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The effect of beinaglutide as an glucagon-like peptide-1 receptor agonists on cardiometabolic factors: a systematic review and meta-analysis

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Abstract

Background Considering the important role of cardiometabolic risk factors in different societies on increasing the burden of non-communicable diseases, in this study we will investigate the possible effects of Beinaglutide as an glucagon-like peptide-1 receptor agonists (GLP-1RAs) on these risk factors.

Methods In order to identify all randomized controlled trials that investigated the effects of Beinaglutide on cardiometabolic factors, a systematic search was conducted in the original databases using predefined keywords until July 2024. The pooled weighted mean difference and 95% confidence intervals were computed using the random-effects model.

Results A quantitative meta-analysis results from 7 studies with 872 participants showed that Beinaglutide has a significant lowering effect on weight (WMD: -3.74 kg; 95% CI: -5.03, -2.45), body mass index (BMI) (WMD:-1.64 kg/m^2; 95% CI: -2.10, -1.17), waist circumference (WC) (WMD: -3.19 cm; 95% CI: -4.65 to -1.73), triglycerid (TG) levels (WMD: -0.14 mmol/l with; 95% CI: -0.25, -0.04), and systolic blood pressure (SBP) (WMD: -1.76 mm/Hg; 95% CI: -2.61, -0.91). Furthermore, the results obtain from subgroup analysis showed a greater effect of Beinaglutide on the reduction of weight and TG during the intervention of more than 12 weeks. In addition, body weight loss was greater in doses less than 0.4 mg compared to doses greater than or equal to 0.4 mg.

Conclusions The results of this meta-analysis show that Beinaglutide is effective in reducing factors related to obesity, TG as wll as SBP, especially with longer interventions and lower doses.

Keywords Beinaglutide, GLP-1 agonist, Obesity, Cardiometabolic, Meta-analysis

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Introduction

Cardiometabolic risk has been defined as a cluster of metabolic and cardiovascular abnormalities, including excess weight and abdominal obesity, insulin resistance, hypertension, dyslipidemia and atherosclerosis, that predispose individuals to cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) and future cardiovascular events such as ischemic heart disease, myocardial infarction, and valvular disease [1, 2]. These factors are best identified by primary care providers, as most patients will present at an early stage with no symptoms [3]. Effective management of these conditions is crucial for improving patient outcomes and reducing the burden on healthcare systems [4].

Strong evidence has been established that excess weight included overweight and obesity increase the risk of major noncommunicable diseases including cardiovascular disease, T2DM, and cancer, which are associated with premature death and disability [5, 6]. Studies have confirmed that maintaining a stable healthy weight and losing weight in early adulthood and midlife are important for better life quality during the aging process [7].

In recent years, glucagon-like peptide-1 receptor agonists (GLP-1RAs) have emerged as promising therapeutic agents for managing cardiovascular risk factors in individuals with T2DM [8, 9]. Beinaglutide, a novel GLP-1RA, has garnered attention for its potential to improve cardiometabolic parameters by modulating glucose metabolism, reducing body weight, and exerting favorable effects on blood pressure and lipid profiles [10, 11]. It is an approved treatment for T2DM according to the Chinese Guideline for the Prevention and Treatment of T2DM [12]. Despite its growing use in clinical practice, the overall efficacy and safety of Beinaglutide in cardiometabolic management remain to be comprehensively evaluated through high-quality evidence synthesis [11].

This systematic review and meta-analysis aims to critically assess the effect of Beinaglutide on cardiometabolic factors, including glycemic control, body weight, blood pressure, lipid levels, and cardiovascular outcomes. By analyzing data from randomized controlled trials (RCTs), this study seeks to provide a robust summary of the therapeutic potential of Beinaglutide and its implications for managing cardiometabolic disorders.

Methods

Search strategy

This systematic review and meta-analysis was conducted without any time or language restrictions, following the writing of Preferred Reporting Criteria for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [13]. A comprehensive search strategy was completed by March 2024, encompassing major databases including PubMed/MEDLINE, Web of Science, Scopus, and Embase. This search strategy incorporated the medical subject headings (MeSH) and Emtree (Embase subject title) and included the following search terms:: (Beinaglutide OR glucagon-like peptide 1) AND ("Clinical Trials as Topic" OR "Cross-Over" OR "Double-Blind" OR "Single-Blind " OR "Random Allocation" OR "Clinical Trial"). To ensure comprehensive coverage, we also manually reviewed reference lists from relevant studies, meta-analyses, and review articles.

Eligibility criteria

To determine eligibility, two authors independently reviewed the studies, removing duplicates and evaluating each base of Population, Intervention, Comparison, Outcomes and Study design (PICOS) criteria.The following criteria were used: (1) The study population includes all healthy or unhealthy individuals with an age greater than or equal to 18 years; (2) The investigated intervention was also limited to the prescription of Beinaglutide; (3) The individulas who used a lifstyle intervention or a placebo were also considered as the control group; (4) Glucose metabolism (Fasting Blood Sugar [FBS], Homeostatic Model Assessment for Insulin Resistance [HOMA-IR], and HbA1c), anthropometry data (weight, body mass index [BMI], waist circumference [WC]), lipid profiles (Low-density lipoprotein [LDL] and high-density lipoprotein [HDL] cholesterol, triglycerid [TG], and total cholesterol [TC]), and blood pressure (systolic blood pressure [SBP] and diastolic blood pressure [DBP]) variables were evaluated as outcomes of this study; (5) Finally, the included studies were designed as a randomized, controlled clinical trial.

Additionally, studies were eligible if the intervention lasted at least 2 weeks and provided baseline and post-intervention data on FBS, HOMA-IR, HbA1c, weight, BMI, WC, LDL and HDL cholesterol, TG, TC, SBP, and DBP. In cases with multiple follow-up periods, only data from the final follow-up were analyzed. Studies involving animals, those with repeated data, those without control groups, and systematic reviews or meta-analyses were excluded from the analysis.

EndNote software was utilized for efficient management of eligible articles and removal of duplicates.

Data extraction

To systematically review and analyze the data, two authors independently extracted the relevant details from the eligible studies, including the first author´s name, year of publication, sample size for both the intervention and control groups, mean age, body mass index of the participants, the study population, details of the interventions for both groups, and the mean and standard deviation (S.D.) of the investigated outcomes at baseline

and at the last follow-up (or the changes between baseline and post-intervention).

