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Original Article

The effectiveness of diet intervention in improving the metabolism of overweight and obese women: a systematic review and meta-analysis

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Abstract: Objectives: Dietary therapy may improve glucose and lipid metabolism function in women. However, there is no systematic review to investigate the association between metabolic effects and different dietary interventions in obese women. The main purpose of this study is to summarize the current literature and investigate whether different dietary interventions have an effect on glucose and metabolic indicators of overweight or obese women. Methods: We conducted a scoping review of randomized controlled trial (RCT) studies from 1991 to 2022 by adopting a systematic review and meta-analysis. The database includes Google Scholar, PubMed, Embase and Web of Science. Literature screening, data extraction, and quality assessment were independently completed by 2 researchers. Meta-analysis was performed with RevMan. Results: Twelve articles were extracted and the meta-analysis results showed that the mean difference of metabolic indexes of obese women before and after dietary intervention, including fasting glucose, fasting insulin, HOMA-IR (Homeostasis model assessment-insulin resistance), TG (triglyceride), TC (total cholesterol), LDL-C (low-density lipoprotein cholesterol), HDL-C (high-density lipoprotein cholesterol) are -0.13 [-0.15, -0.10], -2.41 [-3.44, -1.38], -0.13 [-0.15, -0.10], -21.71 [-24.19, -19.22], -21.71 [-24.19, -19.22], -13.29 [-17.86, -8.72], 3.31 [2.22, 4.40], respectively. Conclusions: Different dietary interventions benefit glucose and lipid metabolism of overweight or obese women. Further study is needed to determine which specific dietary effects have the greatest effect on improving metabolic indicators.

Keywords: Diet intervention, metabolism, obese women, overweight, RCT

Introduction

The World Health Organization (WHO) ranks obesity as one of the top ten chronic diseases [1]. According to an epidemiologic report, the worldwide prevalence of obesity is around 13% and the rate is gradually increasing [2, 3]. Obesity may increase the possibility of cardiovascular disease, type 2 diabetes, cancers, degenerative arthritis and other diseases [4, 5]. Besides, scientists have found that the prevalence of cerebral embolism and heart failure in obese people is twice as high as that of people with normal weight, and people suffering from coronary heart disease, hypertension, diabetes, and cholelithiasis are 3-5 times higher than those of normal people [6, 7].

Some studies suggest that obesity is associated with insulin resistance [8-12]. Insulin resistance and obesity are a mutually causal and have a mutually aggravating relationship [13]. Obesity often coexists with type 2 diabetes, high blood pressure, and dyslipidemia. It is medically called metabolic syndrome [14, 15]. The common pathogenic basis of metabolic syndrome is insulin resistance. Insulin resistance refers to the insensitivity of insulin to the target organs of insulin, such as the liver, muscle and adipose tissue [16, 17]. It has been confirmed that obese people have obvious insulin resistance, which is marked by compensatory hyperinsulinemia, and after weight loss, insulin sensitivity can be improved [18, 19].

Table 1. Search process of literate review

	PubMed	Web of Science	Embase	Google Scholar
Search keywords	'life intervention' 'diet intervention' 'Ketogenic diet' 'Mediterranean diet', 'low-fat diet', 'calorie-restricted diet' and 'obese women' 'overweight women' and 'metabolism' 'metabolic'	'life intervention' 'diet intervention' 'Ketogenic diet' 'Mediterranean diet', 'low-fat diet', 'calorie-restricted diet' and 'obese women' 'overweight women' and 'metabolism' 'metabolic'	'life intervention' 'diet intervention' 'Ketogenic diet' 'Mediterranean diet', 'low-fat diet', 'calorie-restricted diet' and 'obese women' 'overweight women' and 'metabolism' 'metabolic'	'life intervention' 'diet intervention' 'Ketogenic diet' 'Mediterranean diet', 'low-fat diet', 'calorie-restricted diet' and 'obese women' 'overweight women' and 'metabolism' 'metabolic'
Filters	Abstract/title	Article	Abstract/title	Abstract/title
Search filed	All fields	All fields	All fields	All fields
Time limit	1991-2021	2005-2021	2005-2021	2005-2021

Numerous studies have demonstrated that visceral fat accumulation in abdominal obesity is more closely related to insulin resistance [12, 14, 16, 20-22]. After the formation of abdominal obesity, the triglycerides in the fat cells are hydrolyzed to produce a large amount of free fatty acids and glycerol, which affect the body's material metabolism in many ways and constitute a high-risk factor for type 2 diabetes [23]. Hyperinsulinemia can also stimulate the appetite, increase eating, aggravate the disorder of blood lipid metabolism, promote the conversion of glucose into fat, and aggravate the progress of obesity [24-28]. For women, obesity will affect their reproductive function. In obese women, each unit increase in body mass index (BMI) reduces ovulation by 5% [29-31]. Moreover, reports have revealed that high BMI is associated with lower pregnancy rates, lower live birth rates and a higher risk of obstetric complications [32, 33]. Therefore, the management of adult obesity, especially the management of obese women, has become an important public issue [34, 35].

