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The visceral adiposity index as a predictor of chronic kidney disease; a systematic review and meta-analysis

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ABSTRACT

Introduction: Visceral fat accumulation and insulin resistance play significant roles in the pathogenesis of chronic kidney disease (CKD).

Objectives: This study aimed to assess the association between the visceral adiposity index (VAI) and CKD using a systematic review and meta-analysis method.

Materials and Methods: The sources were searched in the Web of Science, Cochrane, PubMed, Embase, and Scopus databases, as well as the Google Scholar search engine. Data were analyzed using STATA 14 at a significance level of $P < 0.05$.

Results: The results obtained from a combination of 21 observational studies revealed that CKD risk increased with high VAI values in total subjects (OR: 1.12, 95% CI: 1.08, 1.16), men (OR: 1.14, 95% CI: 1.07, 1.22), and women (OR: 1.22, 95% CI: 1.13, 1.32), as well as in cross-sectional (OR: 1.12, 95% CI: 1.07, 1.17) and cohort (OR: 1.17, 95% CI: 1.07, 1.29) studies. In addition, high VAI values elevated CKD risk in Taiwan (OR: 1.50, 95% CI: 1.08, 2.08), Turkey (OR: 1.47, 95% CI: 1.02, 2.10), China (OR: 1.35, 95% CI: 1.14, 1.60), Cameroon (OR: 1.13, 95% CI: 1.05, 1.22), and the USA (OR: 1.05, 95% CI: 1.03, 1.07).

Conclusion: The risk of CKD rose with high VAI values in all participants (12%), with a higher rate in women (22%) than in men (14%). Moreover, the highest and least risks were reported in Taiwanese and USA patients.

Registration: This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD420251037963) and Research Registry (UIN: reviewregistry1984) websites.

Implication for health policy/practice/research/medical education:
This research demonstrates the importance of visceral adiposity index (VAI) as a predictor of CKD, which can be useful in chronic kidney disease diagnosis, as the risk of chronic kidney disease rose in all subjects due to high VAI values. Moreover, Taiwanese women and patients were the two groups most exposed to the risk. These results need to be confirmed through further studies in this field.

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Meta-analysis

Introduction

The visceral adiposity index (VAI) is a reliable index for visceral fat accumulation and dysfunction in the adipose tissue (1). VAI is calculated based on the body mass index (BMI), waist circumference (WC), triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C) (2). BMI does not always represent excessive body fat as it is influenced by gender, age, ethnicity, and muscle mass (3). WC is also often used to assess abdominal obesity and cannot accurately detect subcutaneous and visceral abdominal fat (4). Compared to typical obesity indices, however, VAI considers visceral adipose distribution, hence it is closer to MRI findings (2,5). VAI is linked to hypertension and arterial atherosclerosis (2, 6-8). A greater VAI score is reportedly associated with an increase in the risk of chronic kidney disease (CKD) (9,10). On the other hand, the prevalence of CKD and obesity has been on the rise during the last three decades (11). Visceral fat accumulation and insulin resistance play significant roles in the pathogenesis of CKD (12). CKD is also connected to the elevated risk of hospitalization, cardiovascular disease (CVD), and mortality (13-15). Thus, this study aimed to evaluate the association between VAI and CKD as a heightened risk of CKD with a greater VAI score has been reported in some studies (16,17). However, no significant relationship between VAI and CKD risk has been found in other investigations (15,18). Hence, this study focused on this topic with a systematic review and meta-analysis method.

Objectives

This study aimed to assess the association between the VAI and CKD using a systematic review and meta-analysis method.

Material and Methods

This study was designed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (19). Its protocol was registered in the PROSPERO (International Prospective Register of Systematic Reviews) and research registry websites.

Search strategy

The sources in the Web of Science, Cochrane, PubMed, Embase, and Scopus databases, as well as the Google Scholar search engine, were searched up to 10 April 2025. Medical Subject Headings (Mesh) and their equivalents were used in the search strategy. The keywords were combined with (AND, OR) operators.