Quality assessment

The methodological quality of the trials was evaluated using the most recent version of the Cochrane risk-of-bias tool for randomized trials (RoB 2) [14]. Several potential sources of bias were examined and ranked by the study's authors including incomplete outcome data, selective reporting, participant and staff blinding, allocation concealment, blinding of volunteers and researchers, and random sequence generation. Each study was assessed by two authors, who independently determined the level of bias, classifying it as low, high, or unclear. A third author was consulted to resolve any disagreements, ensuring consensus. The quality of this systematic review and meta-analysis was further evaluated using the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) system. The GRADE checklist, a 10-point grading system, assesses various factors affecting study quality across seven distinct domains: [1] risk of bias [2], precision [3], heterogeneity [4], directness [5], publication bias [6], funding bias, and [7] study design [32].

Data synthesis and statistical analysis

Data analysis was performed using software STATA version 12.0. Means and standard deviations (S.D.s) were calculated using a predefined method [15, 16]. In the absence of standard deviations, the following technique was used to determine the amount of the change: To find the formula for the change in standard deviation, we first take the square root of the difference between the sum of the squares of the baseline and final standard deviations, then subtract twice the product of the baseline and final standard deviation correlation coefficients, and finally, we add the absolute values of the standard deviations to get the final SD. This formula was also used to derive the standard deviation from the standard error of the mean (SEM): multiplying SEM by the square root of the sample size (n) for each group provided the S.D. Meta-analysis of the study results was conducted using a random-effects model, applying the inverse variance method. This approach allowed for the integration of multiple time points into a single study cohort. Heterogeneity was assessed using Q statistics and I-squared (I^2) values, with heterogeneity classified as low, moderate, or high based on I^2 values ranging from 0 to 25%, 26–50%, 51–75%, and 76–100%. In STATA, the T-test is performed using the ttest command; for an independent sample T-test, the syntax is ttest var1, by(group), where var1, var2, and group represent the respective variables. Subgroup analysis was used to investigate potential sources of heterogeneity, such as the dosage of Beinaglutide, baseline of BMI, and the duration of the intervention. Sensitivity analysis was conducted to determine the influence of each study on the overall mean difference. Publication bias was assessed using Egger's test, a widely recognized statistical method.

Results

The flow diagram of the study, including identification, screening, eligibility and the final sample, is presented in Fig. 1. After an exhaustive search of the main databases as described in the methodology, 58 publications were entered into the Endnote software. Of these, 12 studies were removed due to duplication, leaving 46 studies for evaluation and screening. After the initial evaluation, which included assessing titles, abstracts, and eligibility based on inclusion and exclusion criteria, 34 studies were excluded, and 12 studies were identified for futher full-text evaluation. Of these 12 studies, 5 studies were excluded for various reasons detailed in Fig. 1, and 7 studies were ultimately included in the meta-analysis for systematic review and data analysis.

Study characteristics

The characteristics of the aggregated studies are summarized in Table 1. As shown, all seven studies reviewed in this meta-analysis were conducted in Asia and China, all using the parallel design. These studies were publicated between 2021 and 2023, with follow-up interventions varied from 8 to 24 weeks.The participants baseline characteristics showed that the average age ranged from 30 to 52.6 years, with the proportion of male participants varying between 0 and 72.25%. The mean baseline BMI across the studies ranged from 24.71 to 33.3. The dosages of the investigated drug varied from 0.3 to 0.6 and in two studies the drug was investigated alone and in other studies it was combined with metformin or lifestyle changes. The studied population in 4 studies included obese or overweight people, and in 3 studies it was done on diabetic people.

Table 2 displays the results of the assessment conducted to evaluate the quality of the eligible studies. Moreover, the quality of the present meta-analysis was evaluated using the GRADE score method, resulting in a grade of 9.5, indicating a very good level of quality (Supplementary Table 2).

Meta-analysis

Glucose metabolism results

The findings obtained from the meta-analysis showed that Beinaglutide has no significant effect on any of the glucose metabolism factors including FBS (WMD: 0.19 mmol/l $P<0.001$; 95% CI: -0.14, 0.51; $p<0.001$; $I^2=94.2\%$), HbA1c(WMD:0.07% with Pvalue $P<0.001$; 95% CI: -0.14, 0.27; $p<0.001$; $I^2=67.2\%$), and HOMA-IR