At present, the treatment for obesity includes regular physical activity (PA), diet intervention, medication and bariatric surgery [36, 37]. Although bariatric surgery is the most effective method of weight control, the WHO reports that diet and regular exercise are the most accessible and affordable strategies to prevent overweight and obesity [38, 39]. So far, many types of diets have been proposed to prevent and treat being overweight and obesity [40]. The overall strategy of dietary therapy is to manipulate the macronutrient composition of the entire diet and focus on controlling one macronutrient [24, 41]. The positive effect of diet control on weight management has been observed in large long-term randomized controlled trials (RCT) [42]. However, no studies have been conducted on the effects of different diets on glucose and metabolic index in obese and overweight women. On this basis, the main purpose of this systematic review and meta-analysis is to summarize the current literature and investigate whether different dietary interventions have an effect on the metabolic indicators of overweight or obese women.

Methods

Search strategy

This study followed the process of PRIMA and we conducted a scoping review of RCT studies from 1991 to 2022 by adopting a quantitive study design. The literature search was carried out using four databases to evaluate changes in metabolic indicators of obese women who have received different dietary interventions. The four databases used were Google Scholar, PubMed, Embase and Web of Science, and the search terms are as follows: ("life intervention" OR "diet intervention" OR "Ketogenic diet" OR "Mediterranean diet" OR "low-fat diet" OR "calorie-restricted diet" [Title/Abstract]) AND ("obese women" OR "overweight women" [Title/Abstract]) AND ("metabolism" OR "metabolic" [Title/Abstract]). The details of search keywords are shown below (**Table 1**). The content of the literature review includes population, intervention, comparison, results and settings, methods of literature retrieval and data extraction. Searches are limited to full text in English.

Study selection

Inclusion criteria: Two independent researchers evaluated the content of all included studies. This review included studies on participants who are overweight or obese women with a BMI over 25 kg/m^2 and participants who were approved have no transmitted diseases (such as sexually transmitted diseases) and

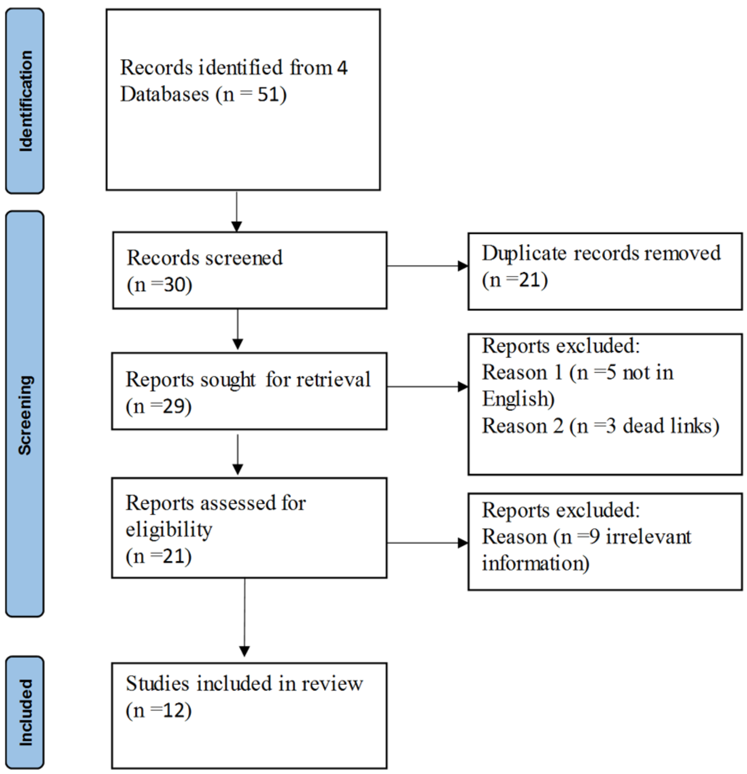


Figure 1. PRISMA flow diagram is illustrated. Prisma flowchart depicts the flow of information through the different phases of a Systematic Review. It maps out the number of records identified, included and excluded, and the reasons for exclusions.

have no food allergies, food intolerances, or food preferences that would affect the execution of the diet plan.

(1) Articles published from 1991 to 2022 focused on the metabolic effects of dietary interventions in obese women. (2) The language is English. (3) The study design should be a RCT. (4) The included RCTs required a duration of at least 4 weeks, as the weight-control diet requires duration to observe results. (5) The outcome of RCTs should include fasting glucose or fasting insulin or TG or LDL-C or HDL-C or HOMA-IR.

Exclusion criteria: (1) Non-RCT. (2) Not in English. (3) No full text.

Data extraction and quality assessment

Articles were initially eliminated by reading titles and abstracts, and full-text screening was performed to determine whether they met the inclusion criteria. If there was a disagreement, a third researcher discussed it and decided whether to include it or not. The primary outcome was fasting glucose, fasting insulin, HOMA-IR, TG, TC, LDL-C, and HDL-C. Based on the risk bias assessment tool recommended by Cochrane Manual 5.1.0, this paper has evaluated the bias risk of the included literature from seven aspects, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, and incomplete outcome data, selective reporting, and other biases. For indicators, "low risk of bias", "unclear" and "high risk of bias" are used to make judgments. The process was independently conducted by two researchers.

