https://doi.org/10.48047/AFJBS.6.Si2.2024.5183-5201

The Analysis Study of Obesity-related hypertension and chronic kidney disease : A Comprehensive Systematic Review and Metaanalysis Study

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Article History

Volume 6, Issue Si2, 2024
Received:18 Apr 2024
Accepted:20 Jun 2024
doi: 10.48047/AFJBS.6.Si2.2024.5183-5201

ABSTRACT

Background: Obesity poses significant challenges to healthcare globally, particularly through its bi-directional relationship with co-morbid metabolic conditions such as type 2 diabetes and hypertension. There is also emerging evidence of an association between obesity and chronic kidney disease (CKD) which is less well characterized. **Method**: This systematic review and meta-analysis, conducted following PRISMA guidelines and employing the PICO format, aim to explore about the analysis study of obesity related hypertension and chronic kidney disease. Inclusion criteria encompass diverse study designs (RCTs, observational, quasi-experimental, and case-control studies) investigating obesity related hypertension and chronic kidney disease, while exclusion criteria filter out studies lacking relevance to obesity related hypertension and chronic kidney disease. **Result**: After three levels of screening, 10 articles directly relevant to the systematic review were chosen for full-text analysis. The selected articles, demonstrate a recent publication trend, with 3 are articles published in PubMed journal, 2 were published in Sage Journal, 2 were published in Lancet, 3 were published in Science Direct from 2014 – 2024. **Conclusion:** Obesity may predispose to CKD directly as it is linked to the histopathological finding of obesity-related glomerulopathy and indirectly through its widely recognized complications such as atherosclerosis, hypertension, and type 2 diabetes.

Keywords: Obesity, hypertension, chronic kidney disease.

INTRODUCTION

The aim of this study is to systematically review and conduct a meta-analysis of obesity related hypertension and chronic kidney disease. By comprehensively synthesizing existing literature, this research seeks to explore the risk factor, complications, and prognosis of obesity related hypertension and chronic kidney disease. Through rigorous evaluation and statistical analysis, the study aims to provide valuable insights into the risk factor, complications, and prognosis of obesity related hypertension and chronic kidney disease. The systematic review and meta-analysis intend to inform healthcare practitioners, researchers, and policymakers about the current state of the risk factor, complications, and prognosis of obesity related hypertension and chronic kidney disease for future research and development in this critical area of public health.

Obesity is a significant chronic disease worldwide. Similar to the global obesity pandemic, the prevalence of obesity in Korea has gradually increased over the last decade. According to the Obesity Fact Sheet in Korea 2021 (endorsed by the Korean Society for the Study of Obesity), the age-adjusted prevalence of obesity in 2019 was 36.3% (obesity is defined as body mass index [BMI] of ≥25 kg/m^2). Hypertension is a major cause of death and has the highest disease burden worldwide. In Korea, the estimated number of people with hypertension exceeded 12 million as of 2019 (hypertension is defined as blood pressure of ≥140/90 mmHg or the use of antihypertensive drugs). Individuals with hypertension had more comorbidities than normotensive individuals.[1–4]

Obesity is a widely recognized risk factor for cardiovascular disease and for various metabolic disorders such as type II diabetes. Less attention has been paid to the link between increased body weight and chronic kidney disease (CKD), although there is evidence that the steady rise in CKD prevalence may be closely associated with increasing obesity. Obesity causes cardiovascular and renal diseases through several mechanisms including hypertension, hyperglycemia, dyslipidemia, inflammation, and atherosclerosis. These disorders often coexist, especially when there is excess visceral fat, and have often been referred to as the “metabolic syndrome.” However, there is substantial evidence that excess visceral fat is the main driving force for almost all of the disorders associated with the metabolic syndrome, including CKD.[5–7]

Chronic renal dysfunction is an important consequence of obesity, at least in part, because of the strong links between visceral adiposity and the two leading causes of CKD: hypertension and diabetes. Current evidence suggests that overweight and obesity account for 65%–75% of the risk for essential hypertension. Type II diabetes, which accounts for over 90%

of diabetes, is almost always associated with increased visceral adiposity. Hypertension and diabetes, along with other disorders associated with the metabolic syndrome, may interact synergistically to increase the risk of CKD and progression to ESRD. However, there is also evidence that obesity may cause renal dysfunction and increased risk for CKD independent of diabetes and hypertension.[5,8–10]

METHODS

This systematic review meta analysis was conducted in adherence to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines. Our health care question was defined a priori using the PICO (Population, Intervention, Comparator and Outcomes) format. Population: Individuals at risk of hypertension and chronic kidney disease. Intervention: Obesity. Comparison: Normal weight. Outcome: complications and prognosis of obesity.