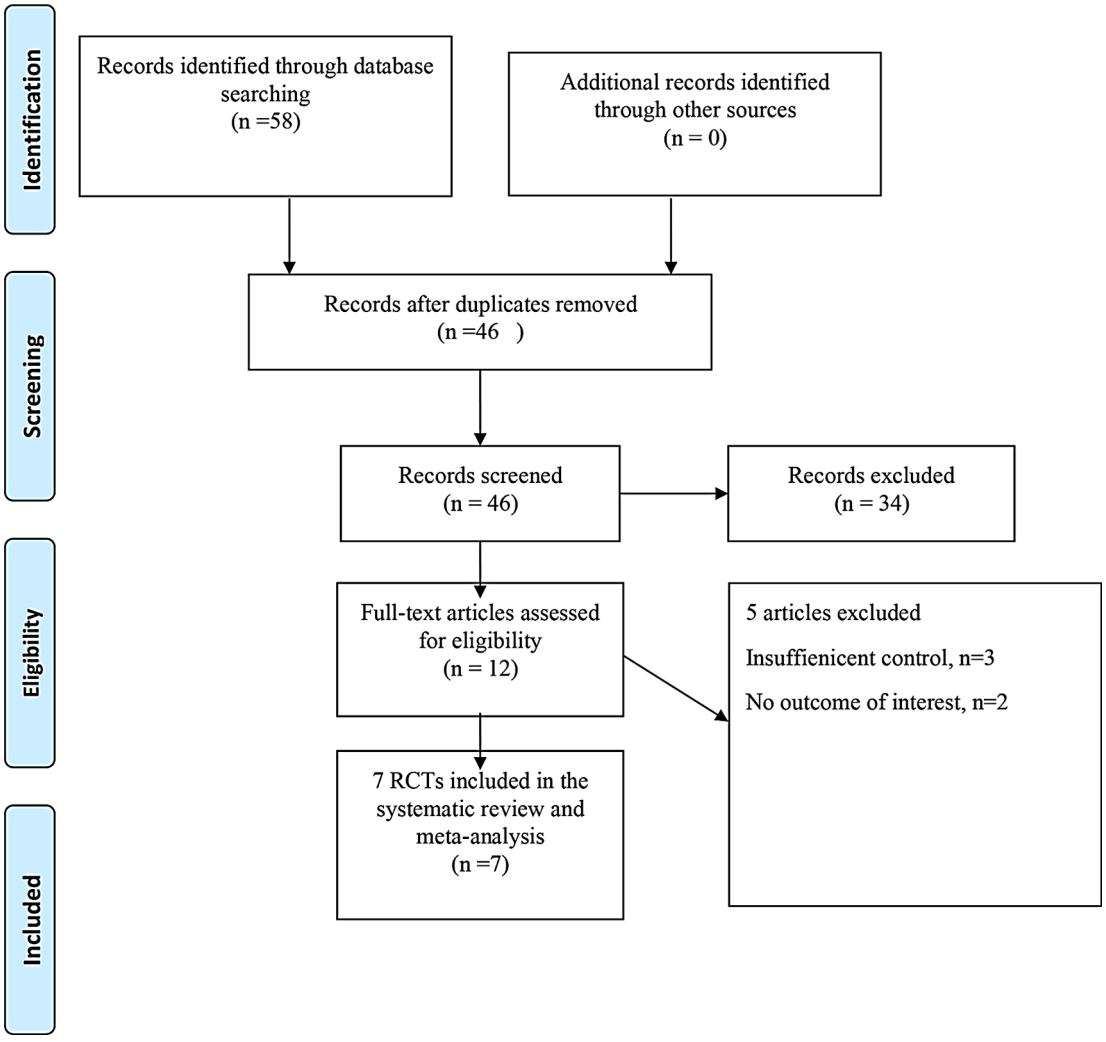


Fig. 1 Flow chart of study selection process

(WMD:-0.90 with Pvalue $P<0.001$; 95% CI: -2.28, 0.48; $p<0.001$; $I^2=96.4\%$)(Fig. 2).

Anthropometric measurements and indicators

A quantitative meta-analysis showed that Beinaglutide has a significant lowering effect on weight (WMD: -3.74 kg with Pvalue $P<0.001$; 95% CI: -5.03, -2.45; $p<0.001$; $I^2=86.6\%$), BMI (WMD:-1.64 kg/m^2 $P<0.001$; 95% CI: -2.10, -1.17; $P=0.120$; $I^2=45.4\%$), and WC (WMD: -3.19 cm $P<0.001$; 95% CI: -4.65 to -1.73; $p<0.001$; $I^2=82.6\%$) (Fig. 3).

Lipid profiles and blood pressure findings

In addition, no significant effect on LDL-C (WMD:-0.17 mmol/l $P=1.00$; 95% CI: -0.38, 0.03; $p<0.001$; $I^2=91.2\%$), HDL-C (WMD:0.01 mmol/l with $P=0.851$; 95% CI: -0.07, 0.08; $p=0.009$; $I^2=67.2\%$), and TC (WMD: 0.00 mmol/l with $P=0.261$; 95% CI: -0.25, 0.26; $p<0.001$; $I^2=94.4\%$) as well as DBP (WMD: -1.53 mm/Hg $P=0.152$; 95% CI: -3.61, 0.56; $p<0.001$; $I^2=90.1\%$) was reported following the intervention with a Beinaglutide. However, based on the findings, the Beinaglutide caused a significant decrease in TG levels (WMD: -0.14 mmol/l with $P=0.010$; 95% CI: -0.25, -0.04; $p=0.015$; $I^2=64.7\%$) and SBP (WMD: -1.76 mm/Hg $P<0.001$; 95% CI: -2.61, -0.91; $p=0.320$; $I^2=14.4\%$) (Fig. 4).

Subgroups analysis

The stratified analysis based on the dosage of Beinaglutide, baseline of BMI, and the duration of the intervention showed a greater effect of Beinaglutide on the reduction of weight and TG during the intervention of more than 12 weeks. In addition, body weight loss was greater in doses less than 0.4 mg compared to doses greater than or equal to 0.4 mg. However, for other variables, no significant differences were observed between subgroup analyses. It also seems that the baseline level of BMI as well as the length of the intervention period is a possible

Table 1 Characteristics of eligible studies

First author et al.	Years	Country	Population	Mean Age year	Sex (Male %)	Sample Size Study		Follow up of intervention (Weeks)	Type of RCTs	Intervention group	Control group	Baseline of BMI (kg/m^2)
						Intervention	Control					
1. **Wu**	*2022*	*China*	*Obese Patients*	*30*	*51.1*	*25*	*57*	*12*	*Parallel*	*Lifestyle modification (LM) + beinaglutide (0.4 mg per day)*	*Lifestyle modification (LM)*	*33.3*
2. **Gao**	*2021*	*China*	*Overweight and Obese Non-diabetic Patients*	*32.5*	*46.8*	*32*	*32*	*12*	*Parallel*	*0.2 mg beinaglutide (three times per day) + 1.5 gr Metformin*	*1.5 gr Metformin*	*32.3*
3. **Chen**	*2023*	*China*	*Overweight or obesity*	*35.3*	*47.85*	*282*	*138*	*16*	*Parallel*	*0.2 mg beinaglutide (three times per day)*	*Placebo*	*31.74*
4. **Wen**	*2023*	*China*	*Obese patients with polycystic ovary syndrome(PCOS)*	*26.75*	*0*	*30*	*30*	*12*	*Parallel*	*0.2 mg beinaglutide (three times per day) + 1.5 gr Metformin*	*1.7 gr Metformin*	*28.65*
5. **Han**	*2023*	*China*	*Patients with type 2 diabetes (T2D)*	*52.1*	*NA*	*67*	*67*	*24*	*Parallel*	*Beinaglutide is 0.1 mg three times daily + metformin*	*Metformin*	*27.08*
6. **Liu**	*2023*	*China*	*Patients with type 2 diabetes (T2D)*	*52.6*	*72.25*	*35*	*33*	*8*	*Parallel*	*Beinaglutide is 0.1 mg three times daily*	*Insulin glargine*	*24.71*
7. **Fan**	*2023*	*China*	*Type 2 diabetes patients with nonalcoholic fatty liver disease*	*47.2*	*56*	*21*	*23*	*24*	*Parallel*	*Lifestyle intervention + beinaglutide (0.3 mg per day)*	*Lifestyle intervention*	*30.5*

BMI: body mass index

source of high heterogeneity for most of the investigated parameters except anthropometric factors (Supplementary Table 1).