Meta-analysis

In order to evaluate the effect of dietary therapy on glucose and metabolic indictors, the mean and SD of change were calculated before and after the intervention. Besides, combined OR values and 95% CI were calculated. Heterogeneity was assessed by I^2. The low, medium, and high of heterogeneity are represented by I^2 of 25%, 50%, and 75%, respectively. I^2 greater than 50% is considered high heterogeneity and random effect model will be used if the heterogeneity is high. All data analysis was conducted by Review Manager 5.1.

Results

Search strategy and selection

Initially, we identified 51 papers from four databases. After using endnote to filter duplicates, there were 30 articles remaining. Eight of them were excluded because they did not have full-text links and were not in English. A detailed evaluation of the content of the article was carried out on the remaining 21 full-text articles. Among them, nine full-text articles were further excluded because they did not meet the inclusion criteria. Finally, twelve papers were included, and their data were reported completely (**Figure 1**). There was some bias in the included literature. Eight of the included articles were of medium quality (As shown in **Table 1**).

Table 2. Findings of this study is summarized

Study	Duration of study	Cases	Intervention	Age (y)	BMI (kg/m^2)	Metabolism index (Mean difference)	Ref.
Wycherley 2010	16 weeks	83	Calorie-restricted diet Moderate energy	55±8.4	35.3±4.5	Fasting insulin (-3.5), TG (-62.02), TC (-19.33), LDL-C (-19.33)	[63]
Bajerska 2018	16 weeks	269	Mediterranean diet	/	/	HAMO-IR (0.04), TC (-20.60), LDL-C (-11.50), HDL-C (-2.00)	[64]
Greco 2014	4 months	130	Mediterranean diet	46-61	Average 37	HAMO-IR (-1.00)	[65]
Yazdanparast 2020	24 weeks	38	Energy-restricted diet	41.4	33.2±0.28	HDL-C (-4.84)	[66]
J. Brehm 2005	6 months	50	low-carbohydrate diet	40±5.9	31.67±4.64	Fasting glucose (-0.18), TG (-48.10)	[67]
Kozłowska 2018	8 weeks	22	a low-caloric diet	24±4	28.0±3.7	/	[68]
Rock 2016	12 months	68	Lower Fat Diet	20-38	24.3±2.5	Fasting insulin (-2.26)	[69]
Paoli 2020	12 weeks	14	ketogenic Mediterranean diet	/	28.84±2.10	TC (-24.74), LDL-C (-26.20), Fasting glucose (-0.46), HAMO-IR (-0.53), TG (-38.98)	[70]
Kim 2022	8 weeks	52	Korean diet	30-50	25-30	HDL-C (-3.50), fasting glucose (-0.04), fasting insulin (-0.72)	[71]
T. SHOJI 1991	4 weeks	6	low calorie diet	25-45	33.6-62.5	TC (-18.00), LDL-C (-13.00), HDL-C (-5.70)	[72]

Table 3. Risk of bias assessment

Authors	Random sequence generation	Allocation concealment	Blinding participants personnel	Blinding outcome assessors	Incomplete outcome data	Selective reporting	Other bias
Wycherley 2010	Low risk	Low risk	High risk	Unknown	Low risk	Low risk	Low risk
Bajerska 2018	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Unknown
Greco 2014	Low risk	Low risk	High risk	High risk	Low risk	Low risk	Low risk
Yazdanparast 2020	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Unknown
J. Brehm 2005	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk
Kozłowska 2018	Low risk	Unknown	High risk	High risk	Low risk	Low risk	Low risk
Rock 2016	Low risk	High risk	High risk	High risk	Low risk	Low risk	Low risk
Paoli 2020	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk
Nearmeen M. 2019	Low risk	Unknown	High risk	High risk	Low risk	Low risk	Low risk
Elena 2021	Low risk	Low risk	High risk	High risk	Low risk	Low risk	Low risk
Kim 2022	Low risk	High risk	High risk	High risk	Low risk	Low risk	Low risk
T. SHOJI 1991	Low risk	High risk	High risk	Low risk	Low risk	Low risk	Low risk