Eligibility Criteria

For inclusion in this systematic review and meta-analysis on the exploration of obesity related hypertension and chronic kidney disease, studies with diverse designs will be considered. This encompasses randomized controlled trials (RCTs), observational studies, quasi-experimental designs, and case-control studies. Studies must specifically investigate about obesity related hypertension and chronic kidney disease, such as risk factor, complications, and prognosis of obesity.

The eligible population includes individuals at risk of obesity related hypertension and chronic kidney disease or those already diagnosed, with no restrictions based on age, gender, or geographical location. Exclusion criteria encompass studies not directly relevant to obesity related hypertension and chronic kidney disease, reviews lacking original data, and studies solely not focusing on obesity related hypertension and chronic kidney disease.

Comparison groups are essential for this analysis, and eligible studies must incorporate a comparison group using the other methods for obesity related hypertension and chronic kidney disease. Excluded are studies without a comparison group or those comparing different of obesity related hypertension and chronic kidney disease.

Outcome measures of interest include risk factor, complications, and prognosis of obesity related hypertension and chronic kidney disease. Studies reporting outcomes unrelated to these measures or not directly addressing the obesity related hypertension and chronic kidney disease will be excluded. These criteria are designed to ensure the comprehensive

inclusion of studies exploring the risk factor, complications, and prognosis of obesity related hypertension and chronic kidney disease, facilitating a thorough systematic review and meta-analysis of the current literature.

Data Sources and Search Strategy

In pursuit of exploring obesity related hypertension and chronic kidney disease, a comprehensive search strategy was deployed. Authors systematically scoured relevant bibliographic databases, including the PubMed, Lancet, Sage Journal, and Science Direct. The final search was conducted in June 2024. MeSH terms related to obesity related hypertension and chronic kidney disease, and articles with relevant terms within the title or abstract were identified ("Obesity"[All Fields] OR "Overweight"[MeSH Terms] OR "Complications of Obesity"[All Fields]) AND ("Hypertension"[MeSH Terms] OR "Risk factor of hypertension"[All Fields] OR "Chronic kidney disease"[All Fields] OR "Risk factor of chronic kidney disease"[All Fields] OR "Impact of obesity"[All Fields] OR "Obesity related hypertension"[All Fields]) AND ("Obesity related chronic kidney disease"[MeSH Terms] OR ("mechanism of hypertension in obesity"[All Fields] AND "Mechanism of chronc kidney disease in obesity"[All Fields]) OR "Outcome of obesity"[All Fields]).

Study Selection

Title and abstract screening for eligibility was conducted by two independent investigators. Studies meeting the eligibility criteria were selected, and the full-text articles were obtained and reviewed. Any discrepancies in study selection were resolved through consensus agreement among all authors.

Data Extraction

Data extraction was performed in duplicate from full-text versions of eligible studies by authors. The data included the total number of events and controls for the risk factor, complications, prognosis of obesity related hypertension and chronic kidney disease. Data presented in tabular format were the primary source for extraction.

Risk of Bias

The GRADE system was utilized to assess the quality of evidence. The risk of bias was evaluated based on limitations in study design, with RCTs considered high-quality evidence

and observational studies as low-quality evidence. Each study underwent scrutiny for limitations, and bias was established across studies for each outcome.

Heterogeneity

Heterogeneity was evaluated based on similarity of point estimates, overlap of confidence intervals, and the statistic. Subgroup comparisons were created to explore potential sources of heterogeneity.

Evaluating the Quality of Evidence

The GRADE approach was employed to upgrade the quality of evidence, considering factors such as large pooled effects, dose-response relations, and confounders.

