astragali Radix, Atractylodes Rhizome, Poria Sclerotium, Cocicis Semen, Stephaniae Tetrandrae Radix, Ponciri Fructus, Nelumbinis Folium, Aurantii Nobilis Pericarpium, Codonopsis Pilosulae Radix, Mori Folium</i>	100 ml	2 times
Ye (2020) ³¹	Modified Wendan Decoction <i>Pinelliae Rhizoma 10g, Bambusae Calulis in Taeniam 10g, Ponciri Fructus 10g, Aurantii Nobilis Pericarpium 10g, Alismatis Rhizoma 10g, Acori Graminei Rhizoma 10g, Polygalae Radix 10g, Poria Sclerotium 15g, Glycyrrhizae Radix et Rhizoma 6g, Zingiberis Rhizome 5g, Zizyphi Fructus 3g</i>	NR	2 times
Ye (2024) ³²	Modified Ljin Decociton <i>Cassiae Semen 30g, Gynostemma pentaphyllum 30g, Crataegi Fructus 30g, Poria Sclerotium 20g, Pinelliae Rhizoma 12g, Alismatis Rhizoma 12g, Glycyrrhizae Radix et Rhizoma 5g, Aurantii Nobilis Pericarpium 10g</i>	200 ml	2 times
Zhang (2021) ³³	Heze granule <i>Nelumbinis Folium 10g, Atractylodes Rhizome 9g, Alismatis Rhizoma 9g, Cocicis Semen 9g, Crataegi Fructus 6g, Cassiae Semen 6g, Ponciri Fructus 3g, Anemarrhenae Rhizoma 3g</i>	NR	NR
Zhang (2023) ³⁴	Modified Huangya Decoction <i>Gypsum 40g, Scrophulariae Radix 15g, Forxythiae Fructus 6g, Oryzae Semen 9g, Poria Sclerotium 15g, Zingiberis Rhizome 3g, Gingseng Radix 9g, Glycyrrhizae Radix et Rhizoma 9g, Atractylodes Rhizome 6g, Crataegi Fructus 20g, Maydis Stigma 20g, Dioscoreae Tokoro Rhizoma 12g, Bambusae Calulis in Taeniam 12g</i>	75 ml	2 times
Zhao (2023) ³⁵	Spleen-Fortifying and Phlegm-Resolving Decoction <i>Epimedi Herba 15g, Cuscutae Semen 15g, Lycii Fructus 15g, Glycyrrhizae Radix et Rhizoma 15g, Angelicae Gigantis Radix 12g, Arisaema Praeparatus cum Bile 12g, Atractylodes Rhizome 10g, Poria Sclerotium 10g, Glycyrrhizae Radix Praeparata 10g</i>	100 ml	2 times
Zheng (2024) ³⁶	Modified Banxia Xiexin Decoction <i>Pinelliae Rhizoma 6g, Scutellariae Radix 6g, Coptidis Rhizoma 6g, Zingiberis Rhizome 6g, Codonopsis Pilosulae Radix 9g, Poria Sclerotium 18g, Atractylodes Rhizome 18g, Ponciri Fructus 6g, Zizphi Fructus 6g, Glycyrrhizae Radix Praeparata 6g</i>	NR	2 times
Zhou (2016) ³⁷	Fangfeng Tongsheng Powder <i>Ledebourielae Radix, Schizonepetae Spica, Forxythiae Fructus, Menthae Herba, Cnidii Rhizoma, Angelicae Gigantis Radix, Paeoniae Radix, Atractylodes Rhizome, Gardeniae Fructus, Rhei Rhizoma, Natrri Sulfas, Gypsum, Scutellariae Radix, Platycodi Radix, Glycyrrhizae Radix et Rhizoma, Talcum</i>	NR	1 time

Abbreviations: NR, not reported; yr, year.

Table 3. Frequency of the Herb

Frequency	Herb
16	<i>Poria Sclerotium</i>
13	<i>Atractylodes Rhizome</i>
11	<i>Aurantii Nobilis Pericarpium</i>
10	<i>Glycyrrhizae Radix et Rhizoma, Pinelliae Rhizoma</i>
8	<i>Alismatis Rhizoma, Crataegi Fructus</i>
7	<i>Astragali Radix</i>
6	<i>Nelumbinis Folium</i>
5	<i>Zingiberis Rhizome, Bambusae Calulis in Taeniam</i>
4	<i>Cocicis Semen, Ponciri Fructus</i>
3	<i>Zizphi Fructus, Polygalae Radix, Acori Graminei Rhizoma, Codonopsis Pilosulae Radix, Glycyrrhizae Radix Praeparata, Pseudostellariae Radix, Stephaniae Tetrandrae Radix, Maydis Stigma, Angelicae Gigantis Radix, Paeoniae Radix, Magnoliae Cortex, Scutellariae Radix</i>
2	<i>Saussureae Radix, Salviae Radix, Cyperi Rhizma, Cnidii Rhizoma, Coptidis Rhizoma, Achyranthis Radix, Rhei Rhizoma, Cassiae Semen, Gypsum, Forxythiae Fructus</i>
1	<i>Rhei Rhizome, Polyporus, Agastachis Herba, Puerariae Radix, Dolichoris Semen, Massa Medicata Fermentata, Plantaginis Semen, Aurantii Fructus, Arecae Pericarpium, Dioscoreae Radix, Salviae Radix Pinelliae Rhizoma, Bupleuri Radix, Fritillariae Bulbus, Prunellae Herba, Litchi Semen, Leonuri Herba, Trichosanthis, Mori Folium, Zizyphi Fructus, Gynostemma pentaphyllum, Anemarrhenae Rhizoma, Scrophulariae Radix, Oryzae Semen, Gingseng Radix, Dioscoreae Tokoro Rhizoma, Epimedi Herba, Cuscutae Semen, Lycii Fructus, Arisaema Praeparatus cum Bile, Ledebourielae Radix, Schizonepetae Spica, Menthae Herba, Gardeniae Fructus, Natrri Sulfas, Platycodi Radix, Talcum</i>

Table 4. Adverse Events

First author (year)	Group	n (Total)	n (Adverse events)	Details
Liu (2022) ²¹	E	43	4	Nausea (n=2), Diarrhea (n=1), Muscle pain (n=1)
	C	43	2	Nausea (n=1), Muscle pain (n=1)
Luan (2023) ²²	E	30	3	Abdominal pain (n=1), Muscle pain (n=2)
	C	30	5	Muscle pain (n=5)
Yang (2003) ²⁷	E	35	NR	Diarrhea (n=NR)
	C	20	NR	Diarrhea (n=NR)
Yang (2018) ²⁸	E	54	1	Skin rash (n=1)
	C	54	0	None
Yang (2021) ²⁹	E	34	0	None
	C	34	0	None
Yang (2025) ³⁰	E	35	2	Muscle pain (n=2)
	C	26	2	Muscle pain (n=2)
Zheng (2024) ³⁶	E	36	0	None
	C	35	0	None