Characteristics of included studies

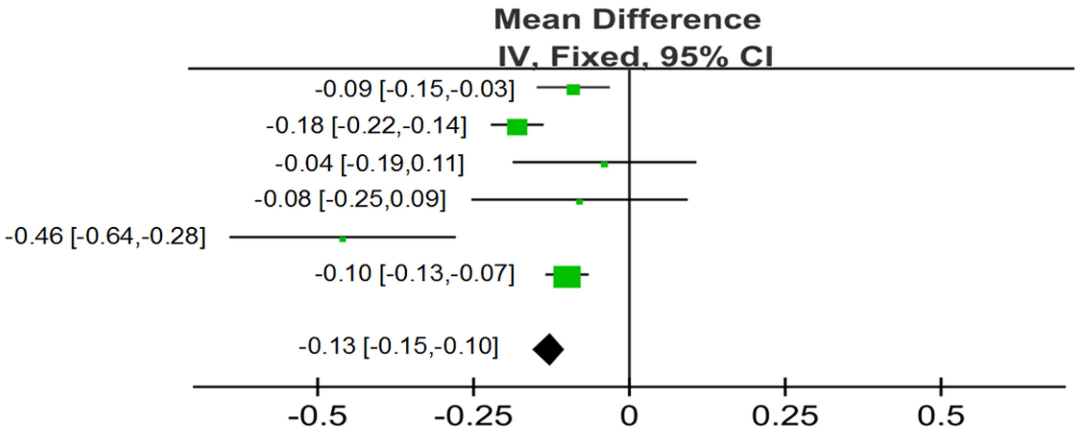
Most of the included literature adopted a non-blind method. The duration of dietary therapy was usually an average of 19 weeks, from 4 weeks to 24 weeks. Dietary interventions included a calorie-restricted diet, a Mediterranean diet, a low-carb diet, a low-fat diet, and a ketogenic diet. Three articles measured fasting blood glucose and fasting insulin. Six of them measured LDL-C, HDL-C, TG and TC. Five of them measured the value of HOMAIR. Details of the descriptions of the included studies are shown in **Table 2**.

Quality assessment and risk bias

The Cochrane tool was used for assessing risk of bias from seven perspectives, including random sequence generation, allocation concealment, blinding participants & personnel, blinding outcome assessors, incomplete outcome data and other bias [43]. The two researchers evaluated the literature independently. If there was a disagreement, it was decided by a third person. The details of quality assessment are shown in the **Table 3**.

Meta-analyses results

Glucose metabolism: Glucose metabolism is one of the most important metabolisms in the human body, and fasting glucose is a vital indicator that reflects the state of glucose metabolism. In order to measure the effect of dietary therapy on glucose metabolism in women, this study focused on changes in fasting blood glucose and fasting insulin. The results of meta-



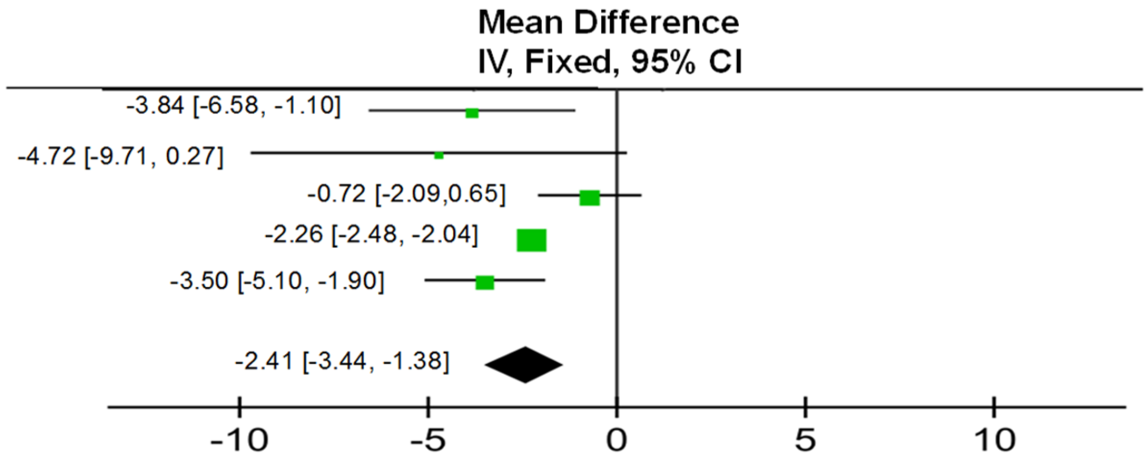
	Experimental		Control		Mean Difference
Study	Mean	SD	Mean	SD	IV, Fixed,95% CI
Baetge 2016	5.29	0.11	5.38	0.11	-0.09[-0.15, -0.03]
Brehm 2005	5.2	0.11	5.38	0.11	-0.18[-0.22, -0.14]
Kim 2022	5.2	0.05	5.24	0.38	-0.04[-0.19,0.11]
Nearmeen 2019	4.97	0.47	5.05	0.37	-0.08[-0.25,0.09]
Paoli 2020	4.64	0.24	5.1	0.25	-0.46[-0.64, -0.28]
Tanvig 2014	5.1	0.1	5.2	0.12	-0.10[-0.13, -0.07]
Total (95% CI)					-0.13[-0.15, -0.10]
Heterogeneity	Chi^2=24.43	df=5	p=0.0002		I^2=80%

Figure 2. Forest plot of changes in fasting glucose of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.

analysis demonstrated that the mean difference of fasting glucose of obese women before and after diet intervention was -0.13 and the 95% confidence interval was [-0.15, -0.10], respectively. The result of meta-analysis is statistically significant since the *p*-value is 0.0002. However, the I^2 is equal to 80% which indicated a high heterogeneity between included studies (**Figure 2**). It was estimated that different durations of the experiment and the different inclusion criteria of participants may lead to a high heterogeneity. Moreover, the mean difference of fasting insulin of obese women before and after diet intervention was -2.41 and the 95% confidence interval was [-3.44, -1.38]. The heterogeneity of included studies is moderate around 50% (**Figure 3**).