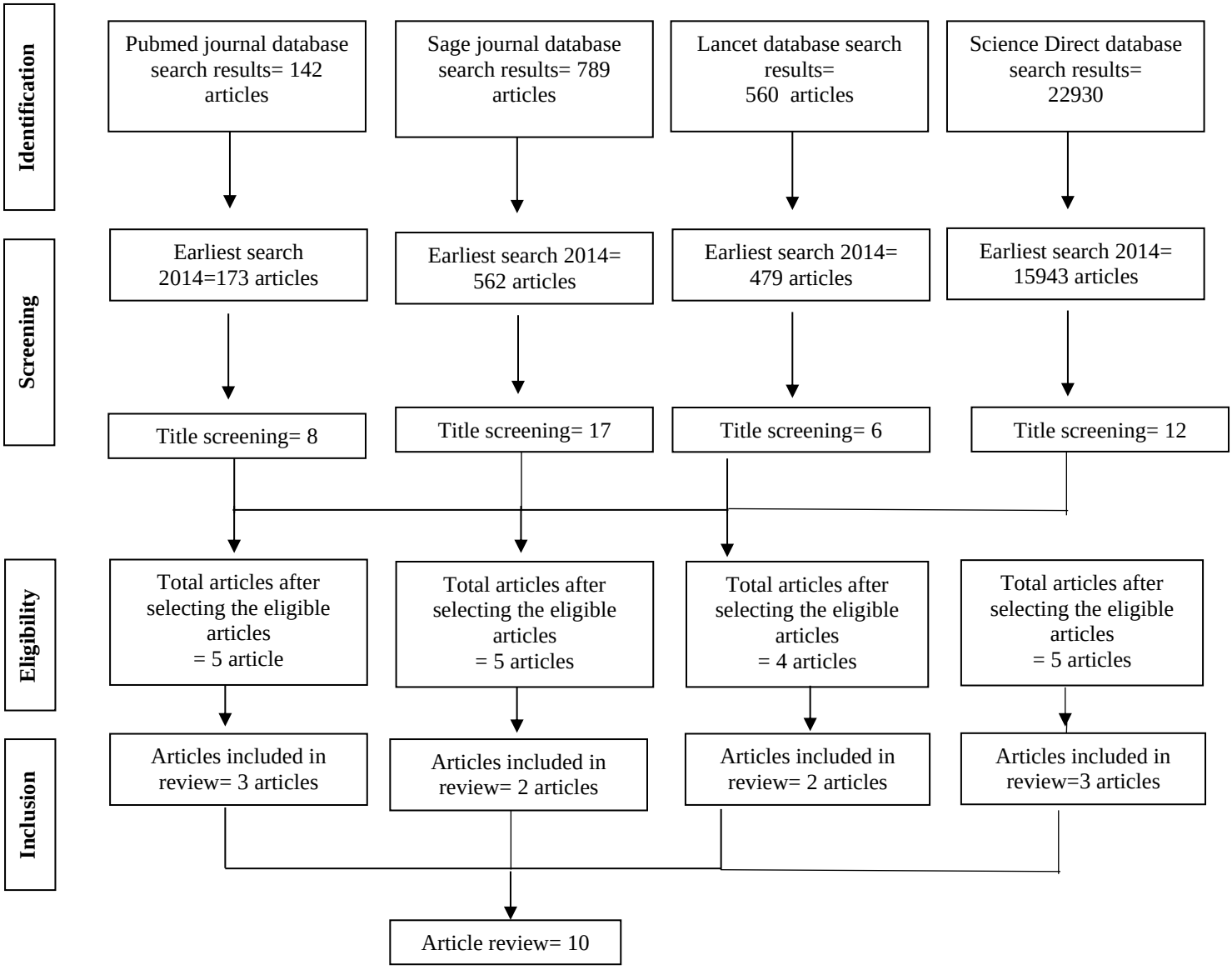

Figure 1. Article search flowchart

RESULT

After conducting three levels of screening, 10 articles that have a direct relationship with the current systematic review have been selected for further screening based on full-text reading and analyses. The selected articles and their respective publication year along with the distribution of the publications years have been shown in Figure 1 above. As shown in Figure 1, the articles used for this systematic review included studies that have been published recently, where the majority of the studies representing 3 are articles published in PubMed journal, 2 were published in Sage Journal, 2 were published in Lancet, 3 were published in Science Direct from 2014 – 2024.

