Journal of Nutrition and Food Security
Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition

Shahid Sadoughi University of Medical Sciences School of Public Health

eISSN: 2476-7425 pISSN: 2476-7417 JNFS 2025; 10(4): 594-602 Website: jnfs.ssu.ac.ir

The Association between Potassium Intake and Obesity: A Systematic Review of Observational Studies

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ARTICLE INFO

SYSTEMATIC REVIEW

Article history:
Received: 8 Mar 2025
Revised: 10 Jun 2025
Accepted: 10 Jun 2025

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Keywords:
Potassium;
Intake;
Obesity;
Systematic review.

ABSTRACT

Background: Obesity is a global health concern across all age groups, primarily influenced by lifestyle and dietary patterns. Potassium, an essential nutrient is involved in various diseases, including hypertension and cardiovascular disorders. It aids insulin secretion, impacting fat accumulation and obesity. However, the role of potassium in obesity remains underexplored, with inconsistent findings. This systematic review aims to assess the association of potassium intake with obesity. **Methods:** This study is a systematic review using the keywords "obese" or "overweight" and "potassium" or "obesity" and "potassium intake," with a publication time frame of the last ten years (2014-2024). The articles were retrieved from PubMed, Google Scholar, and ResearchGate. **Results:** Ten articles analyzed potassium's link to obesity. Four articles examined body composition (fat mass and muscle mass). In comparison, six articles examined assessed Body Mass Index (BMI), with two of these also exploring its relationship with abdominal obesity (AO) (waist circumference (WC) and waist-to-hip ratio). Six articles found that increased potassium intake was associated with lower body weight, BMI, WC, waist-to-hip ratio, or fat mass. Meanwhile, the other four articles suggested that higher potassium intake was linked to an increased risk of obesity. **Conclusions:** The ten articles on potassium's role in reducing obesity presented inconsistent findings. Most assessed potassium intake alongside sodium (Na: K ratio), which showed more consistent results in reducing obesity. It is recommended that obesity outcomes be evaluated through body composition measures (fat mass, muscle mass, WC) in addition to BMI rather than relying on a single measurement.

Introduction

Obesity is defined as having a body mass index (BMI) greater than or equal to 30 kg/m^2. Several mechanisms lead to obesity. The usual main cause is the excessive accumulation of body fat stored in fat tissue, leading to weight gain and potential health problems. The excess energy is stored in fat cells, thereby developing the characteristic obesity pathology (Lin and Li, 2021).

According to World Obesity data from 2023, middle-to-upper-income countries, including Indonesia, are expected to see an increase in obesity rates from 19% to 28% in women and from 14% to 27% in men between 2020 and 2035 (World Obesity Federation, 2023). The rising obesity rates have become a major concern for society. Obesity increases the risk of various diseases, including type

This paper should be cited as: Fatimatuzahroh D, Farapti F, Dhandapani Sh. ***The Association between Potassium Intake and Obesity: A Systematic Review of Observational Studies.*** *Journal of Nutrition and Food Security (JNFS),* 2025; 10(4): 594-602.

[DOI: 10.18502/jnfs.v10i4.20015]

2 diabetes, fatty liver disease, osteoarthritis, Alzheimer's disease, depression, and several types of cancer (such as breast, ovarian, prostate, liver, kidney, and colon cancer) (Blüher, 2019). In addition, obesity can lower the quality of life, increase the risk of unemployment, reduce productivity, and lead to social disadvantages (World Obesity Federation, 2023).

Obesity can be prevented and managed through healthy lifestyle changes. In the long term, this can be achieved through regular physical activity and guidance from healthcare professionals. In the short term, significant results can be seen by following a controlled-portion diet (Lin and Li, 2021). According to Yuniarti, eating vegetables and fruits plays an important role in weight management (Yuniarti, 2023). These foods not only help with weight loss but also support overall nutritional balance.