Sensitivity analysis

The leave-one-out method was applied to assess the influence of each individual study on the pooled effect size. The findings remained robust after sequential elimination of studies (Supplemental Figs. 1–3).

Publication bias

The visual inspection of funnel plot revealed no evidence of publication bias regarding the impacts of Beinaglutide on outcome measures. Additionally, the results of Egger's regression test supported the absence of significant publication bias for weight ($p = 0.652$), BMI ($p = 1.00$), WC ($p = 0.881$), LDL-C ($p = 0.851$), HDL-C ($p = 0.573$), TC ($p = 0.896$), TG($p = 0.348$), FBS($p = 0.293$), HbA1c ($p = 0.327$), HOMA-IR ($p = 0.602$), SBP($p = 0.497$), and DBP($p = 0.497$) (Supplemental Figs. 4–6). Meta trim-and-fill analysis did not find the article.

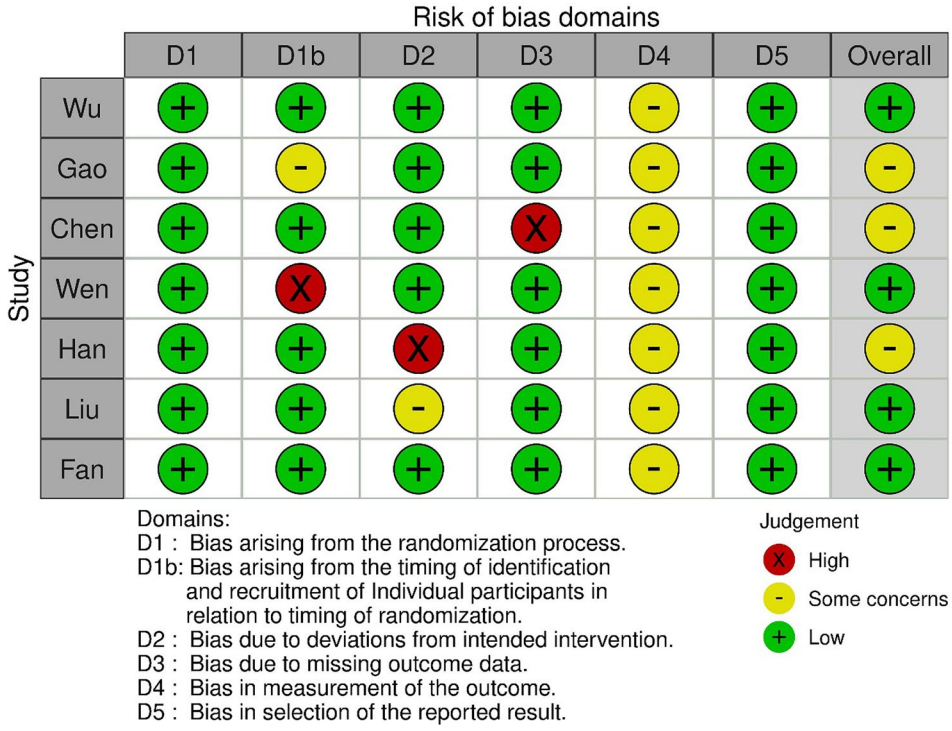
Discussion

The results of the meta-analysis show that Beinaglutide does not have a significant effect on factors related to glucose metabolism, such as fasting blood sugar (FBS), glycated hemoglobin (HbA1c) and HOMA-IR. This suggests that, despite its pharmacological action, Beinaglutide may not be effective in directly improving these glycemic parameters. The high heterogeneity (I^2) indicates significant variability between the included studies, suggesting that factors such as the study population or methodology may have influenced the results. This finding is crucial in highlighting that, despite expectations about the drug's effect on glycemic control, it may not be effective for all patient profiles [17].

On the other hand, the meta-analysis showed that Beinaglutide had a significant effect on reducing body weight, BMI and WC. The reduction in weight was approximately 3.74 kg, which is clinically relevant, especially in obese or overweight individuals [18]. These results indicate an important potential of Beinaglutide in weight management, which may in turn contribute to improved general health and associated comorbidities such as cardiovascular disease [5]. Progressive body weight loss with beinaglutide treatment results from food intake reduction consequent to GLP-1 activation [19]in the hypothalamic and gastric pathways, leading to suppressed appetite and delayed gastric emptying [20, 21]. The lower heterogeneity for BMI (I^2 = 45.4%) suggests greater consistency in the studies that evaluated this variable, compared to other parameters.

With regard to lipid profiles and blood pressure, the results show that Beinaglutide had no significant effects

Table 2 Risk of bias assessment according to the Cochrane collaboration's risk of bias assessment tool



on LDL cholesterol, HDL cholesterol or total cholesterol. However, there was a significant reduction in triglyceride (TG) levels and systolic blood pressure (SBP). Although the effects on the lipid profile are limited, the reduction in triglycerides is relevant [22], since high TG levels are associated with greater cardiovascular risk [23]. The reduction in systolic blood pressure may also indicate an indirect benefit in preventing cardiovascular events, especially in individuals with mild hypertension. The stratified analysis showed that the efficacy of Beinaglutide in reducing weight and triglycerides was greater in interventions lasting longer than 12 weeks and at doses lower than 0.4 mg. This suggests that the response to treatment may be time- and dose-dependent, which may guide clinical practice in terms of optimizing therapy. The fact that there were no significant differences for other parameters suggests that the drug has a narrower efficacy profile. It is important to note that for all parameters without statistical significance, coupled methods of lifestyle change are effective [24], such as the inclusion of a proper and healthy diet, physical exercise, sleep monitoring and attention to mental health [25–28]. Prolonged treatment allows gradual physiological adaptation, maintaining receptor responsiveness and minimizing tolerance. Extended exposure enhances lipid metabolism, improves insulin sensitivity, and recalibrates appetite-regulating hormones like leptin and ghrelin, promoting sustained weight loss and metabolic benefits. Additionally, lower doses reduce adverse effects, improving patient adherence over time. This approach may balance efficacy and safety, but further research is needed to confirm its mechanisms and practical applicability.