Author	Origin	Method	Sample Size	Outcome	Result
Sorling, A et al., 2023[11]	Sweden	This nationwide case-control study with data from mandatory national registries included 4684 patients (cases) admitted to the intensive care units (ICUs) requiring mechanical ventilation and 46,840 population-based controls matched by age, sex, and district of residency.	4648	The primary outcome, severe COVID-19, was defined as ICU admission because of COVID-19 with a laboratory-confirmed SARS-CoV-2 infection registered in SIR, with at least 1 episode of invasive mechanical ventilation during the ICU stay. All eligible patients during the study period between March 1, 2020, and June 8, 2021, were included as cases in the study. Secondary outcomes were acute kidney injury in need of CRRT defined as at least 1 episode of CRRT during the ICU stay and all-cause mortality after	The median age was 64 years, and 27.7% were female. CKD was observed in 5.4% of the cases and 1.5% of the controls, whereas 1.9% and 0.3% had end-stage CKD, respectively. CKD was associated with severe COVID-19 (OR, 2.20 [95% CI, 1.85–2.62]), continuous renal replacement therapy (CRRT) in ICU (OR, 7.36 [95% CI, 5.39–10.05]), and death any time after ICU admission (OR, 2.51 [95% CI, 1.96–3.22]). The risk associated with CKD for severe COVID-19 did not differ significantly by weight but was higher in those without diabetes (OR, 2.76 [95% CI, 2.15–3.55]) than in those with diabetes (OR, 1.88 [95% CI, 1.37–2.59]).

				admission to the ICU during the total follow-up until August 31, 2021.	
Chen, IJ et al., 2022[12]	Taiwan	This cross-sectional, community-based study recruited 400 participants (141 males and 259 females) aged 50 years or over from a community health promotion project at the Linkou Chang Gung Memorial Hospital (Guishan District, Taoyuan City) in 2014.	400	There were three parts of data collection, including anthropometric measurements, laboratory examination, and a structured questionnaire. For anthropometric measurements, blood pressure (BP), heart rate, BMI, and waist circumference (WC) were recorded. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate were checked at least twice after 5 min of rest on a chair. BMI was calculated as weight (kg) divided by height squared (m^2).	A total of 81 participants were identified as having CKD [estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m^2 or urine albumin/creatinine ratio ≥30 mg/g], and their mean triglyceride/high-density lipoprotein cholesterol (TG/HDL-C) ratio was 3.37 ± 2.72. The mean TG/HDL-C ratio of the 319 participants without CKD was 2.35 ± 1.66. After adjusting for age, TG/HDL-C was significantly positively correlated with blood pressure, body mass index, waist circumference, and fasting plasma glucose but not low-density lipoprotein cholesterol. There was a negative correlation between TG/HDL-C and eGFR. Multiple logistic regression model analysis showed that TG/HDL-C was still significantly associated with CKD (OR: 1.17, 95% CI: 1.01–1.36, p = 0.04) after adjusting for multiple covariates. The cut-off point of TG/HDL-C as a predictor of CKD was 2.54 with an area under the ROC curve of 0.61 (95% CI: 0.53–0.68).

					There was a significant positive correlation between TG/HDL-C and several cardiovascular disease risk factors, including obesity indices.
Wen, J et al., 2017[13]	China	This cross-sectional study included 48,054 adult subjects. CKD was defined as an estimated glomerular filtration rate <60 ml/min/1.73 m^2 or dipstick-positive proteinuria. Logistic regression models were used to examine the relationship between lipid variables and CKD.	48054	Any personal history of hypertension, diabetes mellitus, stroke or heart disease (defined as self-reported myocardial infarction, angina, or coronary artery bypass graft), as well as medication use for hypertension, dyslipidemia or diabetes was recorded. Body height and body weight were recorded while participants were wearing light indoor clothing without shoes. WC was measured at the middle point between the costal margin and the iliac crest. BP was measured according to the Joint	The prevalence of CKD in this study was 3.7%. When the participants exhibited higher serum triglyceride (TG), a higher TG/high-density lipoprotein cholesterol (TG/HDL-c) ratio or a higher non-HDL-c/HDL-c ratio or HDL-c in a lower quartile, the prevalence of CKD tended to be higher. The multivariate adjusted odds ratios for CKD per 1 standard deviation increase in lipid level were 1.17 (1.10-1.23) for TG, 0.86 (0.79-0.93) for HDL-c, 1.21 (1.13-1.31) for the TG/HDL-c ratio, and 1.14 (1.06-1.22) for the non-HDL-c/HDL-c ratio. No significant association was detected between CKD and total cholesterol (TC), non-HDL-c or the low-density lipoprotein cholesterol/HDL-c (LDL-c/HDL-c) ratio.