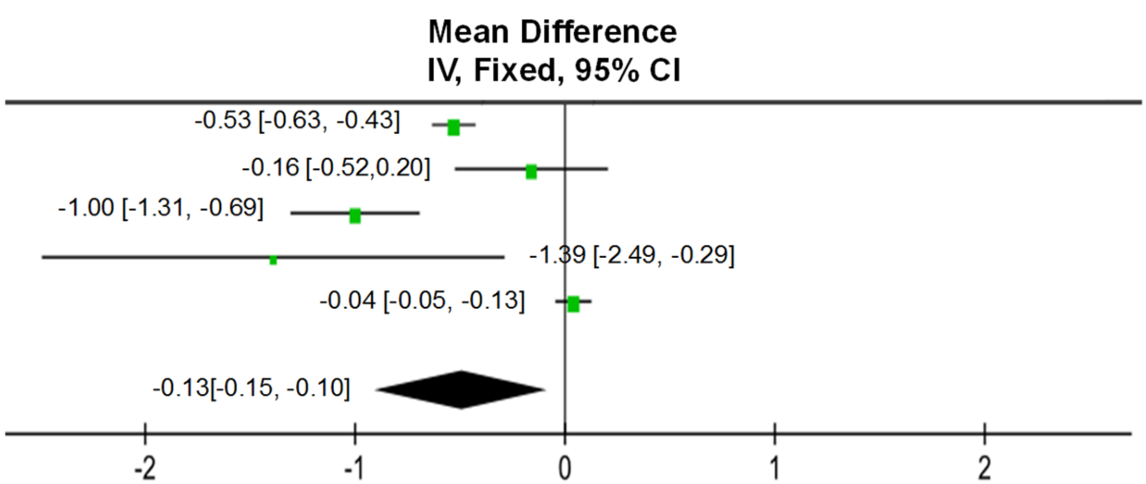
To further understand the association between dietary therapy and glucose metabolism, the indicator of HOMA-IR was recorded. HOMA-IR is an index used to evaluate the level of insulin resistance. Commonly, it is an essential index for clinical evaluation of insulin sensitivity, insulin resistance and pancreatic β-cell function. Generally, the higher the HOMA-IR value, the lower the sensitivity of the body to insulin and the more severe the insulin resistance [44]. Compared with the control group, the mean difference of HOMA-IR in the diet intervention group decreased (MD = -0.13, 95% CI = -0.15, -0.10), and the heterogeneity between studies was high (I^2 = 96%, P<0.0001) (**Figure 4**).

Lipid metabolism: Lipid metabolism is another important metabolic method in the human body, and abnormal lipid metabolism usually causes cardiovascular disease. It is believed that obese women have a higher possibility of abnormal lipid metabolism than normal-weight women [45]. Therefore, the changes of lipid metabolism indexes such as TG, TC, LDL, and HDL were observed in this paper. After diet intervention, TG levels were significantly de-



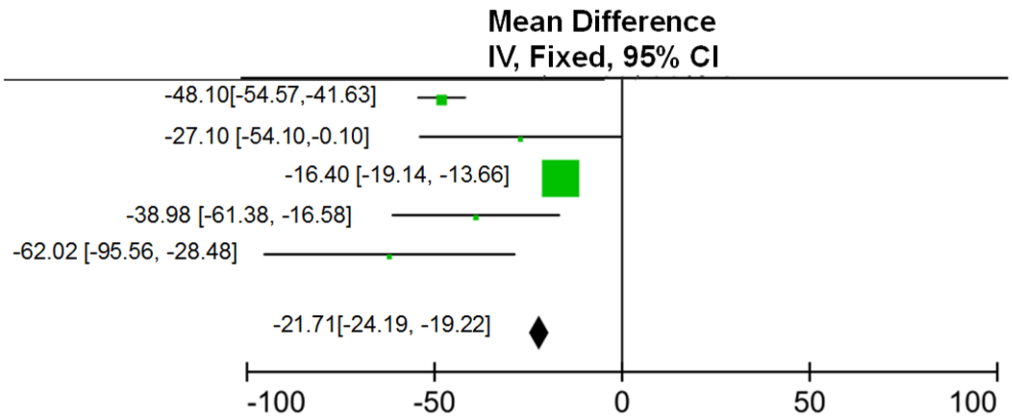
	Experimental		Control		Mean Difference
Study	Mean	SD	Mean	SD	IV, Fixed,95% CI
Baetge 2016	9.24	4.78	13.08	5.44	-3.84 [-6.58, -1.10]
Elena 2021	7.93	6.1	12.65	7.31	-4.72 [-9.71, 0.27]
Kim 2022	7.24	0.48	7.96	3.53	-0.72 [-2.09,0.65]
Rock 2016	12.24	0.8	14.5	0.5	-2.26 [-2.48, -2.04]
Wycherle 2010	8.8	3.4	12.3	4.8	-3.50 [-5.10, -1.90]
Total (95% CI)					-2.41 [-3.44, -1.38]
Heterogeneity	Chi^2=9.38	df=4	p=0.05		I^2=57%

Figure 3. Forest plot of changes in fasting insulin of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.