Abbreviations: E, Experimental group; C, Control group; NR, Not Recorded

Figure 2. Risk of Bias Graph

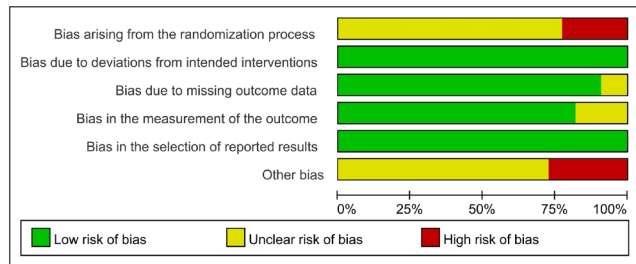
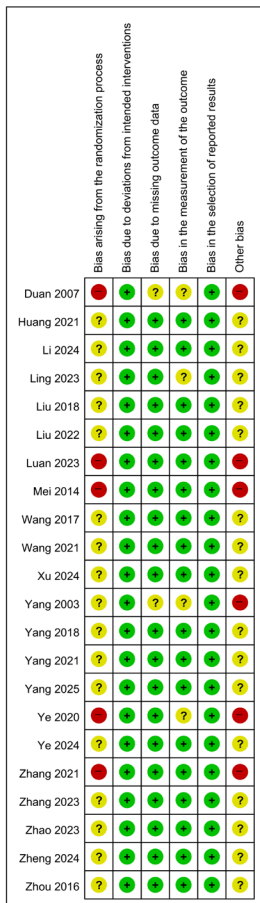


Figure 3. Risk of Bias Summary



review identified data inaccuracies during the extraction process; 2 LDL-C,^{20,34} 1 TG,³⁴ and 2 TC^{20,34} results were excluded due to transposition of values or the absence of baseline data necessary for evaluating therapeutic effects.

Secondary outcomes included TER and adverse events. The TER represents the proportion of patients who demonstrated improvement in clinical symptoms among the total subjects. It is a widely used outcome measure in Chinese controlled trials to report the overall effectiveness of an intervention, typically categorizing outcomes into tiers (e.g., “cured,” “markedly improved,” “improved,” and “no effect”). In this review, TER was interpreted as reported by the original authors of the included RCTs. Specifically, TER was evaluated in 19 studies.^{17–23,25,26,28–33,35–38}

In most studies,^{18–23,28–31,33,35–37} TER was assessed based on improvements in primary obesity related symptoms such as degree of obesity, excessive appetite, and heaviness of the limbs, along with secondary symptoms including headache, dizziness, fatigue, lethargy, and thirst. Several studies^{17,25,26,32} stated that TER was determined according to the degree of reduction in major symptoms. One study³⁸ defined TER primarily based on BMI reduction and normalization of fasting insulin levels. Adverse events were reported in 7 studies,^{22,23,28–31,37} of which one study²⁸ was excluded from this analysis because group allocation and case numbers were not reported. Further details on adverse events are provided in Table 4. Comprehensive data on outcome measures and corresponding *P* values are available in Supplementary File S4.

Quality Assessment

RoB was assessed using the Cochrane RoB 2 tool. Most studies were judged to have concerns in the randomization process, primarily due to inadequate reporting of allocation sequence concealment. Specifically, one study¹⁷ allocated participants by order of enrollment, two^{23,34} by odd/even numbers, and two^{24,32} by clinician judgment. These approaches do not ensure adequate allocation concealment and were therefore considered high RoB in randomization.

All studies were considered to have some concerns regarding deviations from intended interventions. While the planned interventions or procedures appeared to be delivered consistently to all participants, the possibility that participants’ awareness of group assignment could influence their behaviors was not ruled out, as double blinding was unfeasible owing to the inherent nature of studies comparing HM combined with LI versus LI alone. Most were also rated as low risk for missing outcome data, though two studies^{17,28} did not adequately report prespecified secondary outcomes, raising some concerns. For outcome measurement, most studies were rated low risk, but three^{17,28,32} lacked sufficient detail on criteria for secondary outcomes, while one²⁰ raised concerns over potential inaccuracies in post-treatment reporting. All studies were assessed as having a low RoB in the selection of reported results.

For overall RoB, seven studies^{17,20,23,24,28,32,34} were classified as high risk, while the remaining were judged as having “some concerns”. A summary of the RoB assessment is presented in Figures 2 and 3.

Meta-Analysis Results

This meta-analysis compared the outcomes of HM combined with LI versus LI alone in the treatment of childhood simple obesity. When significant heterogeneity was present, subgroup analyses by HM type were conducted to further investigate the outcomes. Baseline comparisons across all included studies revealed no statistically significant differences in any outcome measures between the experimental and control groups.

Body Mass Index. An SMD approach was adopted to ensure consistency and comparability across studies and to account for methodological and clinical differences in BMI assessment, such as variations in height and weight measurement tools and measurement time points.

A total of 14 studies,^{19–21,23,25,27,29–32,35–38} involving 1044 patients, reported pre- and post-treatment BMI values and were included in the meta-analysis. The pooled analysis demonstrated a significant overall effect (SMD = -1.09 , 95% CI: -1.47 to -0.71), indicating a BMI reduction with intervention. However, considerable heterogeneity was observed ($I^2 = 88\%$, $P < .00001$), suggesting considerable variation in treatment effects among the included studies. A random-effects model was therefore applied. Despite high heterogeneity, the overall effect remained statistically significant ($Z = 5.66$, $P < .00001$), supporting the potential therapeutic efficacy of HM combined with LI. Nevertheless, the substantial variation across studies warrants cautious interpretation (Figure 4).

Although subgroup analysis by HM type was prespecified in the protocol, its implementation was constrained by the limited number of studies within each subgroup. Specifically, WD, the most frequently used formula, was reported in only two studies^{29,32} assessing BMI outcomes, while the remaining 12 studies each employed distinct HM prescriptions. When a subgroup analysis was attempted, heterogeneity remained high, and no significant differences were observed. Thus, the limited number of trials precluded robust conclusions about formula-specific effects.

Lipid Profile Indicators. An SMD approach was also applied for LDL-C, TG, and TC outcomes to account for variations in baseline concentrations, measurement time points, and laboratory assay techniques.

Twelve studies^{18,21,23,25–27,29–33,36} including 983 patients, reported pre- and post-treatment serum LDL-C levels (mmol/L). A pooled analysis of these studies demonstrated a significant reduction in LDL-C following intervention (SMD = -0.86 , 95% CI: -1.16 to -0.56), though significant heterogeneity was observed ($I^2 = 80\%$, $P < .00001$). Despite considerable heterogeneity, the random-effects model showed a significant effect ($Z = 5.57$, $P < .00001$), supporting the potential therapeutic efficacy of HM combined with LI upon LDL-C levels. However, the marked variability across studies necessitates cautious interpretation (Figure 5).