				National Committee (JNC) 7 report	
Tsai, MH et al., 2018[14]	Taiwan	A prospective cohort study was designed with an integrated community-based multiple screening program of 106,094 individuals aged ≥20 years in Keelung, Taiwan, in 1999–2009.	106094	We used the CKD Epidemiology Collaboration (EPI) equation to evaluate the estimated glomerular filtration rate (eGFR) of the patients	The participants' mean age was 47.7 ± 15.4 years. The estimated prevalence was 15.46% for total CKD and 9.06% for CKD stages 3–5. The incidence was 27.21/1,000 person-years (PY) for total CKD and 16.89/1,000- PY for CKD stages 3–5. Older patients, males, and those patients with comorbidities of diabetes mellitus (DM), hypertension, and metabolic syndrome (MetS) exhibited higher prevalence and incidence rates than their opposing counterparts. Moreover, the ADT of CKD stages 3–5 was 5.37 years (95% CI 5.17–5.57). Males and those with comorbidities of DM or MetS had shorter ADTs in CKD stages 3–5 than their opposing counterparts. Interestingly, the ADT of participants with hypertension was longer than those without.
Niu, Y et al., 2024[15]	China	This study employed a nationally representative subsample of 1,051 youth aged 13–20 from the US National Health and Nutrition Examination Survey (NHANES) conducted between January 2017 and March 2020.	1051	The serum uric acid (SUA) levels of the participants were compared to the reference values provided by Mayo Clinic Laboratories, which vary based on	The study encompassed a cohort of 1,051 youth aged 13–20 years, comprising 538 boys and 513 girls. The overall prevalence of HUA was found to be 7% (74 out of 1,051). Univariate analysis revealed that the HUA group exhibited greater age, body mass index (BMI), waist

				sex and age. For boys, the reference values are as follows: 13 years: 3.4–6.9 mg/dL, 14 years: 3.7–7.4 mg/dL, 15 years: 4.0–7.8 mg/dL, and ≥ 16 years: 3.7–8.0 mg/dL. For girls, the reference values are ≥13 years: 2.7–6.1 mg/dL. For participants above 18 years of age, HUA was defined as 7.0 mg/dL for males and 6.0 mg/dL for females.	circumference (WC), hip circumference (HC), and waist-to-hip ratio (WHR). Additionally, the prevalence of obesity was significantly higher in the HUA group compared to the non- HUA group (all $p < 0.05$). Regarding biochemical indicators, the levels of urea nitrogen, creatinine (Cr), alanine aminotransferase (ALT), glutamic oxalic aminotransferase (AST), gamma-glutamyl transferase (GGT), total cholesterol (TC), triglyceride (TG), and HS C reactive protein (Hs CRP) were found to be significantly higher in the HUA group compared to the non-HUA group (all $p < 0.05$).
Fouad, M et al., 2016[16]	Egypt	A Cross-sectional study was carried out among students of the Zagazig University between January 2014 and April 2015. The study was approved by the Institutional Ethics Committee and conformed to the Helsinki Declaration.	3000	The participants were subjected to clinical examination, anthropometric measurements, laboratory investigation, including urinary albumin/creatinine ratio (ACR) and estimation of glomerular filtration rate (eGFR).	The prevalence of overweight, obesity, and metabolic syndrome (MS) was 31.7%, 30.1%, and 16%, respectively. The prevalence of CKD among subjects with BMI >25 was 6.5%, almost all of them had BMI >35. ACR and eGFR rose progressively with increasing BMI. Elevated mean arterial pressure (MAP), high sensitivity C-reactive protein, and MS increased the risk of development of CKD. Moreover, MAP, waist to height ratio, and