The PECO components (Population, Exposure, Comparison, Outcomes) were used as the search strategy in the PubMed database. The sources of related studies were also searched manually. The search strategy in the Scopus database was as follows: (TITLE-ABS-KEY (chronic AND kidney AND disease OR chronic AND renal AND disease OR "Renal Insufficiency, Chronic") AND TITLE-ABS-KEY (visceral AND adiposity AND index))

The study population consisted of studies that investigated the relationship between VAI and CKD. The exposure was high VAI values. The comparison group included individuals with low VAI values. The main outcome was examining the association between VAI and the risk of CKD.

Inclusion criterion

Observational studies that examined the connection between VAI and the risk of CKD.

Exclusion criteria

Non-observational studies, those that used the Chinese VAI, repeated studies, repeated studies, studies with poor quality in the qualitative assessment phase, letters to the editor-in-chief, review studies, studies without accessible full texts, and those lacking required data for analysis.

Quality assessment

Two authors assessed the quality of studies with the Newcastle Ottawa Scale, in which each question was assigned one star at maximum (except for the comparison question to which two stars could be assigned). Therefore, the minimum and maximum scores were zero and 10, respectively (20).

Data extraction

Data such as the author's name, study type, mean age, the link between VAI and CKD with a confidence interval of 95%, country, comparison group, year, and sample size were extracted by two authors.

Statistical analysis

Data were analyzed using the logarithm of each index (OR: Odds ratio; HR: Hazard ratio; RR: Relative risk; SIR: Standardized incidence ratio), and the studies were combined together. The heterogeneity between the studies was evaluated using the I^2 indicator. The fixed effect and random effect models were used in conditions with low and high heterogeneity, respectively. Data were analyzed with STATA 14 at a significance level of $P < 0.05$ for all statistical tests.

Results

In total, 301 articles were retrieved at the search stage, among which 398 repeated studies were excluded from the study. After reviewing the abstracts, nine studies without full texts were removed from this meta-analysis. Of the 155 remaining articles, 69 studies without the

required data for analysis were excluded from this review. Of 86 remaining articles, 65 studies were omitted based on exclusion criteria, and 21 articles were included in this review (Figure 1).

Of the 21 reviewed studies, 15 and 6 articles were cross-sectional and cohort, respectively (Table 1).

As shown in Figure 2, high VAI values increased the risk of CKD (OR: 1.12, 95% CI: 1.08, 1.16). Among the studied countries, high VAI values raised CKD risk in Taiwan (OR: 1.50, 95% CI: 1.08, 2.08), Turkey (OR: 1.47, 95% CI: 1.02, 2.10), China (OR: 1.35, 95% CI: 1.14, 1.60), Cameroon (OR: 1.13, 95% CI: 1.05, 1.22), and the USA (OR: 1.05, 95% CI: 1.03, 1.07). The highest and least risks were reported in Taiwanese and USA patients (Figure 3). Additionally, the risk of CKD rose in cross-sectional (OR: 1.12, 95% CI: 1.07, 1.17) and cohort (OR: 1.17, 95% CI: 1.07, 1.29) studies due to heightened VAI values (Figure 4).

The risk of CKD was amplified in men (OR: 1.14, 95% CI: 1.07, 1.22) and women (OR: 1.22, 95% CI: 1.13, 1.32) because of elevated VAI values (Figures 5 and 6).

The meta-regression (Figure 7) revealed no statistically significant relationship between "multiplied VAI values and CKD risk" and the publication years of the studies (P = 0.193).

According to the sensitivity analysis, sources 21 and 29 were the most influencing studies on the final result of this meta-analysis (Figure 8).

Discussion

In total, the 21 reviewed observational studies indicated that the risk of CKD increased in total subjects (12%), men (14%), and women (22%), as well as in cross-sectional (12%) and cohort (17%) studies due to high values of VAI. Furthermore, CKD risk rose in Taiwan (50%), Turkey (47%), China (35%), Cameroon (13%), and the USA (5%).