Eating vegetables and fruits provides many health benefits, including increasing the intake of essential nutrients such as potassium, fiber, and vitamin C (Farapti *et al.*, 2022). Potassium intake may help with weight loss since its main sources, vegetables and fruits, are known to support a healthy weight (Tal *et al.*, 2019). Additionally, potassium plays a role in insulin secretion, which can influence fat storage and obesity development in the body (Nichols *et al.*, 2022). Previous studies investigating the association between potassium intake and obesity have reported inconsistent and sometimes conflicting results. While some studies suggest that higher potassium intake may be associated with a lower risk of obesity, others have found no significant relationship. Therefore, this systematic review aims to assess the role of potassium intake in obesity to clarify these inconsistencies and provide a clearer understanding of the relationship.

Materials and Methods

Search strategy

This study is a systematic review that analyzes the association between potassium intake and obesity incidence from PubMed, Google Scholar, and ResearchGate with a publication time limit of the last ten years (2014–2024) using the following search terms "obesity" or "obese" or "overweight" and "potassium" or "potassium intake". The time limitation was applied to focus on the most recent and relevant evidence, considering that dietary patterns, measurement methods, and obesity prevalence may have changed over time.

Eligibility criteria

The inclusion criteria required that studies explicitly examine the relationship between potassium intake and obesity. Only observational studies published in English and with full-text availability were included. Studies were excluded if they involved experimental designs using animal models or did not align with the topic of interest. The PICO framework used in the systematic review is presented in **Table 1**.

Table 1. PICO component table.

PICO Component	Considerations
Patient population	Individuals of any age or sex
Intervention/ Exposure	Potassium intake (dietary and urinary levels)
Comparison	Lower or different potassium intake
Outcome	Obesity incidence or prevalence

Data extraction

The characteristics of the selected articles were collected as follows: the first author's name, publication year, country where the study was conducted, participants' age, sample size, number of cases, method of potassium measurement, gender distribution, outcomes of the association between potassium and obesity, and adjustments made for confounding factors.

Quality assessment

The quality of the included studies using the Newcastle-Ottawa Scale, has a maximum score of nine stars. Studies scoring 0–3 stars were considered low quality, 4–6 stars moderate quality, and 7–9 stars were regarded to have high quality (Cai *et al.*, 2016).

Results

Included studies

The initial search identified a total of 2,757 potentially relevant studies. After removing 1,909 duplicate records, 848 studies remained for

[DOI: 10.18502/jnfs.v10i4.20015]

screening. Of these, 831 were excluded based on their titles and abstracts, leaving 17 articles for full-text review. Among these, two were excluded due to the use of animal models, and five were not relevant to the study theme. The result was a final selection of 10 articles comprising 8 cross-sectional studies (Chu *et al.*, 2023, Elfassy *et al.*, 2018, Ferguson *et al.*, 2023, Ge *et al.*, 2016, Lee *et al.*, 2020, Liu *et al.*, 2023, Rafie *et al.*, 2019, Wang *et al.*, 2023) and 2 cohort studies (Tal *et al.*, 2019, Yeung *et al.*, 2022) for the systematic review, as presented in **Figure 1**.