					triglycerides to high-density lipoprotein ratios at levels of >95 mm Hg, >0.6, and >3 had sensitivity 91.7%, 88.4%, and 86.7%; and specificity 92.3%, 96.4%, and 96.5%, respectively to predict CKD. The prevalence of obesity among Egyptian young adults was high (30.1%) and was associated with increased the risk of CKD (6.5%).
B Rajinikanth, S et al., 2023[17]	India	This cross-sectional observational study was conducted at private schools in Chennai, Tamil Nadu, India, for one year. Data analysis was performed on a cohort of participants who underwent health assessments, including blood pressure measurements, self-reported dietary habits, and socio-economic status information.	500	A standardized proforma collected participants' information, including demographic details and anthropometric measures. Vitals and blood pressure examinations were conducted and meticulously recorded as part of the data collection process. Height measurements were taken using a standardized stadiometer placed on a level surface.	There were 255 (51.0%) males and 245 (49%) females. Among the female participants, only two individuals (0.8%) had HTN, while among males, 11 individuals (4.3%) had HTN, indicating a significant association between sex and HTN (P=0.014). In terms of dietary habits, the prevalence of HTN was similar among non-vegetarians (2.5%) and vegetarians (3.1%), and the association was not statistically significant (P=0.777). Among the obese individuals in the study population, eight individuals (8.8%) had HTN, while the remaining 83 individuals (91.2%) did not have HTN, with a P-value of <0.0001, which indicates a significant association between HTN and obesity.

Zhang, Y et al., 2022[18]	China	Data were derived from the China Health and Retirement Longitudinal Study (CHARLS) conducted in 2015. Stratified sample households covered 150 counties/districts and 450 villages/urban communities from 28 provinces by using household questionnaires, clinical measurements, and blood-based bioassays.	13013	Blood samples were analyzed by whole blood cell count in the local county health centers immediately. Then the samples were transported to the headquarters, where they were analyzed for hsCRP, HbA1c, blood lipids, blood glucose, blood urea nitrogen, creatinine, and uric acid.	The prevalence of obesity-related hypertension was 22.7%, ~120 million people, among adults aged 45 years or older in China. For people in the age ranges of 45–54, 55–64, 65–74, and ≥75 years, the prevalence of obesity-related hypertension was 16.7, 24.3, 27, and 26.7%, respectively, and the prevalence of obesity-related hypertension among hypertensive participants was 66.0, 60.9, 54.2, and 47.3%, respectively. Compared with non-obesity-related hypertension, the obesity-related hypertensive patients had a higher prevalence of diabetes mellitus, dyslipidemia, and hyperuricemia (all $P < 0.0001$). The prevalence of obesity-related hypertension showed a decreasing gradient from north to south and from east to west. Multivariate logistic regression analysis showed that female gender, living in urban areas, diabetes mellitus, dyslipidemia, and hyperuricemia were positively correlated with obesity-related hypertension.
Zhang, Y et al., 2019[19]	China	rom September 2013 to March 2014, a multi-stage, stratified sampling method was conducted on 10,589 people aged 40 to 79	10589	All subjects filled out the same on-site questionnaire, which included	he prevalence of obesity-related hypertension and hypertension overall (systolic ≥130 mmHg and/or diastolic ≥80 mmHg or treated