In the meta-analysis of seven studies by Fang et al, the VAI was a predictor of CKD incidence (OR: 6.00, 95% CI: 3.00, 14.00) (37), which corresponds to our results,

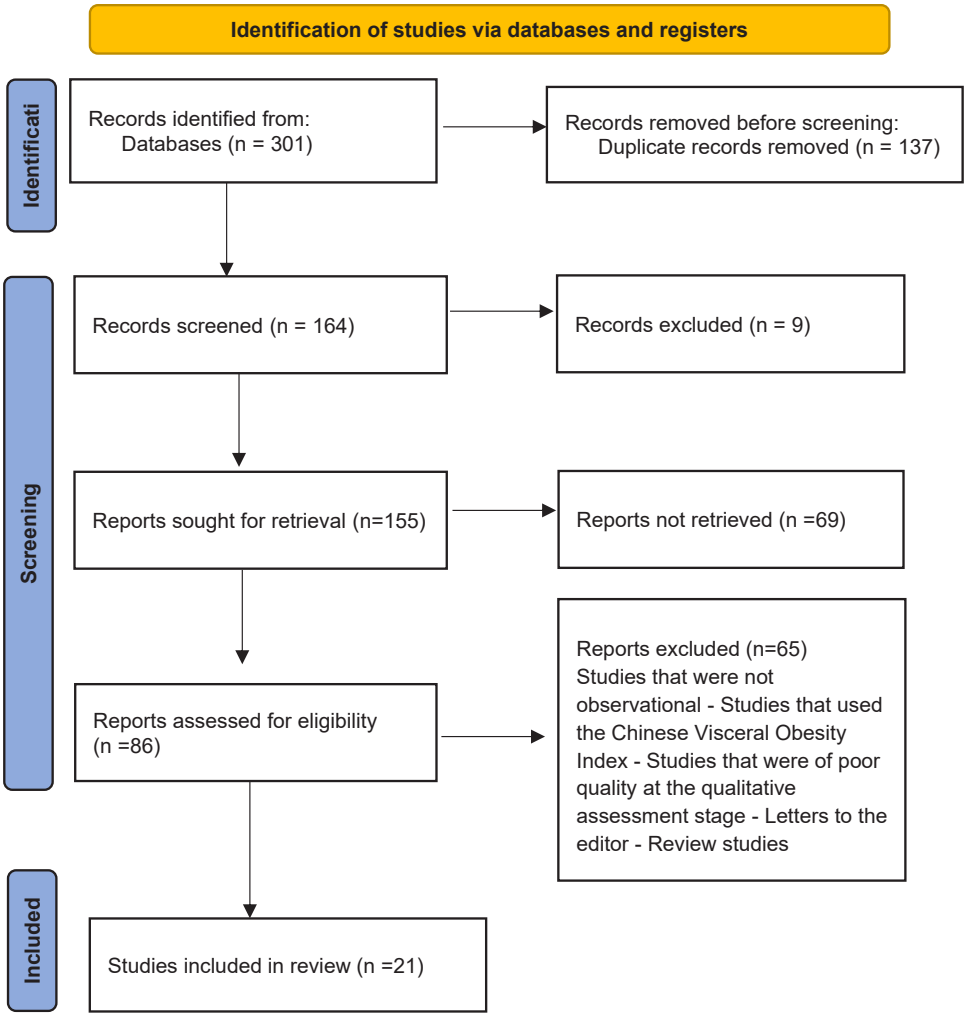

Figure 1. The PRISMA flow chart of study selection.