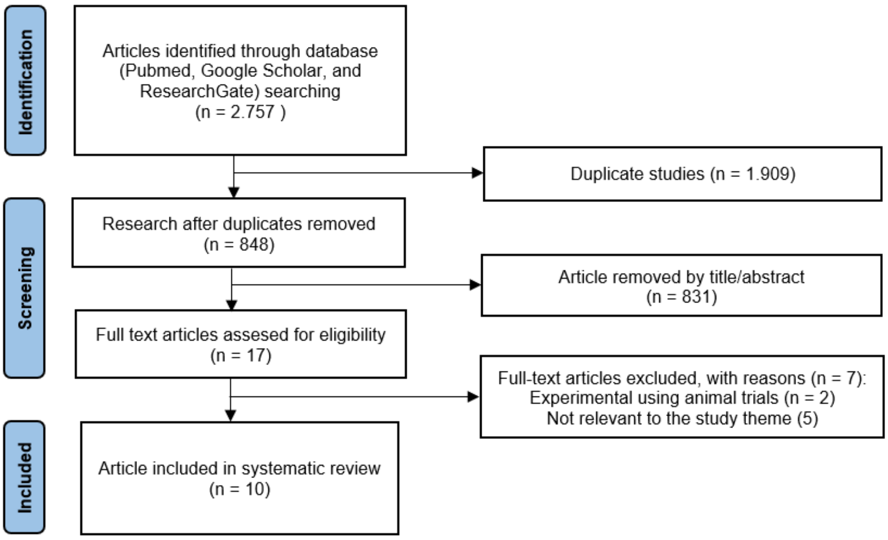

Figure 1. Flowchart of included studies.

Study characteristics

Some studies assessed multiple outcomes. Among the 10 articles examining the relationship between potassium intake and obesity, four studies evaluated body composition (fat mass and muscle mass). In contrast, six studies assessed BMI, with two of them also exploring its relationship with WC and waist-to-hip ratio. Six studies found that higher potassium intake was associated with lower body weight, BMI, WC, waist-to-hip ratio, or fat mass. Meanwhile, the other four studies suggested that increased potassium intake was linked to a higher risk of obesity. Previous studies assessed potassium intake using a food frequency questionnaire (FFQ), with some studies validating the FFQ data using 24-hour dietary recall. Additionally, some studies relied solely on 24-hour urine samples.

The largest study population included 16,558 participants, while the smallest study comprised 68 participants. In total, 55,980 participants (8,601 from cohort studies and 47,379 from cross-sectional studies) were analyzed, and all articles included both genders. The studies were published between 2014 and 2024 across various countries, including China (Chu *et al.*, 2023, Ge *et al.*, 2016, Liu *et al.*, 2023), the United States (Elfassy *et al.*, 2018, Wang *et al.*, 2023), Israel (Tal *et al.*, 2019), Korea (Lee *et al.*, 2020), Iran (Rafie *et al.*, 2019), the Netherlands (Yeung *et al.*, 2022), and Jamaica (Ferguson *et al.*, 2023). The description studies are presented in **Table 2**.

[DOI: 10.18502/jnfs.v10i4.20015]

Table 2. Description studies included in systematic review.

Study	Study design	Country	Age	Gender	Participants	Measurement of potassium	Measurement of obesity	Outcome
(Liu *et al.*, 2023)	Cross-sectional	China	18–31	Male and female	512	FFQ	BMI, WC, WHR, and Body Composition	Potassium consumption ≥ 2000 mg/day was significantly associated with higher BMI and WC compared to consumption < 2000 mg/day (P<0.05). Increased potassium consumption was associated with a gradual decrease in the odds ratio for skeletal muscle mass index and lean body nass index (P<0.05).
(Wang *et al.*, 2023)	Cross-sectional	USA	2–17	Male and Female	10450	Food recall 2x24 hours	BMI	Potassium intake was positively correlated with an increase in BMI after adjusting for daily intake (β=0.62, 95% CI: 0.19 to 1.05).
(Tal *et al.*, 2019)	Cohort	Israel	18–70	Male and Female	68	Dietary record 7x24 hours	BMI	The increase in potassium density was higher in the group with above-average BMI reduction (2.1±0.4 mg/kcal/day) compared to the group with below-average BMI reduction (1.9±0.6 mg/kcal/day; P<0.001).
(Lee *et al.*, 2020)	Cross-sectional	Korea	≥ 19	Male and Female	16558	Food recall 2x24 hours	BMI and SMI	High potassium intake significantly reduced the risk of low muscle mass in men (P<0.001). Additionally, higher potassium intake was linked to a greater skeletal muscle index (SMI) compared to lower intake (P< 0.001). Nevertheless, increased potassium intake was also correlated with higher BMI (P<0.001).
(Chu *et al.*, 2023)	Cross-sectional	China	63-63	Male and Female	155	Food record 3x24 hours	BMI and percentage of body fat (PBF)	The Na:K ratio was correlated with weight gain (r=0.173, P=0.031), and higher potassium intake was significantly associated with lower body fat after adjusting for age and gender (β=-0.002, P=0.001).
(Rafie *et al.*, 2019)	Cross-sectional	Iran	11–18	Male and Female	374	24-hour urine sample and FFQ	BMI, WC, WHtR, and PBF	Among girls, a higher urinary sodium-to-potassium ratio was significantly correlated with an increased risk of WC after controlling for caloric intake (OR 2.71, 95% CI 1.14-6.43). Similarly, in boys, the Na:K ratio was associated with percentage body fat after adjusting for sugar-sweetened beverage (SSB) consumption and caloric intake (OR 4.47, 95% CI 1.44-9.87).