An additional subgroup analysis by HM type was conducted to explore potential sources of heterogeneity in

Figure 4. Forest Plot Showing the Effect of HM Combined With LI Versus LI Alone on BMI

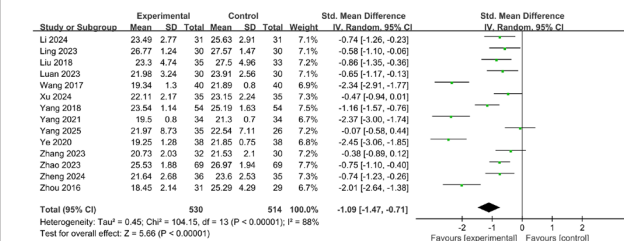


Figure 5. Forest Plot Showing the Effect of HM Combined With LI Versus LI Alone on Serum LDL-C Levels

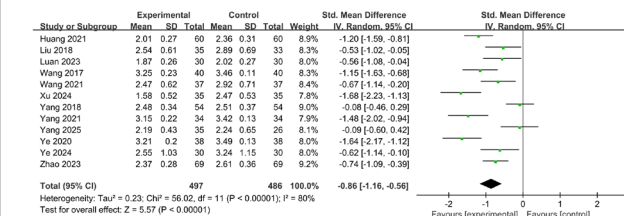
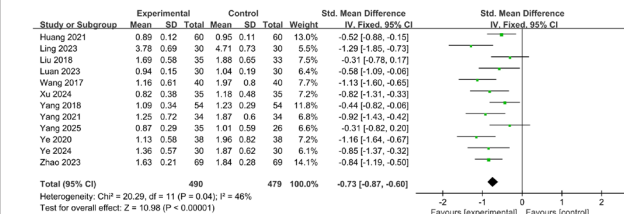


Figure 6. Forest Plot Showing the Effect of HM Combined With LI Versus LI Alone on Serum TG levels



LDL-C outcomes. However, WD, which was the most frequently prescribed formula, was evaluated in only three trials^{18,29,32} with LDL-C as an outcome measure, while the remaining nine studies each investigated distinct HM prescriptions. After the subgroup analysis, heterogeneity remained substantial, and no statistically significant differences were observed between subgroups. These findings suggest that subgroup stratification by formula did not resolve heterogeneity, and the limited number of WD trials constrains conclusions regarding the relative effects of HM types on serum LDL-C.

Serum TG levels (mmol/L) were reported across twelve studies^{18,20,21,23,25,27,29–33,36} involving a total of 969 patients. The meta-analysis demonstrated a significant pooled effect (SMD = -0.73 , 95% CI: -0.87 to -0.60), indicating a reduction in TG following intervention. The overall effect was highly significant ($Z = 10.98$, $P < .00001$). As the heterogeneity across the included studies was low ($I^2 = 46\%$, $P = .04$), a fixed effect model was applied, indicating a relatively consistent treatment effect across studies (Figure 6).

For TC (mmol/L), eleven studies^{18,21,23,25,27,29–33,36} involving 909 patients met the criteria for inclusion in the meta-analysis. The pooled analysis indicated a significant reduction in TC levels following intervention (SMD = -1.00 , 95% CI: -1.20 to -0.80). The effect was highly significant ($Z = 9.73$,

Figure 7. Forest Plot Showing the Effect of HM Combined With LI Versus LI Alone on Serum TC Levels

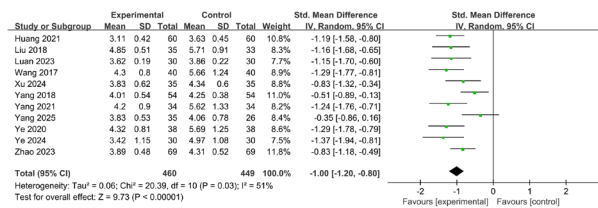


Figure 8. Forest Plot Showing the Effect of HM Combined With LI Versus LI Alone on TER

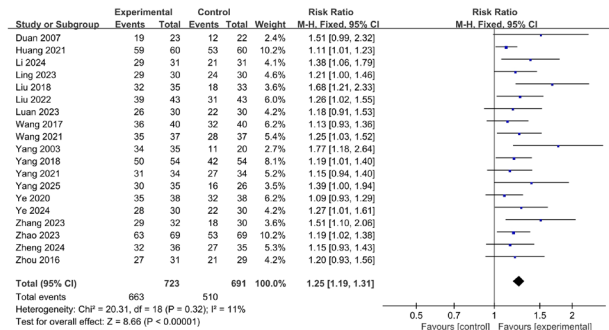


Figure 9. Forest Plot Showing the Effect of HM Combined With LI Versus LI Alone on Adverse Events

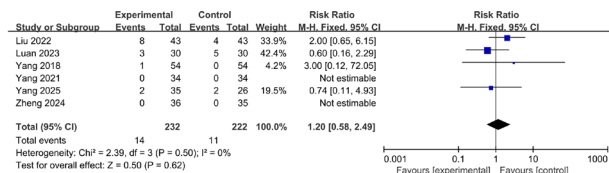
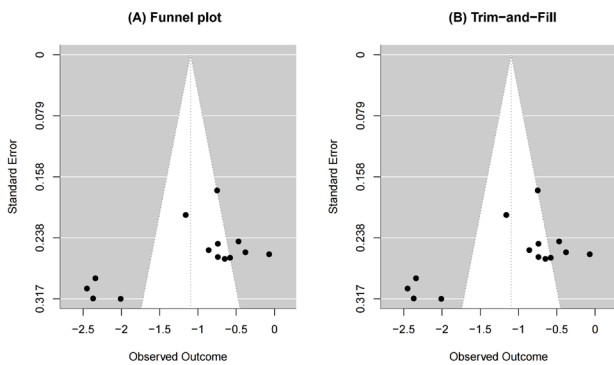


Figure 10. Funnel Plot (A) and Trim-and-Fill Analysis (B) Assessing Potential Publication Bias in Studies Reporting BMI Outcomes



$P < .00001$). Unlike TG outcomes, heterogeneity was moderate ($I^2 = 51\%$, $P = .03$), prompting the use of a random-effects model, which confirmed the overall benefit while suggesting variability in the magnitude of treatment effects across studies (Figure 7).

Total Effective Rate: To assess TER as an outcome, a meta-analysis of 19 RCTs,^{17–23,25,26,28–33,35–38} comprising 1414

participants, was conducted. The pooled analysis demonstrated a statistically significant improvement in the clinical response rate in favor of the treatment group ($RR = 1.25$, 95% CI: 1.19 to 1.31, $P < .00001$), indicating a higher clinical response rate compared to controls. Study heterogeneity was low ($I^2 = 11\%$, $P = .32$), justifying the use of a fixed-effect model. The overall effect was statistically robust ($Z = 8.66$), supporting the intervention's efficacy in improving TER (Figure 8).

Adverse Events

Six studies^{22,23,29–31,37} comprising 454 patients assessed the incidence of adverse events. In the experimental group, reported events included five cases of myalgia, four gastrointestinal symptoms, one skin rash, and four other minor events. In the control group, eight cases of myalgia, one gastrointestinal symptom, and two other events were reported. Across the included studies, adverse events were primarily monitored through periodic assessments by investigators, incorporating reports from both participants and their caregivers during the intervention period.

The pooled analysis found no significant difference between the two groups ($RR = 1.20$, 95% CI: 0.58 to 2.49; $P = .62$). Low heterogeneity was observed across studies ($I^2 = 0\%$, $P = .50$), supporting the use of a fixed-effect model. The overall effect was not statistically significant ($Z = 0.50$), suggesting that adding HM did not increase the risk of adverse events compared with LI alone (Figure 9). Only one study²¹ explicitly reported laboratory monitoring of hepatic and renal function indices, including alanine transaminase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), and creatinine. At baseline, no significant differences were observed between the HM and the control groups ($P > .05$). After treatment, ALT and AST levels in the HM group were lower than in the control group ($P < .05$), and all groups' levels were within the normal range. No significant differences in BUN or creatinine were observed between groups after treatment ($P > .05$). The remaining studies either did not report objective laboratory assessments or simply stated that no abnormalities in liver or kidney function were detected.