Table 1. Characteristics of studies

Author, year	Index	Country	Type of Study	Duration of study	Total number	Mean age (year)	Association Between VAI and CKD			Association Between VAI and CKD in male			Association Between VAI and CKD in female		
							OR/HR	Low	Up	OR/HR	Low	Up	OR/HR	Low	Up
Zhao X, 2025 (16)	OR	China	Cohort	from Jan 2017 to Aug 2021	1817	63.33	1.38	1.18	1.63	1.03	1.01	1.06	1.53	1.1	2.14
Yu J, 2025 (17)	HR	China	Cohort	from Jun to Nov 2011	5252	55.7	1.2	1.07	1.33	1.21	1.01	1.44	1.17	1.01	1.35
Li C, 2024 (21)	OR	USA	Cross-sectional	2007 to 2018	2508	5876	1.05	1.049	1.05	1.04	1.01	1.08	1.03	1	1.08
Arslan N, 2023 (18)	OR	Turkey	Cohort	between Mar 2020 and Sep 2021	188	56.21	1.468	0.951	1.952	NR	NR	NR	NR	NR	NR
Jin J, 2023 (22)	OR	Korea	Cross-sectional	2016 to 2018	NR	NR	NR	NR	NR	1.24	0.80	1.92	1.77	1.08	2.91
Qin Z, 2023 (10)	OR	USA	Cross-sectional	2005–2018	35018	46.44	1.04	1.02	1.06	0.97	0.9	1.05	1.04	1.01	1.07
Peng W, 2023 (23)	OR	USA	Cross-sectional	2011-2018	6085	69.2	1.23	1.02	1.48	1.31	1.02	1.68	1.16	0.87	1.53
Bullen AL, 2022 (24)	OR	USA	Cohort	between Jan 2003 and Jun 2007	27550	65	1.12	1.04	1.2	NR	NR	NR	NR	NR	NR
Choumessi AT, 2022 (25)	OR	Cameroon	Cross-sectional	from Jun to Aug 2020	200	55-64	1.13	1.05	1.22	NR	NR	NR	NR	NR	NR
Shi Y, 2022 (26)	OR	China	Cross-sectional	from Mar 2018 to Aug 2018	13055	63.81	1.67	1.29	2.16	NR	NR	NR	NR	NR	NR
Lei L, 2022 (27)	HR	China	Cohort	between Jan 2017 and Jul 2021	5583	70.69	1.052	1.029	1.076	1.09	1.02	1.16	1.05	1.02	1.07
Kim B, 2022 (28)	OR	Korea	Cross-sectional	2015–2019	7736	69.7	NR	NR	NR	3.19	2.12	4.79	2.41	1.94	3
Li M, 2021 (29)	OR	China	Cross-sectional	NR	8591	64.8	1.59	1.31	1.93	NR	NR	NR	NR	NR	NR
Chen IJ, 2021 (30)	OR	Taiwan	Cross-sectional	between Jan and Oct 2014	400	64.47	NR	NR	NR	1.2	0.85	1.69	1.32	1.04	1.69
Seong JM, 2021 (31)	OR	Korea	Cross-sectional	between Jan and Dec 2015	4947	51.75	NR	NR	NR	6.26	2.25	17.40	2.78	0.88	8.74
Bamba R, 2020 (32)	HR	Japan	Cohort	from 1994 to 2016	15159	41.71	NR	NR	NR	1.08	1.03	1.14	1.18	1.01	1.39
Xiao H, 2020 (33)	OR	China	Cross-sectional	From Dec 2017 to Mar 2018	1877	54.28	NR	NR	NR	2.03	0.84	4.91	1.06	0.56	1.99
Chen YC, 2018 (34)	OR	Taiwan	Cross-sectional	between Jan and Dec 2013	23570	>=18	1.5	1.08	2.08	1.62	1.13	2.32	1.28	0.66	2.47
Xu X, 2016 (15)	OR	China	Cross-sectional	between Jun and Oct 2012	1581	57.47	1.68	0.99	2.83	NR	NR	NR	NR	NR	NR
Dai D, 2016 (35)	OR	China	Cross-sectional	from Jan 2012 to Aug 2013	11192	53.83	NR	NR	NR	4.8	1.94	11.92	4.21	2.09	8.47
Huang J, 2015 (36)	OR	China	Cross-sectional	Jun–Oct 2012	2142	44.9	NR	NR	NR	1.41	0.71	2.82	1.68	0.92	3.06

NR: Not reported; VAI: Visceral adiposity index; CKD: Chronic kidney disease; OR: Odds ratio; HR: Hazard ratio.

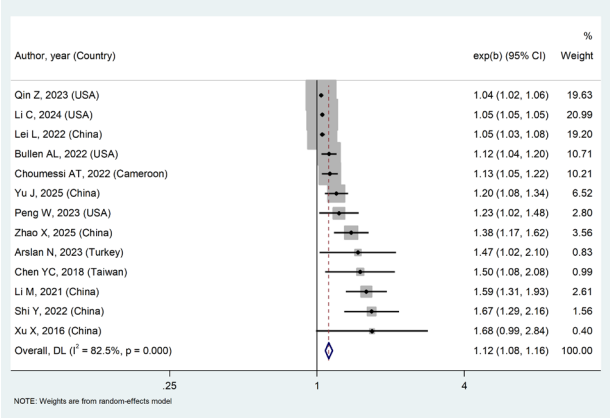

Figure 2. Forest plot showing the association between VAI and risk of CKD.