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Table 2. Description studies included in systematic review.

Study	Study design	Country	Age	Gender	Participants	Measurement of potassium	Measurement of obesity	Outcome
(Elfassy *et al.*, 2018)	Cross-sectional	USA	Mean 41	Male and Female	16415	24-hour urine sample and food recall 2x24 hour	BMI, WC, body fat, and percentage of body fat (PBF)	Among immigrants who had lived in the US for 10+ years and native US residents, a higher potassium intake of 500 mg/day was significantly associated with lower BMI and smaller WC (−0.13 kg/m², *P*<0.01; and −0.36 cm for immigrants, and −0.62 kg/m², *P*<0.01 for native residents).
(Ge *et al.*, 2016)	Cross-sectional	China	18–69	Male and Female	1906	24-hour urine sample	BMI, WC, and WHR	For every 1 standard deviation increase in the Na:K ratio, the odds of WC and waist-to-hip ratio increased significantly by 12% and 15%, respectively.
(Yeung *et al.*, 2022)	Cohort	Netherlands	28–75	Male and Female	8533	24-hour urine sample	BMI and WC	Potassium intake of less than 2100–2500 mg/day increased the risk of all-cause mortality. This was associated with low potassium excretion, which was linked to an increased risk of all-cause mortality across all BMI and WC groups (*P*=0.001, *P*=0.002).
(Ferguson *et al.*, 2023)	Cross-sectional	Jamaica	≥ 15	Male and Female	1009	24-hour urine sample	BMI	There was a significant association between obesity and a 43% higher consumption of potassium (*P*<0.001).

[DOI: 10.18502/jnfs.v10i4.20015]

Potassium and obesity

Among cohort and cross-sectional studies, increased potassium intake was associated with modest reductions in BMI and WC (Elfassy *et al.*, 2018, Tal *et al.*, 2019, Yeung *et al.*, 2022). However, some cross-sectional studies reported a positive association between potassium intake and BMI (Ferguson *et al.*, 2023, Liu *et al.*, 2023, Wang *et al.*, 2023). Higher urinary sodium-to-potassium ratios were consistently linked to increased risk of abdominal obesity (Ge *et al.*, 2016). Higher potassium intake correlated with lower body fat and improved muscle mass indices in some studies, although findings were inconsistent (Chu *et al.*, 2023, Lee *et al.*, 2020, Rafie *et al.*, 2019).

Discussion

The findings of this systematic review indicate that assessing potassium intake alone may be insufficient. Rather, the sodium-to-potassium ratio serves as a more sensitive marker for obesity by accounting for the combined effects of both minerals. Furthermore, the accuracy of potassium intake measurement can be improved by utilizing 24-hour urine samples, which offer a more reliable reflection of actual intake. An increase in potassium intake is a strong predictor of weight loss (Tal *et al.*, 2019). This is because potassium-rich foods play a key role in the relationship between weight loss and potassium intake (Farapti *et al.*, 2022). Potassium is typically obtained from minimally processed foods, such as lean meats and dairy products, as well as through the adoption of healthier dietary patterns emphasizing vegetable and fruit consumption (Liu *et al.*, 2023). The high fiber content of vegetables and fruits slows gastric emptying and promotes satiety. This increased satiety can lead to reduced overall food consumption, thereby lowering the risk of obesity (Zaki *et al.*, 2022).