Assessment of Reporting Bias

The effect of HM combined with LI on BMI reduction was statistically significant. However, publication bias could not be ruled out. Visual inspection of the funnel plot showed mild asymmetry (Figure 10A), and Egger's regression test indicated significant small-study effects ($Z = -2.7167$, $P = .0066$). Although Rosenthal's fail-safe N was relatively low (62), suggesting limited tolerance to unpublished null results, the trim-and-fill analysis did not impute additional studies (Figure 10B). Despite heterogeneity and indications of publication bias, the overall findings suggest that the main conclusions are reasonably robust.

Sensitivity Analyses

To evaluate the robustness of the findings for BMI and LDL-C, a leave-one-out sensitivity analysis was performed by

Table 5. Quality of Evidence

Outcomes	No. participants (studies)	Anticipated absolute effects (95% CI)		Relative effect (95% CI)	Heterogeneity (I^2)	Quality of evidence (GRADE)
		Risk with control group	Risk with intervention group			
BMI	1044 (14 RCTs)	SMD 1.09 lower (1.47 lower to 0.71 lower)		-	88	⊕⊕○○ Low ^{a,b,c}
LDL-C	983 (12 RCTs)	SMD 0.86 lower (1.16 lower to 0.56 lower)		-	80	⊕⊕⊕○ Moderate ^{a,b}
TG	969 (12 RCTs)	SMD 0.73 lower (0.87 lower to 0.6 lower)		-	46	⊕⊕⊕○ Moderate ^a
TC	909 (11 RCTs)	SMD 1 lower (1.2 lower to 0.8 lower)		-	51	⊕⊕⊕○ Moderate ^{a,b}
TER	1414 (19 RCTs)	185 more per 1000 (140 more to 229 more)		RR 1.25 (1.19 to 1.31)	11	⊕⊕○○ Low ^{a,c}
Adverse effect	454 (6 RCTs)	10 more per 1000 (21 fewer to 74 more)		RR 1.20 (0.58 to 2.49)	0	⊕○○○ Very low ^{a,d,e}

^aOverall bias was unclear in $\geq 50\%$ of the studies

^bDespite substantial heterogeneity ($I^2 > 50\%$), all studies showed effect estimates in the same direction, and variability in effect sizes was considered clinically acceptable. As such, no downgrade was applied for inconsistency

^cPublication bias could not be ruled out; d, Sample size did not meet the OIS criterion; e, 95% CI included RR = 1.

Abbreviations: CI, confidence interval; RR, risk ratio; SMD, standardized mean difference; RCT, randomized controlled trial; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; TER, total effective rate; OIS, optimal information size; ⊕ represents higher certainty of evidence; ○ represents lower certainty of evidence.

sequentially omitting each study to assess its impact on the overall results.

For BMI, the overall treatment effect remained stable across all iterations (SMD range: -0.99 to -1.17), consistently favoring the intervention group with statistical significance maintained ($P < .00001$). Notably, significant heterogeneity persisted across all iterations ($I^2 = 85\text{--}88\%$), indicating that the observed variability could not be attributed to any single study (Supplementary File S5A).

For LDL-C, results were similarly stable (SMD range: -0.79 to -0.94), with the intervention consistently favored and statistical significance maintained throughout ($P < .00001$). Substantial heterogeneity also remained ($I^2 = 75\text{--}82\%$) throughout the analysis, suggesting variability arose from clinical or methodological differences rather than a single influential study (Supplementary File S5B).

GRADE Certainty of Evidence

The certainty of the evidence was assessed using the GRADE approach (Table 5). Outcomes for LDL-C, TG, and TC were rated as moderate quality. In contrast, evidence for all other outcomes was assessed as low or very low, due to concerns regarding high RoB, possible publication bias, and imprecision. Detailed explanations for downgrading decisions are provided in Table 5.

DISCUSSION

Review Summary

This systematic review and meta-analysis of RCTs investigated whether combining HM with LI can provide an effective and safe management strategy for childhood simple obesity. Following a comprehensive literature search across 12 databases, 22 RCTs involving 1694 children were included in the final meta-analysis.

The combined intervention of HM and LI (including dietary and physical activity guidance) demonstrated therapeutic benefits compared with LI alone. Significant improvements were observed in key outcomes, such as BMI and lipid profile indicators (including LDL-C, TG, and TC), with TER significantly higher in the experimental group. Although the limited statistical power and wide confidence intervals preclude drawing firm conclusions about safety, the

most frequently reported adverse event was mild, post-exercise muscle soreness. In terms of safety, there were no significant differences in adverse events between the two groups, suggesting that HM combined with LI may be a useful and generally safe strategy for managing childhood simple obesity.

Despite these beneficial findings, considerable heterogeneity existed across studies, including differences in HM prescriptions, treatment durations, and types of LI applied. Subgroup analyses were conducted to explore the sources of heterogeneity; however, results remained inconsistent even among studies in the same HM category. According to the GRADE approach, the overall quality of evidence ranged from “moderate” to “very low”, with no outcomes rated as “high” quality. Most included RCTs were judged to have “some concerns” for RoB, and seven studies were assessed as “high” RoB, primarily due to issues with random sequence generation and blinding. Publication bias was evaluated for the main outcome, BMI, revealing mild asymmetry and significant small-study effects. However, subsequent trim-and-fill analysis suggested that despite these indications of potential publication bias, the overall therapeutic conclusions remain reasonably robust.

Overall, this study provides evidence that HM, when combined with LI, may offer a valuable and generally safe approach to managing childhood simple obesity. However, interpretation should be cautious due to methodological limitations and heterogeneity across the included studies.

Clinical Interpretation

Major clinical guidelines for childhood obesity recommend LI as the primary therapeutic strategy; however, their real-world effectiveness is often limited by low adherence, resource demands, and socio-environmental barriers. When lifestyle changes are insufficient, pharmacotherapy (e.g., metformin, glucagon-like peptide-1 receptor agonists) or bariatric surgery may be considered, primarily for adolescents with severe obesity. However, these options are restricted by age, side effects (e.g., gastrointestinal symptoms, hypoglycemia, and mood changes), and limited long-term safety data.³⁹⁻⁴²

Amid these constraints, our study provides quantitative evidence that HM combined with LI leads to greater

improvements in BMI and lipid profile indicators than LI alone, without serious adverse events. This supports the potential role of HM as a complementary therapy to enhance the effectiveness of current treatments and address gaps in childhood simple obesity management.

An analysis of pre- and post-treatment BMI values revealed that both groups achieved BMI reductions following the interventions. Specifically, the control group demonstrated mean BMI reductions ranging from 0.7 to 3.78 kg/m², indicating the baseline contribution of conventional treatments. In comparison, the experimental group showed greater mean BMI reductions, ranging from 2.2 to 9.8 kg/m².

To improve clinical interpretability, we back-transformed the pooled SMD derived from the meta-analysis of post-treatment BMI values between the two groups, using the SD from the study³⁶ with the largest sample size. This calculation suggests that at the end of the intervention, the experimental group achieved a BMI approximately 2.11 kg/m² lower than the control group. Reductions of this magnitude are associated with improvements in metabolic profiles, including insulin sensitivity and lipid levels, suggesting that adding HM to LI may enhance weight-related outcomes.⁴³ However, given the substantial heterogeneity across studies and the inherent growth-related variability in children's BMI, these pooled estimates should be interpreted with caution.