	Experimental		Control		Mean Difference
Study	Mean	SD	Mean	SD	IV, Fixed,95% CI
Paoli 2020	2.32	0.13	2.85	0.15	-0.53 [-0.63, -0.43]
Kim 2022	1.71	0.13	1.87	0.94	-0.16 [-0.52,0.20]
Greco 2014	3	0.8	4	0.8	-1.00 [-1.31, -0.69]
Elena 2021	1.78	1.82	3.17	2.62	-1.39 [-2.49, -0.29]
Bajerska 2018	1.48	0.22	1.44	0.28	0.04 [-0.05, -0.13]
Total (95% CI)					-0.13[-0.15, -0.10]
Heterogeneity	Chi^2=98.07	df=4	P<0.00001		I^2=96%

Figure 4. Forest plot of changes in HAMO-IR of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.



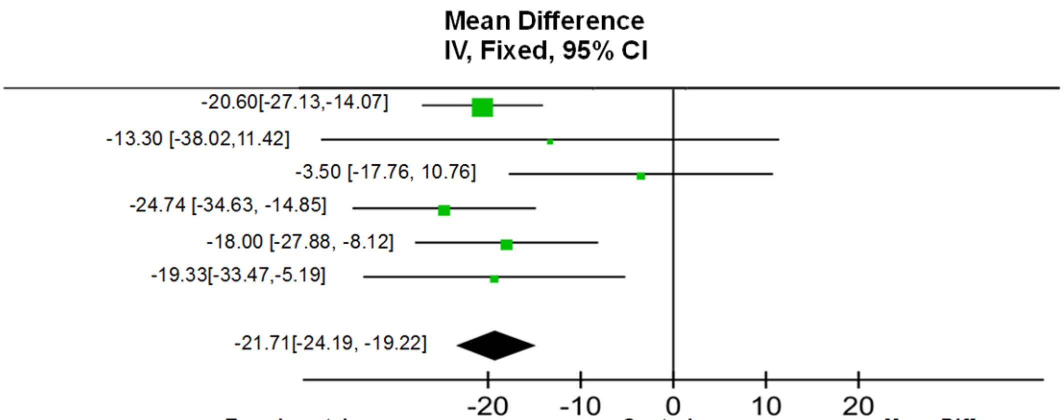
	Experimental		Control		Mean Difference
Study	Mean	SD	Mean	SD	IV, Fixed,95% CI
Brehm 2005	80.75	6.11	128.85	13.44	-48.10 [-54.57,-41.63]
Elena 2021	77.6	31.1	104.7	41.1	-27.10 [-54.10,-0.10]
Kim 2022	76.8	5.6	93.2	4.4	-16.40 [-19.14, -13.66]
Paoli 2020	165.68	23.92	204.66	35.44	-38.98 [-61.38, -16.58]
Wycherle 2010	141.76	44.3	203.78	115.18	-62.02 [-95.56, -28.48]
Total (95% CI)					-21.71 [-24.19, -19.22]
Heterogeneity	Chi^2=86.34	df=4	P<0.00001		I^2=95%

Figure 5. Forest plot of changes in TG of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.

creased and the mean difference of TG is -21.71 [-24.19, -19.22] (**Figure 5**). Similarly, the mean difference of TC was -21.71 [-24.19, -19.22] and it is statically significant (P< 0.0001) (**Figure 6**). Low-density lipoprotein is the main carrier for transporting endogenous cholesterol, and high concentration of LDL-C is an independent risk factor for atherosclerosis [46]. After diet therapy, obese women had a significant improvement in LDL-C levels, with a mean difference of -13.29 [-17.86, -8.72]. The heterogeneity of included studies was proven to be relatively low (**Figure 7**). HDL-C is an anti-atherosclerotic plasma lipoprotein, and the content of HDL-C is significantly negatively correlated with the degree of arterial lumen stenosis [47]. This study found that dietary therapy significantly increased the level of HDL with a mean difference of 3.31 [2.22, 4.40] (**Figure 8**).