Studies comparing Beinaglutide with other interventions highlight its notable efficacy in glycemic control, weight reduction, and lipid profile improvement. The BMJ (2024) study [29] on GLP-1 receptor agonists demonstrated that this class, including Beinaglutide, effectively improves these parameters, with Beinaglutide showing particular promise for weight loss. In contrast, taurine was shown to reduce metabolic syndrome risk and improve cardiovascular outcomes [30, 31], focusing more on long-term cardiometabolic health rather than immediate weight or glucose control. Additionally, Capsicum annuum supplementation [32] modestly improved components of metabolic syndrome but lacked the robust glycemic and weight-reduction effects seen

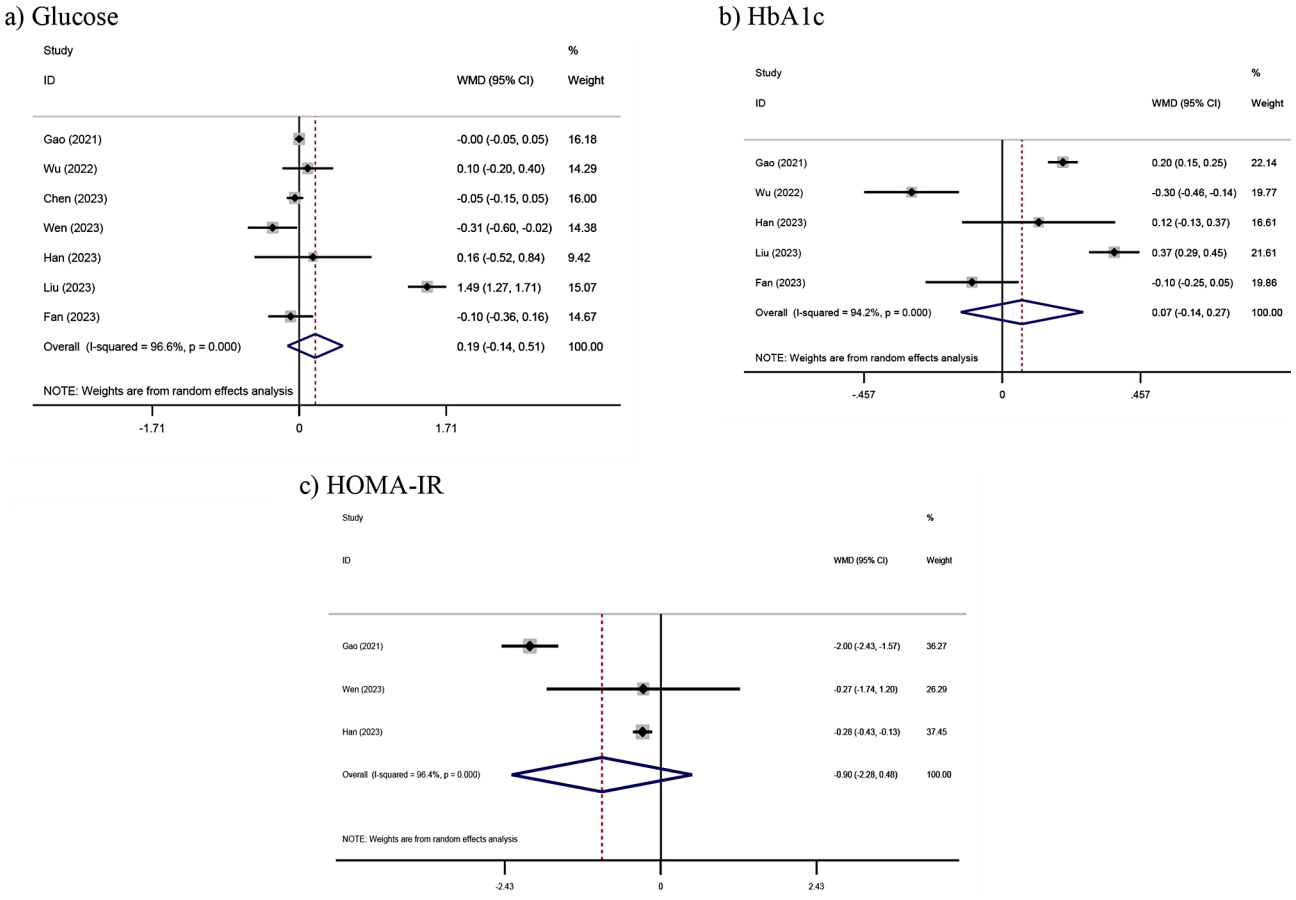


Fig. 2 Forest plots from the meta-analysis of clinical trials investigating the effects Beinaglutide on (**a**) glucose, (**a**) HbA1c, (**c**) Homeostatic Model Assessment for Insulin Resistance (HOMA-IR). WMD: weighted mean

with Beinaglutide. Overall, while taurine and Capsicum annuum provide broader metabolic and cardiovascular benefits, Beinaglutide is superior in targeted weight loss and glycemic management for type 2 diabetes.

As strengths of this study, we highlight the rigorous methodology was used based on the PRISMA guidelines [33]; removal of duplicates from a reliable source [34]; a comprehensive literature search included independent databases; search, selection, and data extraction applied to the selected studies were performed separately, and in duplicate, by two researchers; and a third party was accessed to resolve disagreements. Furthermore, because the evaluation of this drug was recent, few studies were found and this is our main limitation. However, the sensitivity analysis confirms the robustness of the findings, reinforcing confidence in the overall results. In addition, the absence of publication bias, verified by visual inspection of the funnel plot and Egger's regression test, increases the validity of these results. Moreover, since the evaluation of this drug is relatively recent, the limited number of available studies represents a major limitation. Both clinical and statistical heterogeneities were observed, which may be attributed to variations in intervention-specific factors (such as drug dosages and protocol duration), differences in the control group status (e.g., metformin/insulin vs. lifestyle modifications) or from baseline disease comorbidities (e.g., diabetic vs. non-diabetic populations), and patient-specific characteristics (including genetics, age, sex, ethnicity, medical history, and dietary carbohydrate and fat intake). Additionally, the novel nature of the drug has contributed to the scarcity of studies in this area. Another constraint was the inability to register the current study in PROSPERO due to time limitations.