One included study,²⁹ reported rebound rates as a follow-up outcome. At six months post-treatment, the experimental group had a significantly lower rebound rate (9.26%) than the control group (24.07%, $P < .05$). Rebound rate is an important indicator of sustained weight loss in pediatric obesity, as long-term maintenance is challenging. The findings from this study suggest that HM may contribute not only to initial weight reduction but also to its maintenance. However, further studies with extended follow-up are needed to validate these results and clarify the long-term impacts of integrative approaches for childhood simple obesity.

This review analyzed 20 types of oral HM formulations (usage frequencies detailed in Table 3), with *Poria Sclerotium* being the most frequently used herbal component in the included RCTs (16 studies). Its polysaccharides have been shown to improve metabolic syndrome by modulating lipid and glucose metabolism,⁴⁴ and to reduce adipose tissue mass by regulating fat accumulation through modulation of gut microbacteria.⁴⁵ The second most common herb was *Atractylodes Rhizome* (13 studies), which exerts anti-obesity effects partly by promoting energy metabolism through increased activity of brown adipose tissue, mediated by upregulation of PGC1 α and UCP1.⁴⁶ *Aurantii Novilis Pericarpium* (11 studies) inhibits 3T3-L1 adipocyte differentiation and has demonstrated antioxidant and anti-obesity effects.⁴⁷ *Glycyrrhizae Radix et Rhizoma* (10 studies) shows anti-obesity activity via glycyrrhizin,⁴⁸ though its high frequency may partly reflect its common inclusion in multi-herb prescriptions. *Pinelliae Rhizoma* (10 studies) contains gallic acid as a major active component, which has been shown to inhibit macrophage activation associated with inflammatory

obesity.⁴⁹ It also contains ephedrine, which has been reported to promote energy expenditure and weight loss.⁵⁰

In contrast, a considerable number of less frequently used prescriptions were identified across the included trials. For example, Modified Huangya Decoction, composed primarily of *Ginseng Radix*, *Zingiberis Rhizome*, *Poria Sclerotium*, and *Glycyrrhizae Radix et Rhizoma*, with additional herbs such as *Gypsum* and *Scrophulariae Radix*, is traditionally prescribed to alleviate symptoms related to impaired digestive function and to support metabolic and fluid regulation.³⁵ However, these formulations were reported in only a small number of studies and often varied in composition across trials. Their specific pharmacological mechanisms remain insufficiently elucidated, so further experimental and clinical research is warranted to clarify their biological effects in the context of childhood simple obesity.

Notably, *Ephedrae Herba*, which contains ephedrine as its major active component, was not used in the included studies. Despite reports on its safety,^{51,52} a conservative approach may have been taken,⁵³ especially for pediatric patients with obesity already undergoing exercise and dietary interventions. Potential adverse events, such as headaches, nausea, palpitations, dry mouth, constipation, insomnia, and disturbed sleep, warrant caution in this population.⁵⁴

Despite the therapeutic potential of HM, concerns remain regarding its potential for unpredictable adverse effects, particularly in multi-herb formulations. A previous systematic review⁵⁵ collected and evaluated case reports of adverse events associated with herbal use in children. Most were mild reactions involving the nervous, gastrointestinal, or dermatological systems and resolved after dose adjustment or discontinuation, though rare severe cases were also noted.

In the present study, adverse events in the experimental group included five cases of myalgia, four gastrointestinal symptoms, one skin rash, and four other events. In comparison, the control group reported eight cases of myalgia, one gastrointestinal symptom, and two other events. The meta-analysis revealed that although the incidence of adverse events was slightly higher in the group receiving HM combined with LI than LI alone (RR 1.20, 95% CI: 0.58 to 2.49, $P = .62$, $I^2 = 0\%$), the difference was not statistically significant. The wide CI crossing 1 indicates considerable uncertainty, precluding definitive conclusions. However, the absence of heterogeneity suggests consistency across studies. Overall, these findings suggest that the addition of HM to LI may not significantly increase the risk of adverse events in children with simple obesity. Nonetheless, given the limited number of included studies and the small number of reported adverse events, caution in interpretation is warranted. Importantly, most studies relied on symptom-based monitoring rather than systematic laboratory testing, and the duration of HM administration ranged from 4 to 24 weeks, reflecting short-term exposure. Therefore, the current evidence is insufficient to establish a comprehensive safety profile, particularly regarding potential subclinical hepatic or renal effects.

Growing evidence also supports the beneficial effects of HM in obesity and related metabolic disorders, including

reductions in body weight and BMI,⁵⁶ waist and hip circumference,⁵⁷ and insulin resistance.⁵⁸ However, children are not simply ‘small adults’; their physiological characteristics differ considerably due to ongoing growth and development. For instance, hepatic or renal disorders can substantially alter drug metabolism and excretion, increasing susceptibility to adverse effects.⁵⁹ Moreover, immature metabolic pathways in pediatric patients may predispose them to more frequent or pronounced acute adverse reactions.⁶⁰ These considerations underscore the need for comprehensive, large-scale pharmacokinetic studies to establish the safety profile of HM in pediatric populations.

Strengths and Limitations

This study demonstrated that combining HM with LI is more effective than LI alone without a statistically significant increase in adverse events. These findings are particularly relevant for pediatric patients, who are often not prescribed pharmacological treatments, and support HM-based integrative approaches as a viable option. To enhance reliability, the review included the latest RCTs and focused exclusively on HM, excluding other traditional therapies such as acupuncture, moxibustion, and cupping. These methodological strengths provide valuable evidence for the future standardization of traditional medical approaches to childhood obesity and the development of relevant clinical guidelines.

However, several limitations should be noted. First, although no restrictions were placed on publication language or region during the literature search, all 22 included RCTs were conducted in China, potentially limiting the generalizability of our findings to other ethnic populations. This regional concentration persists despite the global institutionalization of Traditional and Complementary Medicine (T&CM); as of 2019, 170 out of the 194 WHO Member States (88%) acknowledged T&CM use, and 124 had established regulations for herbal products.⁶¹ A recent umbrella review confirms this research disparity, noting that nearly all synthesized clinical evidence for childhood obesity continues to originate from China and Korea.⁶² Such a trend likely reflects the robust clinical research infrastructure and the systematic integration of HM within academic healthcare settings in these regions, rather than a methodological flaw in our literature search. Therefore, future international multicenter trials are essential to bridge the gap between global regulatory recognition and localized research ecosystems, ensuring the cross-cultural applicability of these interventions.

Second, considerable heterogeneity was observed across the included studies, likely due to variations in HM composition, dosage forms, dosages, and treatment durations. Subgroup analyses based on HM type were limited because WD, the most frequently used formulation, appeared in only three studies, while other prescriptions showed little overlap. These factors hindered the identification of specific therapeutic effects and limited generalizability. Future well-powered RCTs with consistent HM regimens are needed to

allow more refined subgroup analyses. Moreover, no single herbal formula was evaluated in more than one RCT beyond limited repetitions, and no placebo-controlled trials were identified among the included studies. Although subgroup analyses were attempted, the diversity of formulations, including modified WD, precluded robust estimation of formula-specific effects. Therefore, combining diverse HM formulations into a single summary conclusion should be interpreted with caution, as the findings cannot be generalized to imply that any specific HM is definitively effective for childhood obesity. The observed summary effects may reflect a potential adjunctive benefit of HM rather than the confirmed efficacy of individual prescriptions.

