Research Article

Clinical Utility Of Serum Uric Acid For Screening, Risk Stratification, And Prediction Of Metabolic Syndrome In Adults: A Systematic Review

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Abstract

Background: Serum uric acid (SUA) has evolved from a simple marker of gout to a central metabolic mediator and a robust predictor of cardiometabolic risk. This systematic review assesses the clinical utility of SUA for screening, risk stratification, and predicting metabolic syndrome (MetS) in adults.

Methods: A comprehensive analysis was conducted on primary research articles, including data from large-scale national surveys (e.g., KNHANES, NHANES), prospective longitudinal cohort studies (e.g., CHIEF, Tromsø Study), and community-based cross-sectional investigations. The evidence from diverse global populations, including cohorts from Taiwan, China, Korea, South Asia, Brazil, and Europe, was synthesized to evaluate the association between SUA and MetS, identify optimal screening thresholds, and assess its predictive and prognostic value across different age groups and sexes.

Results: Elevated SUA was consistently associated with an increased risk of incident MetS and remained predictive even within the upper normal range, with optimal thresholds of approximately 4.9 mg/dL in women and 6.3 mg/dL in men. The diagnostic performance of SUA was greater in women (AUC ≈0.77) than in men (AUC ≈0.66), and its predictive power is most robust during young adulthood. Beyond screening, the triglyceride-glucose (TyG) index and SUA/creatinine ratio enhanced cardiovascular risk stratification, while SUA demonstrated high diagnostic accuracy for metabolic dysfunction-associated steatotic liver disease (MASLD). A distinct "diabetes paradox" was also observed, with SUA levels peaking during prediabetes and declining after the onset of overt diabetes.

Conclusion: Current evidence supports SUA as a simple, inexpensive, and clinically useful biomarker for the screening, risk stratification, and prediction of MetS. The application of sex-specific thresholds and integration with complementary biomarkers such as the TyG index and SUA/creatinine ratio may improve early identification of high-risk individuals. Future research must prioritise large-scale randomized controlled trials to establish the definitive therapeutic role of urate-lowering therapies in managing metabolic disease.

Key Words: uric acid, metabolic syndrome, central obesity, systematic review, risk stratification, prediction.

Introduction

Cardiovascular disease and type 2 diabetes mellitus have increased substantially over recent decades, largely driven by lifestyle changes and nutritional transitions [1]. A major contributor to this burden is metabolic syndrome (MetS)**,** a cluster of central obesity, hypertension, hyperglycaemia, and dyslipidaemia that more than doubles the risk of atherosclerotic cardiovascular disease and cardiovascular mortality [2–4]. MetS affects approximately 30% of urban adults in India and up to 45% of adults in parts of the Asia–Pacific region, highlighting the need for early identification of individuals at increased metabolic risk [4–6].

Serum uric acid (SUA), the final product of purine metabolism, has traditionally been regarded as a biomarker of gout and nephrolithiasis [7,8]. Increasing evidence, however, suggests that SUA is independently associated with hypertension, insulin resistance, dyslipidaemia, and other cardiometabolic abnormalities [7–10]. Mechanistically, elevated SUA promotes oxidative stress and chronic inflammation through increased xanthine oxidase activity and reactive oxygen species generation, leading to endothelial dysfunction, impaired nitric oxide bioavailability, and insulin resistance [7–12]. These findings support a plausible biological link between SUA and the development of MetS.

The clinical relevance of SUA extends beyond overt hyperuricaemia. Prospective studies have shown that SUA concentrations within the conventional normal range, as well as longitudinal increases in SUA, independently predict the future development of MetS [9,12]. These observations suggest that traditional reference ranges established for gout may not adequately identify individuals at increased cardiometabolic risk [8,12].

Despite the growing evidence, uncertainty remains regarding the optimal SUA thresholds and its clinical utility for screening, risk stratification, and prediction of MetS across different populations [8]. Therefore, this systematic review synthesizes the available

evidence to evaluate the role of SUA as a simple, inexpensive, and widely accessible biomarker for the early identification of adults at risk of MetS and its associated cardiometabolic complications [8,12].

Methods

Study Design: This systematic review was conducted in strict accordance with the PRISMA 2020 guidelines to ensure transparency and methodological rigor [10]. The review synthesized primary research evaluating the clinical utility of SUA as a biomarker for screening, risk stratification, and longitudinal prediction of MetS in adult populations [8].