		years and living in Chengdu and Chongqing investigated by using a questionnaire and performing physical and biochemical measurements.		demographic characteristics, lifestyle risk factors, and personal and family history, according to the cardiovascular survey methods of World Health Organization (WHO). The questionnaire also included height, weight, WC, and blood pressure measurements.	hypertension) was 22.8% and 57.4%, respectively, among all participants. For obesity-related hypertension, the prevalence was higher in women than in men (24.7% versus 19.4%, $p < 0.001$). For people in the age ranges of 40–49, 50–59, 60–69, and ≥70, the prevalence of obesity-related hypertension were 11.8%, 22.6%, 30.7%, and 36.6%, respectively. Participants with obesity-related hypertension as opposed to those with non-obesity-related hypertension had a higher prevalence of hypertriglyceridemia, high low-density lipoprotein cholesterolemia, diabetes, and hyperuricemia (all $p < 0.05$).
Kivimaki, M et al., 2022[20]	UK	We did an observational study and used pooled prospective data from two Finnish cohort studies (the Health and Social Support Study and the Finnish Public Sector Study) comprising 114 657 adults aged 16–78 years at study entry (1998–2013). A cohort of 499 357 adults (aged 38–73 years at study entry; 2006–10) from the UK Biobank provided replication in an independent population.	178375	Weight and height at baseline were self-reported in HeSSup and FPS and were measured as part of the examination in the UK Biobank. We calculated BMI using the formula: weight (kg) divided by height (m) squared.	Mean follow-up duration was 12·1 years (SD 3·8) in the Finnish cohorts and 11·8 years (1·7) in the UK Biobank cohort. Obesity was associated with 21 non-overlapping cardiometabolic, digestive, respiratory, neurological, musculoskeletal, and infectious diseases after Bonferroni multiple testing adjustment and ignoring HRs of less than 1·50.

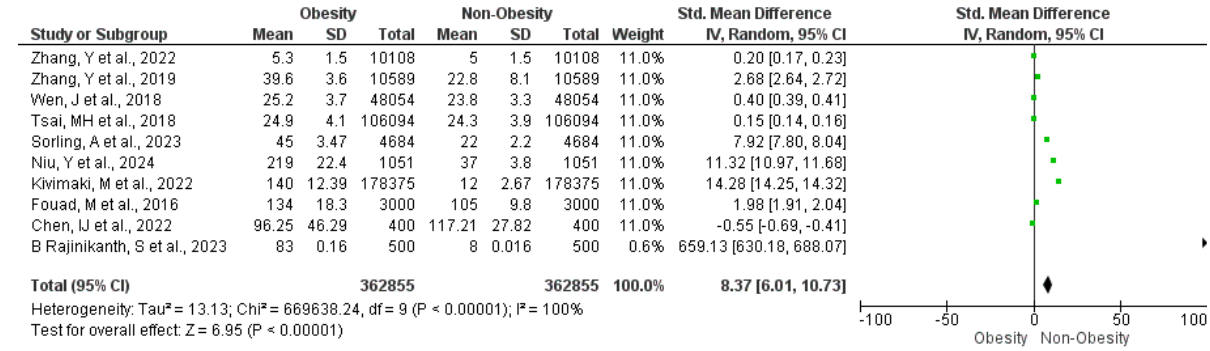

Figure 2. Forest Plot of Related Findings

Based on the Z value of 6.95 and P value <0.00001, there is a significant relationship between obesity and the occurrence of hypertension and chronic kidney disease. The fixed random value is 0.88, where the value here is positive, which means that if a person is obese it will increase the risk of hypertension and chronic kidney disease.