According to Yeung *et al.*, the risk of death from various causes increases when potassium intake is less than 2,100–2,500 mg per day (Yeung *et al.*, 2022). This is consistent with the recommendation of the World Health Organization (WHO), which suggests a minimum daily potassium intake of 3,150 mg (90 mmol/day) for adults (World Health Organization, 2012). Meanwhile, the United States Department of Agriculture (USDA) has set the Adequate Intake (AI) for adult potassium intake at 4,700 mg per day, with lower AI values established for children depending on age and gender (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). Based on observations by Cai *et al.*, consuming a potassium intake of 2200 mg/kcal may reduce the risk of obesity and metabolic syndrome (Cai *et al.*, 2016).

Nutritional status

In a cohort study of Hispanic/Latino individuals, increased potassium intake (500 mg/day) was associated with a 0.13 kg/m² lower BMI among immigrants with 10+ years in the US and a 0.62 kg/m² lower BMI in US-born (Elfassy *et al.*, 2018). These findings are supported by research conducted by Tal *et al.*, which showed that participants with above-average BMI reduction increased their potassium intake by 25% compared to their previous intake, while participants with below-average BMI reduction only increased potassium intake by 3% (P=0.033) (Tal *et al.*, 2019). The increase in potassium density was also higher in the above-average BMI reduction group (2.1±0.4 mg/kcal/day) compared to the below-average BMI reduction group (1.9±0.6 mg/kcal/day; P<0.001).

However, a cross-sectional study of 512 students in China showed contrasting results, finding that respondents who consumed potassium ≥2000 mg/day had a higher BMI compared to those who consumed <2000 mg/day (Liu *et al.*, 2023). These results are consistent with the study by Wang *et al.*, which showed that potassium intake was correlated with increased BMI (β = 0.62, 95% CI: 0.19, 0.05) (Wang *et al.*, 2023). Furthermore, obesity was associated with a 43% higher potassium consumption (P<0.001) (Ferguson *et al.*, 2023). This may be because individuals with obesity tend to pay more attention to the quantity of mineral

[DOI: 10.18502/jnfs.v10i4.20015]

intake but without properly balancing it with control of energy intake (Liu *et al.*, 2023, Wang *et al.*, 2023).

Abdominal obesity

A study on adults in China found that the sodium-to-potassium ratio (Na:K) in urine was significantly and positively associated with an increased risk of abdominal obesity, whether measured by WC or waist-hip ratio (WHR). Each 1 standard deviation (SD) increase in the 24-hour urinary Na:K ratio was associated with a 12% increased risk of abdominal obesity and a 15% increased risk of WHR (Ge *et al.*, 2016) The urinary Na:K ratio reflects a dietary pattern high in sodium and low in potassium, therefore the Na:K ratio can be used as an indicator of diet quality (Murakami *et al.*, 2010). Furthermore, a lower urinary Na:K ratio indicates a protective effect against obesity (Cai *et al.*, 2016).

Consistent with these findings, a cohort study conducted on 16,415 Hispanic/Latino individuals showed that higher potassium intake was associated with a smaller WC of 0.36 cm in immigrants who had lived in the US for 10+ years and 1.42 cm in US-born (Elfassy *et al.*, 2018).

Body composition

Research has shown that higher potassium intake is significantly associated with lower body fat (P=0.001) (Chu *et al.*, 2023). However, a study by Liu *et al.*, found no association between total percentage body fat and potassium consumption (Liu *et al.*, 2023). Despite this, increased potassium intake was linked to increases in muscle-related indicators, such as fat-free mass index (FFMI), appendicular skeletal muscle index (ASMI), skeletal muscle mass index (SMMI), and lean mass index (LMI) (P<0.05)

Consistent with the research by Elfassy *et al.*, every 0.50 increase in the urinary Na:K ratio was associated with a 0.48 kg increase in body fat (95% CI: 0.15, 0.93) and a 0.34% increase in body fat percentage (Elfassy *et al.*, 2018). In addition, body fat percentage was associated with the urinary Na:K ratio in boys, with an OR of 4.47 (95% CI: 1.44-9.87) after adjusting for Sugar-sweetened beverages (SSB) consumption and 3.87 (95% CI: 1.20-8.48) after adjusting for calorie intake (Rafie *et al.*, 2019).