Third, the content of LI was not standardized across the included studies. Detailed information regarding the nature, intensity, duration, and delivery methods of these interventions, as well as participant adherence, was often insufficient or entirely lacking. Additionally, individual-level factors that affect adherence and long-term behavioral intervention (e.g., motivation, family support, and environmental context) were rarely addressed or controlled. These inconsistencies may have influenced treatment outcomes and contributed to the observed heterogeneity. Fourth, participant characteristics such as sex, obesity severity, and socioeconomic status were not sufficiently analyzed, preventing population-specific conclusions. Finally, most trials had short treatment durations (8–12 weeks), leaving long-term efficacy and sustainability uncertain.

Suggestions for Further Studies

Future research should include large-scale, well-designed multicenter RCTs and follow-up cohort studies with standardized interventions, longer follow-up periods, and diverse populations to strengthen the evidence base for HM combined with LI in childhood obesity. In particular, future trials should adopt clearly defined and standardized herbal formulations, such as fixed compositions of modified WD or other frequently used prescriptions, to enable formula-specific efficacy analyses and improve reproducibility. In addition, future studies should incorporate objective safety assessments, including routine monitoring of hepatic and renal function indices, and ensure longer-term follow-up to evaluate delayed or cumulative adverse effects. Age- and sex-specific percentiles for BMI, body weight, and height should be used, with outcomes ideally tracked for at least 6 months to 1 year or into adulthood. Growth monitoring is essential, as excessive weight gain during this period may adversely affect physical development.^{4,63} In addition, future trials should evaluate the efficacy of specific herbal formulations, incorporate psychosocial variables such as obesity stigma and family support,⁶⁴ and assess quality-of-life changes for both children and caregivers.^{65,66} Finally, economic evaluations are needed to assess the cost-effectiveness and sustainability of HM as an adjunctive therapy for childhood simple obesity.

CONCLUSION

This systematic review and meta-analysis suggest that herbal medicine combined with lifestyle interventions may be a safe and effective approach to improving anthropometric outcomes in childhood simple obesity. This combined intervention could serve as an alternative option for patients for whom pharmacologic treatments are not appropriate or have shown limited response to existing interventions.

However, due to the variability in herbal formulations and the predominance of short-term observations, the generalizability of the results should be interpreted with caution. To strengthen the clinical evidence and support the development of institutional and practical guidelines, further large-scale, long-term studies with standardized interventions are warranted.

Supplementary

Supplementary Table S1 PRISMA 2020 Checklist.

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	3
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5-6
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7-8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	7-8
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	8
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	8
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	7
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	9
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	9
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	8
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	8-9
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	8
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	9
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	9
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	9
Study characteristics	17	Cite each included study and present its characteristics.	9-10
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	10-11
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	9-13
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	10-11
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	9-13
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	14
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	14
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	10-11,13
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	14
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	14-15
	23b	Discuss any limitations of the evidence included in the review.	17-18
	23c	Discuss any limitations of the review processes used.	17-18
	23d	Discuss implications of the results for practice, policy, and future research.	17-18
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	6
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	19
Competing interests	26	Declare any competing interests of review authors.	19
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	19

Supplementary File S2. Search Strategies and Results for Each Database

Medline via PubMed

	Searches	Results
#1	"simple obesity"[Title/Abstract] OR "obesity"[Title/Abstract] OR "overweight"[Title/Abstract]	408,945
#2	"child"[Title/Abstract] OR "children"[Title/Abstract] OR "childhood"[Title/Abstract] OR "adolescent"[Title/Abstract]	1,928,729
#3	"herbal medicine"[MeSH Terms] OR "medicine, chinese traditional"[MeSH Terms] OR "medicine, kampo"[MeSH Terms] OR "medicine, korean traditional"[MeSH Terms] OR "Korean medicine"[Title/Abstract] OR "Chinese medicine"[Title/Abstract] OR "Oriental medicine"[Title/Abstract] OR "Kampo medicine"[Title/Abstract] OR "herbal medicine"[Title/Abstract] OR "traditional medicine"[Title/Abstract]	98,047
#4	#1 AND #2 AND #3	18

Supplementary File S2. (continued)

EMBASE

	Searches	Results
#1	'obesity'/exp OR 'overweight'/exp OR 'obesity':ab,ti OR 'overweight':ab,ti	942,972
#2	'child'/exp OR 'adolescent'/exp OR 'child':ab,ti OR 'adolescent':ab,ti	4,918,863
#3	'herbal medic' OR 'medicine, chinese traditional'/exp OR 'medicine, kampo'/exp OR 'medicine, korean traditional'/exp OR 'korean medicine'/exp OR 'chinese medicine'/exp OR 'oriental medicine'/exp OR 'kampo medicine' OR 'herbal medicine'/exp OR 'traditional medicine'/exp OR 'herbal medic':ab,ti OR 'medicine, chinese traditional':ab,ti OR 'medicine, kampo':ab,ti OR 'medicine, korean traditional':ab,ti OR 'korean medicine':ab,ti OR 'chinese medicine':ab,ti OR 'oriental medicine':ab,ti OR 'kampo medicine':ab,ti OR 'herbal medicine':ab,ti OR 'traditional medicine':ab,ti	225,404
#4	#1 AND #2 AND #3	183

CENTRAL

	Searches	Results
#1	MeSH descriptor: [Obesity] explode all trees	21,987
#2	MeSH descriptor: [Overweight] explode all trees	25,799
#3	MeSH descriptor: [Child] explode all trees	82,649
#4	MeSH descriptor: [Adolescent] explode all trees	137,456
#5	MeSH descriptor: [Medicine, Chinese Traditional] explode all trees	1,830
#6	MeSH descriptor: [Medicine, Kampo] explode all trees	65
#7	MeSH descriptor: [Medicine, Korean Traditional] explode all trees	44
#8	(#1 OR #2) AND (#3 OR #4) AND (#5 OR #6 OR #7)	6

China National Knowledge Infrastructure (CNKI)

	Searches	Results
#1	(SU='单纯性肥胖' + '肥胖' + '超重' + '超体重') AND (SU='儿童' + '小儿' + '小孩' + '青少年') AND (SU='中药' + '药' + '汤' + '丸' + '散' + '方' + '颗粒' + '胶囊' + '自拟')	151

Wan Fang Database

	Searches	Results
#1	(Title=('单纯性肥胖'OR'肥胖'OR'超重' OR '超体重') AND Title=('儿童'OR'小儿'OR'小孩'OR'青少年') AND Title=('中药'OR'药'OR'汤'OR'丸'OR'散'OR'方'OR'颗粒'OR'胶囊'OR'自拟'))	411

Chinese Scientific Journal Database (VIP)

	Searches	Results
#1	(M=('单纯性肥胖' OR "肥胖" OR "超重" OR "超体重") AND M=('儿童' OR "小儿" OR "小孩" OR "青少年") AND M=('中药' OR "药" OR "汤" OR "丸" OR "散" OR "方" OR "颗粒" OR "胶囊" OR "自拟"))	94

Korea Citation Index (KCI)

	Searches	Results
#1	(비만 OR 과체중) AND (소아 OR 청소년) AND 한약	10

Korean studies Information Service System (KISS)