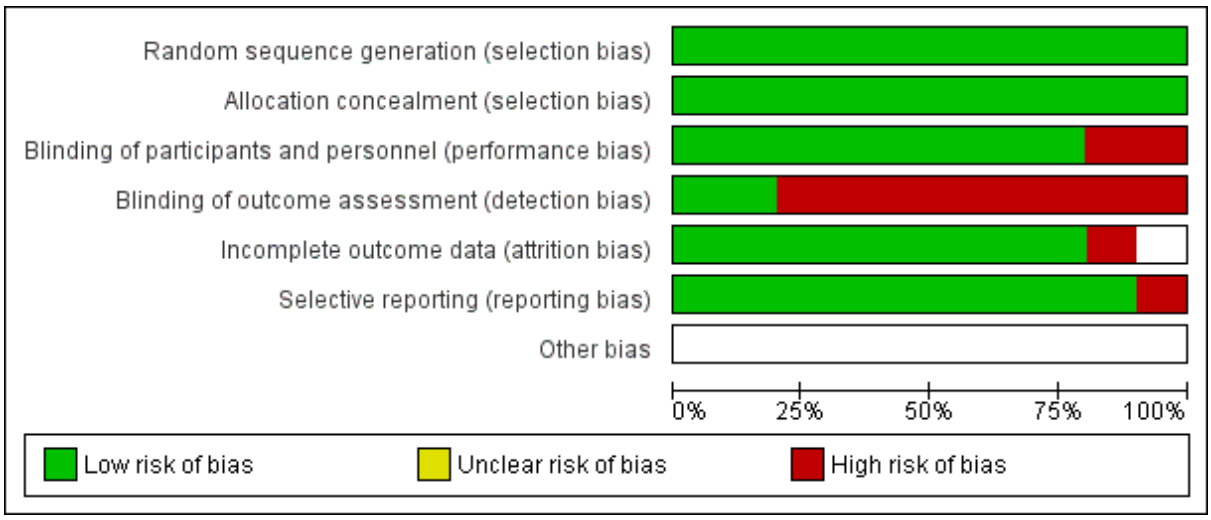

Figure 3. Risk of Bias

Based on the risk of bias, there is a high risk of blinding of outcome assessment in the 10 studies concerned. Meanwhile, other bias components are included in low risk.

DISCUSSION

Obesity is a contributing risk factor of 20-25% of chronic kidney disease (CKD) cases worldwide. As per the 2011-2014 National Health and Nutrition Examination Survey, 44.1% of CKD patients in the United States of America (USA) were obese. The number of end-stage kidney disease (ESKD) kidney transplant recipients who were obese also grew by 44% from 1999—2009. Diabetes and hypertension—the two most common causes of CKD worldwide—frequently accompany obesity and are often put forward as the major causes of obesity-related CKD. However, obesity is a risk factor CKD-related disability and mortality after adjusting for diabetes and hypertension. Othman et al. demonstrated that non-diabetic obese patients were

more likely to undergo CKD progression than non-obese subjects. These results suggest an independent mechanism by which obesity damages the kidney.[1,21,22]

Although obesity was formerly thought to represent only an independent risk factor for numerous diseases, a large amount of data has now shown that obesity itself represents a chronic and progressive disease strongly influenced by environmental factors (e.g., the availability of high caloric food and low physical activity) and genetic factors. As it is characterized by excessive accumulation of adiposity, obesity is commonly estimated by the body mass index (BMI), calculated as weight (kg)/height (m). Based on this parameter, the World Health Organization (WHO) classifies individuals with a BMI between 25 and 29.9 kg m^{-2} as overweight and those over 30 kg m^{-2} as obese. In addition to BMI, waistline (WC) and waist-to-hip ratio are now important tools to assess fat distribution and contribute to risk stratification. Moreover, obese individuals are classified based on cutoff points of BMI values in obese classes I (30–34.99 kg m^{-2}), II (35–39.99 kg m^{-2}), and III (>40 kg m^{-2}).[23–25]

The prevalence of obesity and CKD is increasing, despite decreases in established risk factors for cardiovascular illnesses such as smoking, high blood pressure, and hyperlipidemia. Furthermore, there is a strong link between BMI and the risk of CKD. This research has primarily focused on adults and discovered that results are reliable in adults. Data about children are scarce. Due to its close association with diabetes and hypertension, obesity is a crucial contributor to renal illnesses; also, obesity and excess weight pose a severe hazard to the development of chronic kidney diseases. Obesity affects the progression of stable kidney disease because it increases the risk of developing diabetic nephropathy, hypertensive nephron sclerosis, and focal and segmental glomerulosclerosis, among other conditions. Renal hemodynamic, structural, and histological alterations are linked to obesity. Adipokines, such as leptin, adiponectin, tumor necrosis factor-α, monocyte chemoattractant protein-1, transforming growth factor-β1, and angiotensin-II, are produced by active adipose tissue.[26–28]

CONCLUSION

Obesity may predispose to CKD directly as it is linked to the histopathological finding of obesity-related glomerulopathy and indirectly through its widely recognized complications such as atherosclerosis, hypertension, and type 2 diabetes. The biochemical and endocrine products of adipose tissue contribute to pathophysiological processes such as inflammation, oxidative stress, endothelial dysfunction, and proteinuria. The prevention and management of obesity may prove critical in counteracting both the development and advancement of CKD.

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