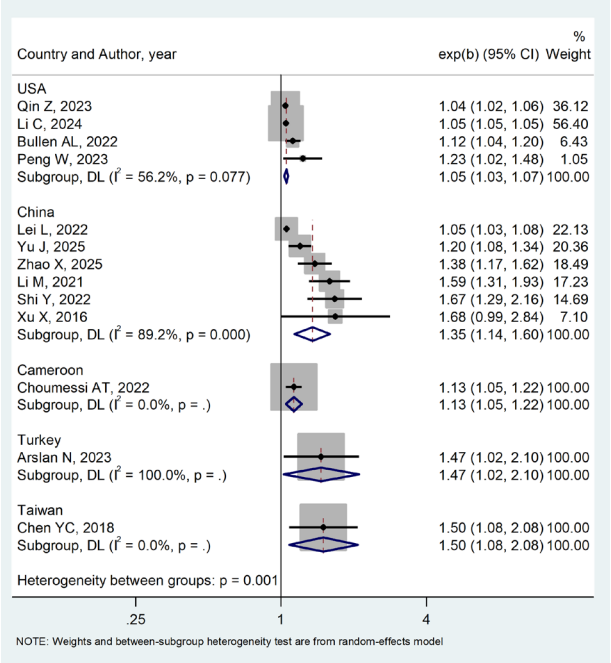

Figure 3. Forest plot showing the association between VAI and risk of CKD by country.

with the difference that the three-fold reviewed studies in our meta-analysis enable more generalizability of the results.

In addition, Zheng et al conducted a meta-analysis on participants in China and reported that elevated VAI values amplified the risk of CKD in all participants (RR: 2.24, 95% CI: 1.70, 2.95), men (RR: 2.36, 95% CI: 1.54, 3.36), and women (RR: 2.57, 95% CI: 1.57, 4.22) (9). Their results completely agree with those of this study because they also reported that the female gender was an intensifying factor for CKD development in those with high VAI levels.

Based on a meta-analysis by Wang et al, the risk of prediabetes rose (OR: 1.68, 95% CI: 1.44, 1.96) because of heightened VAI values (38). The results of a meta-

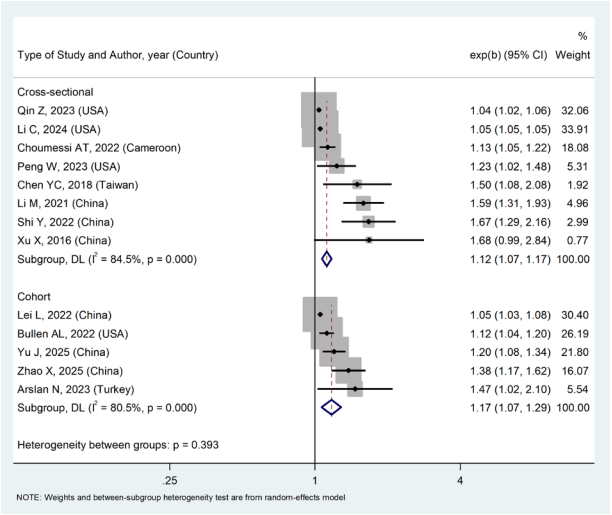

Figure 4. Forest plot showing the association between VAI and risk of CKD by design.

analysis by Shen et al, showed that the VAI could elevate the risk of type 2 diabetics (RR: 1.44; 95% CI: 1.23, 1.68) (39). In a recent meta-analysis by Deng et al, the risk of diabetics was amplified in men (OR: 2.83, 95% CI: 2.30, 3.49) and women (OR: 3.32, 95% CI: 2.48, 4.45) due to elevated VAI values (40). The above-mentioned meta-analysis are in line with the current study in which a high VAI accounts for a risk factor. The present results are also confirmed because of the connection between diabetes and CKD. In a study on diabetes type 2 patients in China, Zhao et al found that high levels of VAI were a risk factor for diabetic kidney disease (HR:1.38, 95% CI: 1.18, 1.63) (16). A cohort study by Yu et al revealed that elevated VAI levels were associated with increased CKD risk (HR: 1.20, 95% CI: 1.07, 1.33) and urine albumin excretion (HR: 1.21, 95% CI: 1.06, 1.37) (17). Heightened VAL raised the risk of CKD (OR: 1.12, 95% CI: 1.04, 1.20) in a cohort study by Bullen et al (24). Similarly, our combined results of cohort studies indicated that the amplified level of VAI was a risk factor for CKD development.