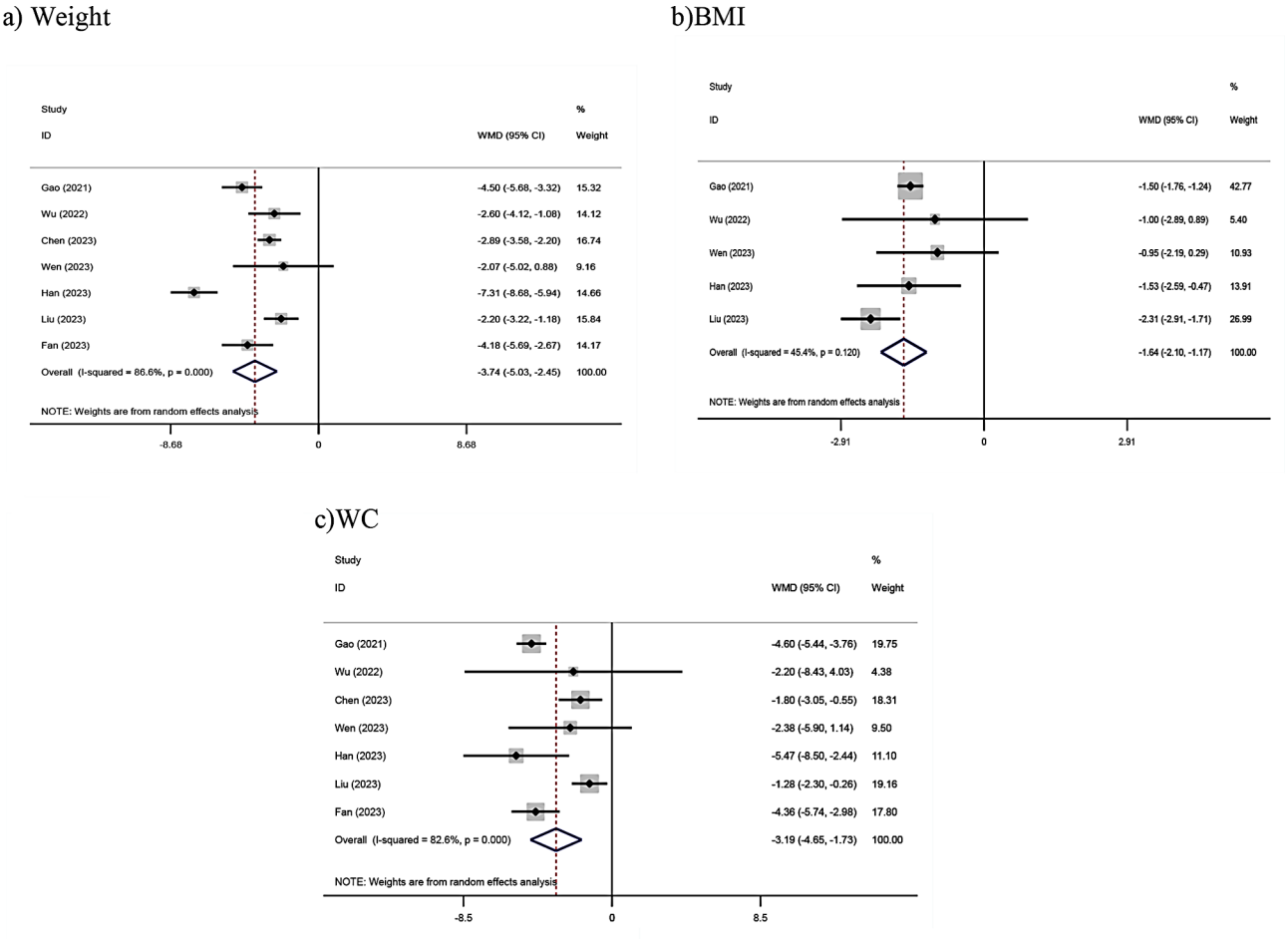


Fig. 3 Forest plots from the meta-analysis of clinical trials investigating the effects Beinaglutide on (**a**) weight, (**b**) Body Mass Index (BMI), and (**c**) Waist Circumference (WC). WMD: weighted mean