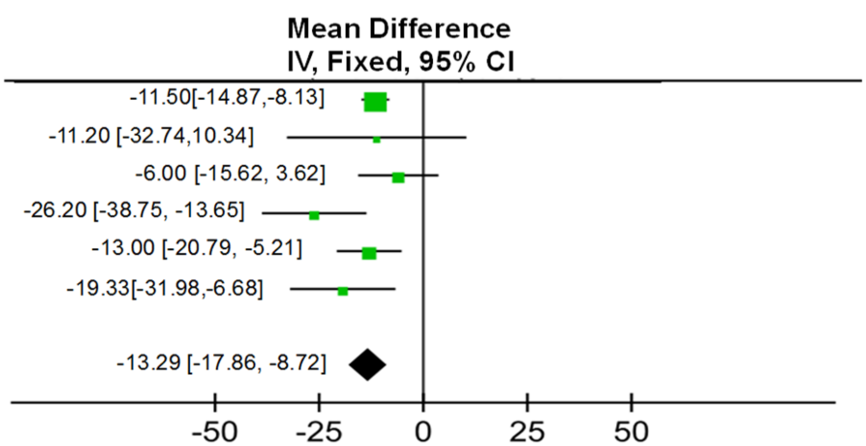
Discussion

In this study, four major databases, including PubMed, Web of Science, Embase and Google Academic, were searched electronically. A total of 51 relevant pieces of literature were found, but only 12 articles were included in the meta-analysis, accounting for about 24% of the total literature review. Due to the numerous and stringent inclusion and exclusion criteria in this analysis, the age range of overweight and obese women was not restricted in this paper in order to avoid too few references being included. In addition, literature with other diseases (except obesity) of about 13.49% were excluded, in order to avoid the influence of diseases other than obesity, such as diabetes, hyperlipidemia and coronary heart disease on the results of meta-analysis.



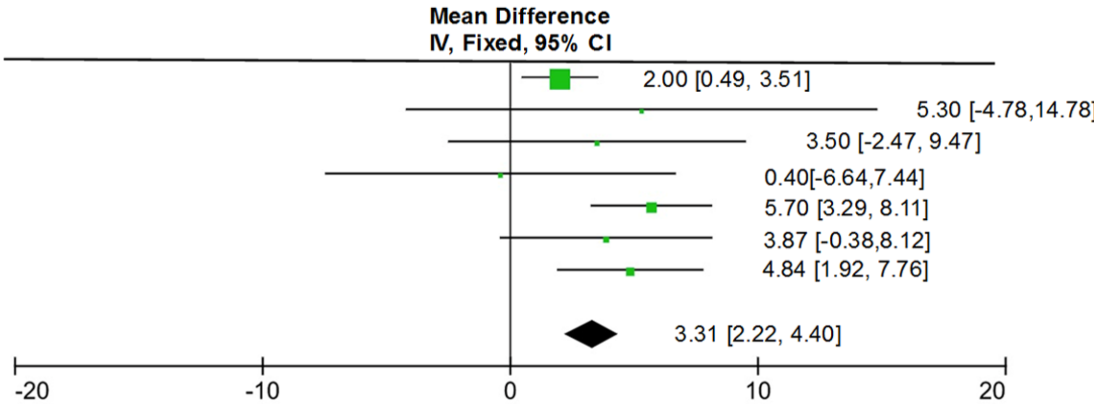
	Experimental		Control		Mean Difference
Study	Mean	SD	Mean	SD	IV, Fixed,95% CI
Bajerska 2018	215.2	18	235.8	20	-20.60[-27.13,-14.07]
Elena 2021	209.7	28.4	223	37.7	-13.30 [-38.02,11.42]
Nearmeen M 2019	181.4	24.83	184.9	11.18	-3.50 [-17.76, 10.76]
Paoli 2020	182.48	12.76	207.22	13.92	-24.74 [-34.63, -14.85]
T.SHOJI 1991	171	16	189	10	-18.00 [-27.88, -8.12]
Wycherle 2010	166.24	34.79	185.57	38.66	-19.33[-33.47,-5.19]
Total (95% CI)					-21.71[-24.19, -19.22]
Heterogeneity	Chi^2=6.31	df=5	P<0.00001		I^2=21%

Figure 6. Forest plot of changes in TC of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.



	Experimental		Control		Mean Difference
Study	Mean	SD	Mean	SD	IV, Fixed,95% CI
Bajerska 2018	138.2	9.8	149.7	9.8	-11.50[-14.87,-8.13]
Elena 2021	132.8	23.7	144	33.6	-11.20 [-32.74,10.34]
Nearmeen M 2019	88.3	3.41	94.3	24.8	-6.00 [-15.62, 3.62]
Paoli 2020	103.5	19.6	129.7	13.77	-26.20 [-38.75, -13.65]
T.SHOJI 1991	117	11	130	10	-13.00 [-20.79, -5.21]
Wycherle 2010	73.45	34.79	92.78	30.93	-19.33[-31.98,-6.68]
Total (95% CI)					-13.29 [-17.86, -8.72]
Heterogeneity	Chi^2=7.80	df=5	P=0.17		I^2=36%

Figure 7. Forest plot of changes in LDL-C of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.