	Searches	Results
#1	(비만 OR 과체중) AND (소아 OR 청소년) AND 한약	9

Korean Medical database (KMbase)

	Searches	Results
#1	(비만 OR 과체중) AND (소아 OR 청소년) AND 한약	0

Oriental Medicine Advanced Searching Integrated System (OASIS)

	Searches	Results
#1	(비만 OR 과체중) AND (소아 OR 청소년) AND 한약	1

Research Information Sharing Service (RISS)

	Searches	Results
#1	(비만 OR 과체중) AND (소아 OR 청소년) AND 한약	6

Citation Information by the National Institute of Informatics (CINII)

	Searches	Results
#1	("simple obesity" OR "obesity" OR "单 满" OR " 满" OR " ") AND ("child" OR "children" OR "childhood" OR "adolescent" OR " " OR " 児" OR "青 " OR " ") AND ("Chinese medicine" OR "traditional herbal medicine" OR "herbal medicine" OR "Japanese medicine" OR "Traditional medicine" OR "Oriental medicine" OR "Kampo" OR "Korean medicine" OR "Complementary medicine" OR "decoction" OR "powder" OR "herb" OR " 薬" OR "ハーブ" OR "散" OR "汤" OR "丸")	97

Supplementary File S3. Detailed Information Regarding Control Intervention

First author (year)	Intervention
Duan (2007) ¹⁶	(1) Diet intervention (2) Exercise intervention (VO2max 50%, cardiovascular exercise, 1-2h/d, 6d/wk)
Huang (2021) ¹⁷	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular exercise, 40-60m/time, 3times/d)
Li (2024) ¹⁸	(1) Diet intervention (nutritional guidance, calorie control ≥1/5) (2) Exercise intervention (cardiovascular exercise, 40m/time, 3times/d)
Ling (2023) ¹⁹	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular exercise, 1time/d)
Liu (2018) ²⁰	(1) Diet intervention (nutritional guidance, food record, calorie control (<1000kcal/d)) (2) Exercise intervention (cardiovascular exercise, 1h/d)
Liu (2022) ²¹	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular exercise, 30m/time, 2times/d, 5d/wk, parent's encouragement)
Luan (2023) ²²	(1) Diet intervention (nutritional guidance, calorie control, correction eating attitude, water intake) (2) Exercise intervention (cardiovascular exercise, 30-60m/d, ≥5d/wk) (3) Behavior intervention (encouragement or punishment, parent education)
Mei (2014) ²³	(1) Diet intervention (2) Exercise intervention (3) Behavior intervention
Wang (2017) ²⁴	(1) Diet intervention (2) Exercise intervention (3) Psychological intervention
Wang (2021) ²⁵	(1) Diet intervention (nutritional guidance, calorie control (<1000kcal/d)) (2) Exercise intervention (cardiovascular exercise)
Xu (2024) ²⁶	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (VO2max 50%, cardiovascular exercise, 1h/d, 6d/wk) (3) Behavior intervention (sleep behavior, reduction screen time)

First author (year)	Intervention
Yang (2003) ²⁷	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (3) Behavior intervention
Yang (2018) ²⁸	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular exercise, 40-60m/time, 2-3times/d)
Yang (2021) ²⁹	(1) Diet intervention (2) Exercise intervention (≥1h/d) (3) Behavior intervention
Yang (2025) ³⁰	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular and anaerobic exercise, 30-60m/d)
Ye (2020) ³¹	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (3) Psychological intervention (4) Health education intervention
Ye (2024) ³²	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (≥1h/time, 3time/d) (3) Behavior intervention (sleep behavior)
Zhang (2021) ³³	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular exercise, 30m/time, heart rate measurement)
Zhang(2023) ³⁴	(1) Diet intervention (nutritional guidance) (2) Exercise intervention (cardiovascular and anaerobic exercise, 40m/d, 5d/wk)
Zhao (2023) ³⁵	(1) Diet intervention (nutritional guidance, calorie control ≥1/5) (2) Exercise intervention (cardiovascular exercise, 30-60m/d)
Zheng (2024) ³⁶	(1) Diet intervention (nutritional guidance, calorie control) (2) Exercise intervention (cardiovascular exercise 3-5d/wk, 50-70m/d, anaerobic exercise 2-3d/wk, heart rate measurement)
Zhou (2016) ³⁷	(1) Diet intervention (nutritional guidance, calorie control (<1400kcal/d)) (2) Exercise intervention (cardiovascular exercise, 40-60m/d, 5d/wk)

Abbreviations: m, minutes; h, hours; d, day; wk, week

Supplementary File S4. Outcome Measurement and Result (*P* value)