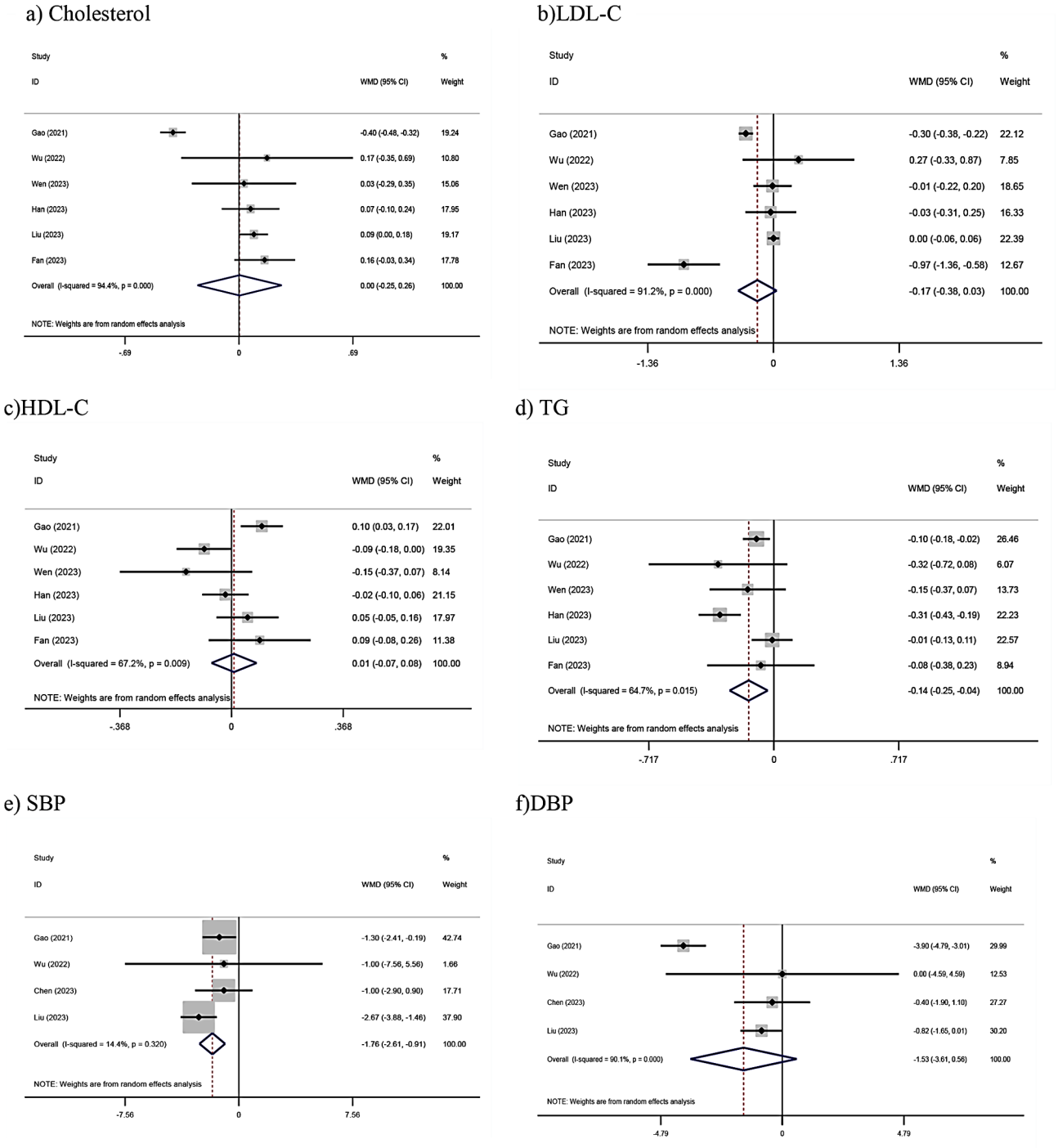


Fig. 4 Forest plots from the meta-analysis of clinical trials investigating the effects Beinaglutide on (**a**) cholesterol, (**b**) Low-density lipoprotein (LDL-C), (**c**) High-density lipoprotein (HDL-C), **d**) Triglycerid (TG), **e**) Systolic Blood Pressure (SBP), and **f**) Diastolic Blood Pressure (DBP). WMD: weighted mean

Conclusion

Although Beinaglutide shows a promising effect in reducing factors related to obesity, triglycerides as well as SBP, it seems to have no significant impact on glycemic parameters or most indicators of lipid profile and DBP. This may indicate that its use may be more effective as part of weight control strategies than as a stand-alone agent for the management of glucose metabolism or dyslipidemia and should be used with caution in clinical practice. For the parameters to work in real harmony, lifestyle changes need to be monitored, with attention paid to diet and physical exercise.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13098-025-01633-8.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions
Y.X, L.H: conception, design, statistical analysis, data collection, writing-original draft, supervision. P.V, N.SG: data collection and writing-original draft. All authors approved the final version of the manuscript.

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Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethical approval
No applicable.

Consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Stefan N, Schulze MB. Metabolic health and cardiometabolic risk clusters: implications for prediction, prevention, and treatment. Lancet Diabetes Endocrinol. 2023;11(6):426–40.
2. Ortega FB, Lavie CJ, Blair SN. Obesity and Cardiovascular Disease. Circul Res. 2016;118(11):1752–70. PubMed PMID: 27230640. Epub 2016/05/28. eng.
3. Chatterjee A, Harris SB, Leiter LA, Fitchett DH, Teoh H, Bhattacharyya OK. Managing cardiometabolic risk in primary care: summary of the 2011 consensus statement. Can Fam Physician. 2012;58(4):389–93. PubMed PMID: 22611605. Pubmed Central PMCID: PMC3325449. Epub 2012/05/23. eng fre.
4. Edgman-Levitan S, Schoenbaum SC. Patient-centered care: achieving higher quality by designing care through the patient's eyes. Isr J Health Policy Res. 2021;10(1):21. PubMed PMID: 33673875. Pubmed Central PMCID: PMC7934513. Epub 2021/03/07. eng.
5. Nyberg ST, Batty GD, Pentti J, Virtanen M, Alfredsson L, Fransson EI, et al. Obesity and loss of disease-free years owing to major non-communicable diseases: a multicohort study. Lancet Public Health. 2018;3(10):e490–7. PubMed PMID: 30177479. Pubmed Central PMCID: PMC6178874. Epub 2018/09/05. eng.
6. Putra I, Daly M, Sutin A, Steptoe A, Scholes S, Robinson E. Obesity, psychological well-being related measures, and risk of seven non-communicable diseases: evidence from longitudinal studies of UK and US older adults. Int J Obes. 2024;48(9):1283–91. PubMed PMID: 38824226. Pubmed Central PMCID: PMC11347379. Epub 2024/06/02. eng.
7. Gong HJ, Tang X, Zhou JB. The association between weight change patterns and obesity-related complex multimorbidity: evidence from NHANES. Front Endocrinol. 2024;15:1400204. PubMed PMID: 38974571. Pubmed Central PMCID: PMC11224475. Epub 2024/07/08. eng.
8. Kunutsor SK, Seidu S, Dey RS, Baidoo IK, Oulhaj A. Cardiovascular and kidney benefits of SGLT-2is and GLP-1RAs according to baseline blood pressure in type 2 diabetes: a systematic meta-analysis of cardiovascular outcome trials. Scandinavian Cardiovasc Journal: SCJ. 2024;58(1):2418086. PubMed PMID: 39425977. Epub 2024/10/19 22:17. eng.
9. Ghusn W, Hurtado MD. Glucagon-like Receptor-1 agonists for obesity: weight loss outcomes, tolerability, side effects, and risks. Obes Pillars. 2024;12:100127. PubMed PMID: 39286601. Pubmed Central PMCID: PMC11404059. Epub 2024/09/17. eng.
10. Wang G, Wu P, Qiu Y, Dong X, Wang Y, Chi Y, et al. Effect of beinaglutide treatment on weight loss in Chinese patients with type 2 diabetes mellitus and overweight/obesity. Archives Endocrinol Metabolism. 2021;65(4):421–7. PubMed PMID: 34283904. Pubmed Central PMCID: PMC10522179. Epub 2021/07/21. eng.
11. Xie Z, Zheng G, Liang Z, Li M, Deng W, Cao W. Seven glucagon-like peptide-1 receptor agonists and polyagonists for weight loss in patients with obesity or overweight: an updated systematic review and network meta-analysis of randomized controlled trials. Metab Clin Exp. 2024;161:156038. PubMed PMID: 39305981. Epub 2024/09/22. eng.
12. Zhang YL, Zhou C, Li XF, Yang MN, Tao L, Zheng XY, et al. Beinaglutide showed significant weight-loss benefit and effective glycaemic control for the treatment of type 2 diabetes in a real-world setting: a 3-month, multicentre, observational, retrospective, open-label study. Obes Sci Pract. 2019;5(4):366–75. PubMed PMID: 31452921. Pubmed Central PMCID: PMC6700512. Epub 2019/08/28. eng.
13. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Reviews. 2015;4(1):1.
14. Higgins JP, Savović J, Page MJ, Elbers RG, Sterne JA. Assessing risk of bias in a randomized trial. Cochrane handbook for systematic reviews of interventions. 2019:205– 28.
15. Higgins J. Cochrane handbook for systematic reviews of interventions. Version 5.1. 0 [updated March 2011]. The Cochrane Collaboration. www cochrane-handbook org. 2011.
16. Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol. 2005;5(1):13.
17. Elissen AM, Hertroijs DF, Schaper NC, Vrijhoef HJ, Ruwaard D. Profiling patients' Healthcare needs to support Integrated, person-centered models for long-term Disease Management (Profile): Research Design. Int J Integr care. 2016;16(2):1. PubMed PMID: 27616957. Pubmed Central PMCID: PMC5015555. Epub 2016/09/13. eng.
18. Rosenbaum M. Metabolic consequences of weight reduction. Textbook of Obesity: Biological, Psychological and Cultural Influences. 2012:333– 43.
19. Aldawsari M, Almadani FA, Almuhammadi N, Algabsani S, Alamro Y, Aldhwayan M. The efficacy of GLP-1 analogues on appetite parameters, gastric emptying, food preference and taste among adults with obesity: systematic review of randomized controlled trials. Diabetes Metab Syndr Obes. 2023;16:575–95. PubMed PMID: 36890965. Pubmed Central PMCID: PMC9987242. Epub 2023/03/10. eng.
20. Flint A, Raben A, Ersbøll AK, Holst JJ, Astrup A. The effect of physiological levels of glucagon-like peptide-1 on appetite, gastric emptying, energy and substrate metabolism in obesity. Int J Obes Relat Metabolic Disorders: J Int Association Study Obes. 2001;25(6):781–92. PubMed PMID: 11439290. Epub 2001/07/06. eng.
21. Zheng Z, Zong Y, Ma Y, Tian Y, Pang Y, Zhang C, et al. Glucagon-like peptide-1 receptor: mechanisms and advances in therapy. Signal Transduct Target Therapy. 2024;9(1):234. PubMed PMID: 39289339. Pubmed Central PMCID: PMC11408715. Epub 2024/09/18. eng.
22. Aberra T, Peterson ED, Pagidipati NJ, Mulder H, Wojdyla DM, Philip S, et al. The association between triglycerides and incident cardiovascular disease: what is optimal? J Clin Lipidol. 2020;14(4):438–47. PubMed PMID: 32571728. Pubmed Central PMCID: PMC7492406. Epub 2020/06/24. eng.
23. Harchaoui KE, Visser ME, Kastelein JJ, Stroes ES, Dallinga-Thie GM. Triglycerides and cardiovascular risk. Curr Cardiol Rev. 2009;5(3):216–22. PubMed PMID: 20676280. Pubmed Central PMCID: PMC2822144. Epub 2010/08/03. eng.
24. Masana L, Ros E, Sudano I, Angoulvant D. Is there a role for lifestyle changes in cardiovascular prevention? What, when and how? Atherosclerosis Supplements. 2017;26:2–15. PubMed PMID: 28434481. Epub 2017/04/25. eng.