Based on a cross-sectional study in the USA by Li et al, the risk of diabetic kidney disease was intensified (OR: 1.35, 95% CI: 1.35, 1.36) by high VAI values (21). Likewise, the risk of CKD rose (OR: 1.23, 95 %CI: 1.02, 1.48) with elevated VAI levels in a cross-sectional study by Peng et al (23). In another cross-sectional study, Qin et al reported that the risks of albuminuria (OR: 1.30, 95% CI: 1.07, 1.58) and CKD (OR: 1.27, 95% CI: 1.08, 1.49) were elevated by increased VAI values (10). The combined results of cross-sectional studies in our review also revealed that heightened VAI levels were linked to the raised risk of CKD.

In Taiwan, Chen et al presented evidence that high VAI values intensified the risk of CKD development (OR: 1.5, 95% CI: 1.08, 2.08), and men were more

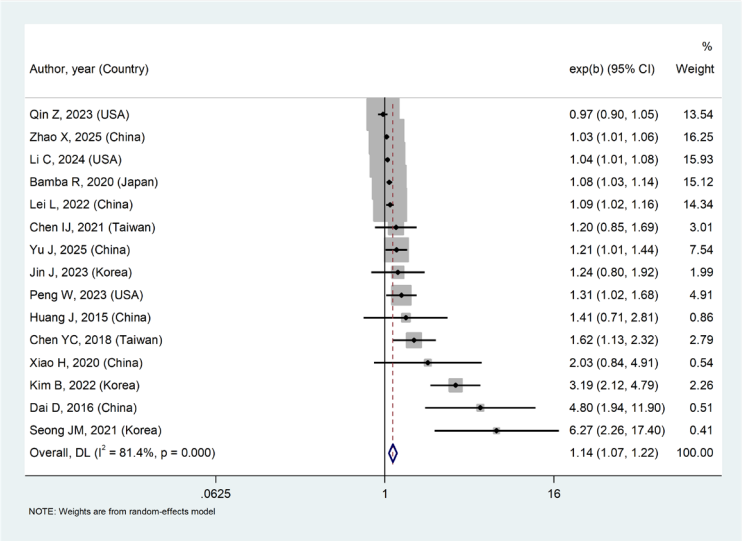

Figure 5. Forest plot showing the association between VAI and risk of CKD in males.

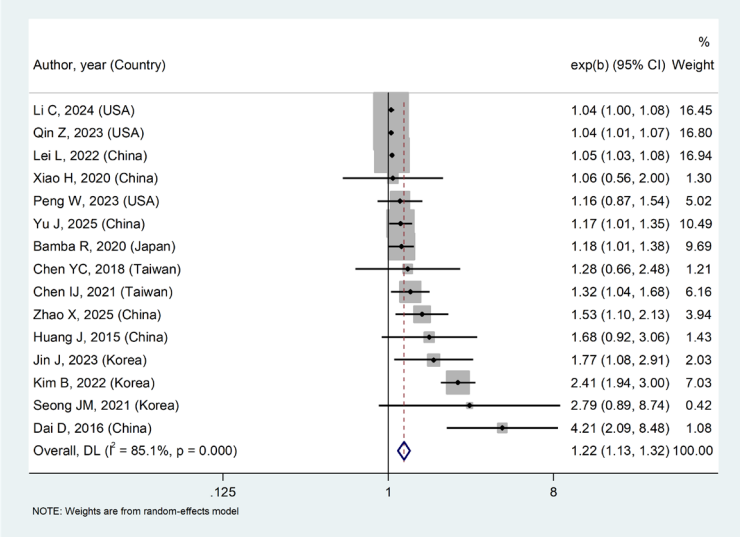

Figure 6. Forest plot showing the association between VAI and risk of CKD in females.

prone to this risk than women (34). In their study, the gender comparison results did not agree with those of our investigation in which women were more predisposed to CKD development than men among those with high VAIs. Nevertheless, the dissimilarities in the study type, ethnicity, and patients' age might have led to the different results in the two studies.