First author (year)	Outcome measurement & Result (<i>P</i> value)	First author (year)	Outcome measurement & Result (<i>P</i> value)	First author (year)	Outcome measurement & Result (<i>P</i> value)	First author (year)	Outcome measurement & Result (<i>P</i> value)
Duan (2007) ¹⁶	(1)TER: E>C ^a	Luan (2023) ²²	(1)TER: E>C ^a (f/u 12wk) (2)Body composition a) BMI: E<C ^a (3)Lipid profile indicator a) TG: E<C ^d b) TC: E<C ^a c) LDL-C: E<C ^a (4)Insulin resistance indicator a) FBG: E<C ^a b) FINS: E<C ^a c) HOMA-IR: E<C ^a (5)TCM syndrome score: E<C ^d (6)Adverse events: E<C	Yang (2025) ³⁰	(1)TER: E>C ^a (f/u 12wk) (2)Body composition a) Weight: E<C ^b b) BMI: E<C ^a (3)Lipid profile indicator a) TG: E<C ^d b) TC: E<C ^d c) LDL-C: E<C ^d d) HDL-C: E<C ^b (4)TCM syndrome score: E<C ^a (5)Adverse events: E=C	Zhou (2016) ³⁷	(1)TER: E>C ^a (f/u 3m) (2)FBG: E<C ^b (3)Insulin resistance indicator a) FINS: E<C ^a b) HOMA-IR: E<C ^a c) HOMA-IS: E<C ^a (4)Body composition a) BMI: E<C ^a b) Waist circumference: E<C ^a
Huang (2021) ¹⁷	(1)TER: E>C ^a (f/u 12wk) (2)Insulin resistance indicator a) FINS: E<C ^a b) HOMA-IR: E<C ^a (3)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a d) HDL-C: E>C ^a	Mei (2014) ²³	(1)Endothelin: E<C ^a (f/u 6m)	Ye (2020) ³¹	(1)TER: E>C ^a (f/u 8wk) (2)Body composition a) BMI: E<C ^a (3)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a	^a <i>P</i> < .05 ^b <i>P</i> > .05 ^c <i>P</i> < .001 ^d <i>P</i> < .01	Abbreviations: ALT, Alanine aminotransferase; APN, Adiponectin; Apo, Apolipoprotein; AST, Aspartate aminotransferase; BMI, Body mass index; BUN, Blood urea nitrogen; Cr, Creatinine; CRP, C reactive protein; FBG, Fasting blood glucose; FFA, Free fatty acid; FINS, Fasting insulin; GH, Growth hormone; GLP-2, Glucagon like peptide-2; HDL-C, High density lipoprotein cholesterol; HOMA-IR, Homeostasis model assessment of insulin resistance; HOMA-IS, Homeostasis model assessment of insulin sensitivity; NPY, Neuropeptide Y; LCN-2, Lipocalin-2; LDL-C, Low density lipoprotein cholesterol; TC, Total cholesterol; TCM syndrome score, Traditional Chinese Medicine syndrome score; TER, Total effective rate; TG, Triglycerides; TNF-α, Tumor necrosis factor alpha; VAS, Visual analogue scale
Li (2024) ¹⁸	(1)TER: E>C ^a (f/u 3m) (2)Body composition a) Weight: E<C ^d b) BMI: E<C ^d c) Fat percentage: E<C ^d (3)TCM syndrome score: E<C ^d	Wang (2017) ²⁴	(1)TER: E>C ^a (f/u 16wk) (2)Body composition a) BMI: E<C ^a (3)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a	Ye (2024) ³²	(1)TER: E>C ^a (f/u 8wk) (2)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a (3)FFA: E<C ^a (4)Insulin resistance indicator a) FINS: E<C ^a b) HOMA-IS: E<C ^a (5)Inflammation indicator a) CRP: E<C ^a b) TNF-α: E<C ^a		
Ling (2023) ¹⁹	(1)TER: E>C ^a (2)TCM syndrome score a) Swelling: E<C ^a b) Fatigue: E<C ^a c) Limb weakness: E>C ^a (3)Gut microbiota: E>C ^a a) Eubacterium rectum: E>C ^a b) Bacteroides thetaiotaomicron: E>C ^a c) Bifidobacterium: E>C ^a d) Lactobacillus: E>C ^a (4)Body composition a) Weight: E<C ^a b) Fat mass: E<C ^a c) BMI: E<C ^a d) Muscle mass: E<C ^b e) Fat percentage: E<C ^a f) Mineral: E<C ^b g) Protein: E<C ^b (5)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a	Wang (2021) ²⁵	(1)TER: E>C ^a (f/u 1m) (2)Lipid profile indicator a) LDL-C: E<C ^a b) HDL-C: E>C ^a	Zhang (2021) ³³	(1)Obesity levels: E<C ^a (f/u 6m) (2)Lipid profile indicator a) TG: E<C ^d b) TC: E<C ^d c) LDL-C: E<C ^d d) HDL-C: E>C ^d		
Liu (2018) ²⁰	(1)TER: E>C ^a (f/u 12wk) (2)Acanthosis nigricans: E<C ^d (3)Body composition a) Weight: E<C ^a b) Height: E>C ^b c) BMI: E<C ^a (4)Blood pressure a) SBP: E<C ^a b) DBP: E<C ^a (5)Blood test indicator a) ALT: E<C ^a b) AST: E<C ^a c) BUN: E<C ^b d) Cr: E>C ^b (6)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a d) HDL-C: E>C ^a e) FFA: E<C ^b (7)FBG: E<C ^a (8)Fatty liver disease(%): E<C ^d	Xu (2024) ²⁶	(1)Body composition a) BMI: E<C ^a (f/u 3m) (2)FBG: E<C ^a (3)Insulin resistance indicator a) FINS: E<C ^a b) HOMA-IR: E<C ^a (4)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a d) HDL-C: E>C ^a (5)GH: E>C ^a	Zhang (2023) ³⁴	(1)TER: E>C ^a (f/u 8wk) (2)Body composition a) BMI: E>C ^a (3)TCM syndrome score: E>C ^a		
Liu (2022) ²¹	(1)TER: E>C ^a (f/u 12wk) (2)Adipokine level a) GLP-2: E<C ^a b) APN: E>C ^a c) LCN-2: E<C ^a (3)Adverse events: E>C ^b	Yang (2003) ²⁷	(1)TER: E>C ^a (f/u 3m) (2)TCM symptom rate: E>C ^a (3)TCM syndrome score: E<C ^c (4)Body composition a) Height: E>C ^b b) Weight: E<C ^a (5)Adverse events	Zhao (2023) ³⁵	(1)TER: E>C ^a (f/u 12wk) (2)TCM syndrome score: E<C ^a (3)Body composition a) Weight: E<C ^a b) BMI: E<C ^a c) Fat percentage: E<C ^a (4)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^a d) HDL-C: E>C ^a (5)Blood test indicator a) Leptin: E<C ^a b) ADP: E>C ^a c) NPY: E<C ^a		
		Yang (2018) ²⁸	(1)TER: E>C ^a (f/u 12wk) (2)TCM syndrome score: E>C ^d (3)Lipid profile indicator a) TG: E<C ^d b) TC: E<C ^d c) LDL-C: E<C ^d d) HDL-C: E>C ^d e) apoA: E>C ^b f) apoB: E<C ^d (4)Body composition a) Weight: E<C ^a b) BMI: E<C ^a c) Fat percentage: E<C ^a (5)Adverse events: E>C ^b (6)Recurrence rate: E<C ^a (f/u 6m)	Zheng (2024) ³⁶	(1)TER: E>C ^a (f/u 2m) (2)TCM syndrome score: E<C ^a (3)Body composition a) Weight: E<C ^a b) BMI: E<C ^a c) Waist circumference: E<C ^a d) Hip circumference: E<C ^a (4)Obesity levels: E<C (5)VAS appetite scale scores: E<C ^a (6)Adverse events: E=C		
		Yang (2021) ²⁹	(1)TER: E>C ^a (f/u 8wk) (2)Body composition a) Weight: E<C ^b b) BMI: E<C ^a (3)TCM syndrome score: E<C ^a (4)Lipid profile indicator a) TG: E<C ^a b) TC: E<C ^a c) LDL-C: E<C ^b (5)Adverse events: E=C				

Supplementary File S5. Sensitivity Analysis for BMI

Excluding study	SMD	95%CI	<i>P</i> (%)	<i>P</i> value
Li 2024 ¹⁸	-1.12	-1.53, -0.71	88	<.00001
Ling 2023 ¹⁹	-1.13	-1.54, -0.73	88	<.00001
Liu 2018 ²⁰	-1.11	-1.52, -0.70	88	<.00001
Luan 2023 ²²	-1.13	-1.53, -0.72	88	<.00001
Wang 2017 ²⁴	-1.00	-1.36, -0.64	85	<.00001
Xu 2024 ²⁶	-1.14	-1.54, -0.74	88	<.00001
Yang 2018 ²⁸	-1.09	-1.50, -0.67	88	<.00001
Yang 2021 ²⁹	-1.00	-1.36, -0.63	86	<.00001
Yang 2025 ³⁰	-1.17	-1.55, -0.79	87	<.00001
Ye 2020 ³¹	-0.99	-1.34, -0.63	85	<.00001
Zhang 2023 ³⁴	-1.15	-1.55, -0.75	88	<.00001
Zhao 2023 ³⁵	-1.12	-1.54, -0.70	88	<.00001
Zheng 2024 ³⁶	-1.12	-1.53, -0.71	88	<.00001
Zhou 2016 ³⁷	-1.03	-1.41, -0.64	87	<.00001

Abbreviations: SMD, Standardized Mean Difference; CI, confidence interval

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DATA ACCESS STATEMENT

All data analyzed in this study are included in this published article and the supplementary files.

ETHICS STATEMENT

Since this is a systematic review and meta-analysis of previously published studies, ethical approval is not required.

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AUTHOR DISCLOSURE STATEMENT

The authors declare that there are no conflicts of interest.

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