25. Khanji MY, van Waardhuizen CN, Bicalho VVS, Ferket BS, Hunink MGM, Petersen SE. Lifestyle advice and interventions for cardiovascular risk reduction: a systematic review of guidelines. Int J Cardiol. 2018;263:142–51. PubMed PMID: 29754910. Epub 2018/05/15. eng.
26. Aerts N, Le Goff D, Odorico M, Le Reste JY, Van Bogaert P, Peremans L, et al. Systematic review of international clinical guidelines for the promotion of physical activity for the primary prevention of cardiovascular diseases. BMC Fam Pract. 2021;22(1):97. PubMed PMID: 34011279. Pubmed Central PMCID: PMC8136198. Epub 2021/05/21. eng.
27. Wang Z, Yang W, Li X, Qi X, Pan KY, Xu W. Association of Sleep Duration, Napping, and sleep patterns with risk of Cardiovascular diseases: a Nationwide Twin Study. J Am Heart Association. 2022;11(15):e025969. PubMed PMID: 35881527. Pubmed Central PMCID: PMC9375484. Epub 2022/07/27. eng.
28. El Baou C, Desai R, Cooper C, Marchant NL, Pilling S, Richards M, et al. Psychological therapies for depression and cardiovascular risk: evidence from national healthcare records in England. Eur Heart J. 2023;44(18):1650–62. PubMed PMID: 37072130. Pubmed Central PMCID: PMC10163979. Epub 2023/04/19. eng.
29. Yao H, Zhang A, Li D, Wu Y, Wang C-Z, Wan J-Y et al. Comparative effectiveness of GLP-1 receptor agonists on glycaemic control, body weight, and lipid profile for type 2 diabetes: systematic review and network meta-analysis. BMJ. 2024;384.
30. Tzang C-C, Lin W-C, Lin L-H, Lin T-Y, Chang K-V, Wu W-T, et al. Insights into the cardiovascular benefits of taurine: a systematic review and meta-analysis. Nutr J. 2024;23(1):93.
31. Tzang C-C, Chi L-Y, Lin L-H, Lin T-Y, Chang K-V, Wu W-T, et al. Taurine reduces the risk for metabolic syndrome: a systematic review and meta-analysis of randomized controlled trials. Nutr Diabetes. 2024;14(1):29.
32. Jang H-H, Lee J, Lee S-H, Lee Y-M. Effects of Capsicum annuum supplementation on the components of metabolic syndrome: a systematic review and meta-analysis. Sci Rep. 2020;10(1):20912.
33. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Reviews. 2015;4(1):1. PubMed PMID: 25554246. Pubmed Central PMCID: PMC4320440. Epub 2015/01/03. eng.
34. Guimarães NS, Ferreira AJF, Ribeiro Silva RC, de Paula AA, Lisboa CS, Magno L, et al. Deduplicating records in systematic reviews: there are free, accurate automated ways to do so. J Clin Epidemiol. 2022;152:110–5. PubMed PMID: 36241035. Epub 2022/10/15. eng.

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