There are various mechanisms regarding the role of potassium in obesity prevention, one of which is through glucose metabolism. In potassium deficiency, the body stimulates an increase in insulin along with a decrease in serum potassium of 0.5 mM over 90 minutes without an increase in potassium excretion in the urine (McDonough and Fenton, 2022). There are two ATP-sensitive potassium (KATP) channels related to glucose metabolism, namely SUR1 and Kir6.2 channels. When potassium intake is low, the function of these two channels is reduced, resulting in pancreatic beta cells continuously secreting insulin ,leading to hyperinsulinemia (Nichols *et al.*, 2022).

Reduced opening of KATP channels is also associated with increased extracellular glucose, which is related to insulin release. When extracellular glucose levels increase, glucose is transported to the cytosol by glucose transporter 2 (GLUT-2); therefore, ATP production increases. The increase in cytosolic glucose results in gradual depolarization, which causes the closure of KATP channels. After closure of KATP channels, the membrane depolarizes to approximately -50 mV, which triggers a potential action and activates L-type voltage-gated Ca2+ channels (L-Ca2+) and T (T-Ca2+) channels. This can cause Ca2+ influx, leading to an increase in intracellular Ca2+ levels, which triggers exocytosis of insulin-containing granules (Rodríguez-Rivera and Barrera-Oviedo, 2024). When insulin levels in the body continue to rise, lipolysis is inhibited and fat storage is increased through the synthesis and storage of triglycerides in adipocytes, ultimately contributing to sustained fat accumulation and increasing the risk of obesity (Cowen and Bhatnagar, 2020).

This systematic review has several strengths. First, the studies used come from various countries, so the data obtained is more diverse. Second, the determinants of obesity are analyzed using several indicators, such as BMI, WC, and

[DOI: 10.18502/jnfs.v10i4.20015]

body composition, including body fat percentage and muscle indicators. Third, this review examines the relationship of potassium from different measurements (intake and Na:K ratio). However, this systematic review also has several limitations. This study has three main limitations. First, the reliance on only three databases restricts the scope of included studies. Second, variations in cut-off points across studies may affect comparability. Third, the predominance of cross-sectional designs limits the ability to establish causal relationships.

Conclusion

Among the ten articles examining the role of potassium in reducing obesity incidence, the results remain inconsistent. Most studies investigated potassium intake simultaneously with the sodium-to-potassium ratio, and the results of this ratio were more consistent in relation to obesity reduction. It is recommended to assess obesity outcomes through measurements of body composition, including fat mass, muscle mass, WC, and BMI, rather than relying on a single measurement. Confounding variables such as caloric intake and potassium-rich food sources should be thoroughly evaluated to understand the role of potassium in obesity comprehensively.

Acknowledgments

The authors would like to thank the Faculty of Public Health, Airlangga University, especially the Nutrition Study Program, for providing quality knowledge that facilitated the completion of this systematic review. Deep gratitude is also directed to the faculty advisor for their guidance and assistance throughout the writing process.

Author's contribution

Fatimatuzahroh D and Farapti F were the design researchers. Fatimatuzahroh D was involved in data curation. Fatimatuzahroh D and Farapti F designed the methodology and supervised the work. Fatimatuzahroh D wrote the original draft and Dhandapani S supervised the manuscript writing. All authors finally read the manuscript and approved it for publishing.

Conflict of interest

The authors declared no conflict of interest.

Funding

This research received no funding.

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[DOI: 10.18502/jnfs.v10i4.20015]