Experimental Study	Mean	SD	Control Mean	SD	Mean Difference IV, Fixed,95% CI
Bajerska 2018	53.1	5.3	51.1	4.4	2.00 [0.49, 3.51]
Elena 2021	58	12.9	52.7	12.7	5.30 [-4.78,14.78]
Kim 2022	54.8	1.55	51.3	11.3	3.50 [-2.47, 9.47]
Nearmeen M 2019	37.2	5.68	36.8	4.4	0.40[-6.64,7.44]
T.SHOJI 1991	42.6	4.1	36.9	2.1	5.70 [3.29, 8.11]
Tanvig 2014	50.26	15.46	46.39	11.59	3.87 [-0.38,8.12]
Yazdanparast 2021	48.27	4.22	53.11	4.96	4.84 [1.92, 7.76]
Total (95% CI)					3.31 [2.22, 4.40]
Heterogeneity	Chi^2=9.36	df=6	P=0.17		I^2=33%

Figure 8. Forest plot of changes in HDL-C of obese women before and after diet intervention. SD = Standard Deviation; df = degrees of freedom; I^2<25% = low heterogeneity between studies; I^2>50% = median heterogeneity between studies; I^2>75% = high heterogeneity between studies; *p*-value <0.05 means statistically significance; The square represents the point estimate of the intervention effect; Diamonds represent the subgroup mean difference and pooled mean differences.

Diet intervention is one of the important ways for obese women to control their weight. According to the European Adult Obesity Management Guidelines, diet management is the A-level recommended method of weight control [48]. Similarly, this study found that dietary intervention had a significant effect on changes in fasting insulin, fasting glucose and HOMA-IR changes in women, and the results of meta-analysis indicated that the mean difference before and after dietary interventions was -.013, -2.41, -0.13, respectively. Importantly, fasting insulin, fasting glucose and HOMA-IR are metabolic indicators that obese women need to pay attention to. A growing body of literature strongly suggest that insulin resistance is a potential problem in obese women [19, 42]. Generally, insulin resistance refers to a condition in which normal doses of insulin produce less than normal biological effects due to a decreased sensitivity to the effects of insulin on the target organ [49, 50]. For obese people, insulin resistance is most likely to lead to abdominal obesity, which is a typical symptom of insulin resistance. Therefore, it is necessary to improve insulin resistance in the process of losing weight [51, 52]. As soon as the symptoms of insulin resistance are lifted, the body's metabolism of sugar will return to normal, without converting too much polysaccharides into fat [23, 52].

Meanwhile, our study found that dietary intervention also had a positive effect on other indicators, such as TG, TC, LDL-C and HDL-C, and dietary intervention improved these results to varying degrees. However, there was no significant effect on the reduction of HDL, LDL and TG, and the final results were highly heterogeneous. Studies have shown that the final results may be biased due to the heterogeneity of methodology. For instance, it is unclear whether the inclusion criteria are similar or whether the intervention time interval is reasonable, and it is unknown whether the withdrawal cases are explained. Therefore, from the perspective of methodological heterogeneity, the intervention time of the 7 included studies was significantly different, ranging from 4 weeks to 52 weeks. The participants ranged in age from 24 to 61 years old. Besides, the included studies compared different dietary interventions, such as calorie-restricted diets and Mediterranean diets, which may also account for the high heterogeneity resulting from the final results. Therefore, future studies should explore the effects of specific interventions (dietary pattern, BMI, duration) to better understand the best interventions.

To the end, although studies have shown that dietary therapy can improve metabolic-related indicators such as LDL in the short term [53, 54], there are few studies investigating cardiovascular events and bone metabolism [55, 56]. Therefore, some large-scale studies are required to conduct and explore the association between dietary therapy and other indicators. In addition, adherence to dietary therapy and long-term efficacy are still a big concern. Therefore, there is still a need to use other measures to maintain compliance of participants in future research.

A number of mechanisms have been proposed to explain the effect of dietary therapy on metabolism, such as enhancing mitochondrial biosynthesis [53] and reducing the formation of reactive oxygen species [57, 58]. However, there is no fundamental mechanisms that can explain the different therapeutic effects of various dietary therapies for different diseases. Moreover, it is not clear whether there are drugs that mimic the effects of dietary therapy. Existing studies have confirmed that some new compounds, such as 2-deoxyglucose and hydroxybutyric acid, can mimic the effects of a ketogenic diet to some extent [59, 60]. However, there is the question of whether these compounds can be used in patients to replace KD therapy through layer upon layer and clinical validation?

Strength and limitation of the study

Current systematic reviews and meta-analysis have shown the association between dietary intervention and metabolic indicators in obese women and emphasized the necessity of dietary intervention for obese women to improve islet resistance and other metabolic indicators. However, there are some limitations in this study. The authenticity and reliability of the research results may be affected by confounding factors, such as exercise intervention programs, mainly reflected in the following aspects: (1) The literature included in this study was only published in English. The comprehensiveness of the study had certain limitations. (2) The included literature did not mention the hidden method of random allocation. The blind method was not clearly implemented by subjects, researchers and outcome evaluators, and only a few studies mentioned it.

Conclusion

The current systematic review reports that different types of dietary intervention are associated with beneficial changes in insulin outcomes in obese women in terms of improving metabolism. Dietary interventions have been shown to be significantly effective in improving metabolic markers and weight loss [15, 61, 62]. However, due to the high degree of heterogeneity of meta-analysis, we recommend that large-scale RCT experiments should be performed on specific diet therapies in the future. At the same time, we recommend regular dietary interventions for obese women to improve their metabolic index.

Disclosure of conflict of interest

None.

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