Conclusion

This research demonstrates the importance of VAI as a predictor of CKD, which can be useful in CKD diagnosis, as the risk of CKD rose in all subjects due to high VAI values. Moreover, Taiwanese women and patients were the two groups most exposed to the risk. These results need to be confirmed through further studies in this field.

Limitations of the study

The subgroup analysis was not possible based on the age variable because the patients' mean age was in their fifth and sixth decades of life in the reviewed studies, with insufficient diversity. ii) Most studies were conducted in China and the USA, and no related study was found in some other countries. iii) The results were not presented based on patients' gender, resulting in a slightly different overall conclusion and results based on patients' gender.

Acknowledgments

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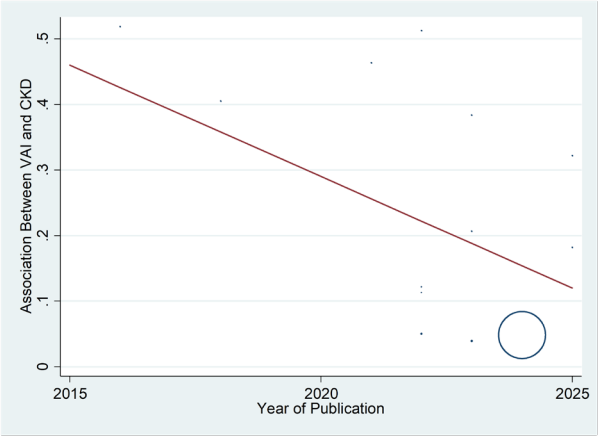

Figure 7. Meta-regression diagram examining the relationship between "VAI and CKD " and the year of publication of studies.

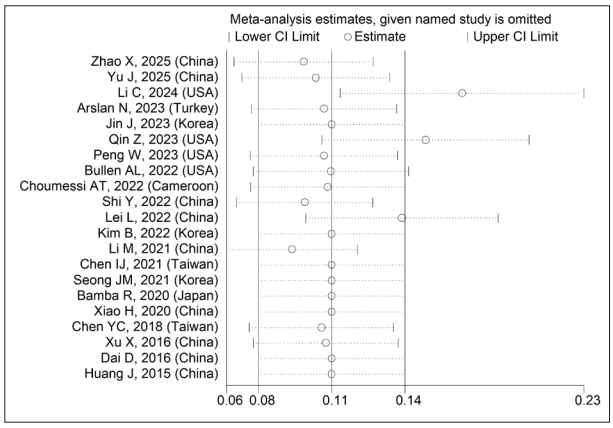

Figure 8. Plot of sensitivity analysis.

Authors' contribution

Conceptualization: Amin Dalili, Mahdi Behi, and Asghar Dalili.
Data curation: Amin Dalili and Hossein Amini.
Formal analysis: Fatemeh Hasanzadeh Sablouei and Babak Gholamine.
Investigation: Asghar Dalili, Mahdi Behi, and Sina Salati.
Methodology: Mahsa Rezaee, Babak Gholamine, and Fatemeh Hasanzadeh Sablouei.
Project management: Asghar Dalili.
Supervision: Amin Dalili and Mahsa Rezaee.
Validation: Fatemeh Hasanzadeh Sablouei and Ehsan Habibi.
Visualization: Hossein Amini and Ehsan Habibi.
Writing–original draft: All authors.
Writing–review and editing: All authors.

Conflicts of interest

There are no competing interests.

Ethical issues

This study has been compiled based on the PRISMA checklist, and its protocol was registered on the PROSPERO (ID: CRD420251037963) and the Research Registry websites (Unique Identifying Number (UIN) reviewregistry1984). Besides, ethical issues (including plagiarism, data fabrication, and double publication) have been completely observed by the author.

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