Eligibility Criteria
Inclusion Criteria:

- Study Design: Original cross-sectional, longitudinal/prospective cohort, and case-control studies.
- Population: Adults aged 18 years and older.
- Exposure: Measurement of SUA levels, including analysis by quartiles or specific clinical thresholds.
- Outcome: Diagnosis of MetS based on established clinical criteria, such as the International Diabetes Federation or the National Cholesterol Education Program's Adult Treatment Panel III [9,12].

Exclusion Criteria:

- Secondary research, including systematic reviews and meta-analyses.
- Pediatric populations.
- Non-primary study types, such as clinical guides or commentaries.
- Animal models, unless explicitly used to support biological plausibility for human observations [7].
- Duplicate records or those with inaccessible full-text data.

Information Sources: A comprehensive literature search was conducted across major electronic databases—including PubMed, EMBASE, COCHRANE library and Web Of Science—supplemented by a search of relevant web repositories to ensure the inclusion of all pertinent primary observational studies.

Search Strategy: The search strategy employed a combination of keywords and Boolean operators: "serum uric acid" OR "hyperuricemia" AND "metabolic syndrome" OR "MetS" AND "screening" OR "risk stratification" OR "prediction". Results were restricted to English-language publications.

Study Selection: All records identified through the database search were imported into Microsoft Excel, and duplicate records were removed. Titles and abstracts were screened against the predefined eligibility criteria by a single reviewer. Studies that met the inclusion criteria or for which eligibility could not be determined from the title and abstract were retrieved for full-text assessment. Full-text articles were subsequently evaluated for eligibility using the same predefined inclusion and exclusion criteria. Reasons for exclusion at the full-text screening stage were documented. The study selection process was conducted in accordance with the PRISMA 2020 guidelines and is summarized in the PRISMA flow diagram.

Data Extraction: Data were extracted using a standardized proforma to capture:

- Study characteristics: Author, year, country, and study design.
- Demographics: Sample size, age range, and gender distribution.
- MetS Definition: Specific diagnostic criteria used (IDF or NCEP-ATP-III)
- SUA Metrics: Analytical methods and gender-specific cut-off values.
- Statistical Findings: Odds ratios, hazard ratios, and area under the curve.

Quality Assessment: The quality of included studies was independently appraised, with a focus on selection bias, the reliability of biochemical measurements, and the robustness of statistical models. For Longitudinal Cohort Studies, the Newcastle-Ottawa Scale (NOS)was used for evaluation, and for Cross-Sectional and Case-Control Studies, the Diagnostic Validity Scale was used
RISK OF BIAS: Risk of bias assessments evaluated whether multivariate models adequately adjusted for confounding factors, such as age, BMI, smoking status, alcohol consumption, and physical activity, to ensure the independent predictive value of SUA [9].

Data Synthesis: A qualitative narrative synthesis was conducted, grouping studies by their clinical utility:

- Screening: Evaluating the strength of cross-sectional associations between SUA and MetS components [8].

- Risk Stratification: Comparing optimal gender-specific thresholds for identifying MetS, insulin resistance, and metabolic liver disease.
- Prediction: Analyzing longitudinal data to determine the role of baseline SUA and longitudinal changes in predicting incident MetS over time [9,12].

Result

Study Selection And Eligibility

The systematic review process identified a total of 4661 articles (PUBMED: 949, EMBASE: 3229, COCHRANE: 50, WEB OF SCIENCE:433). After removing duplicates (n=1632), the screening process removed a total of 1289 records for being case reports, review articles, etc., and 1459 articles were excluded for being not retrievable. Following the assessment of eligibility, 257 articles were excluded. A final set of 23 primary research articles (4 longitudinal cohorts, 18 cross-sectional studies, and 1 case-control study) provided the data for this qualitative synthesis (Figure 1). The aggregated characteristics of the eligible studies for risk stratification are presented in Table 1. Six studies were conducted in China, three each in India & Pakistan, two each in Taiwan and Korea, and one each in Norway, Brazil, Japan, Bangladesh, and Italy. The 23 studies involved 82,173 participants representing a diverse population.

Figure 1: Preferred Reporting Items For Systematic Reviews And Meta-Analyses (Prisma) Diagram Outlining Article Selection For Review.

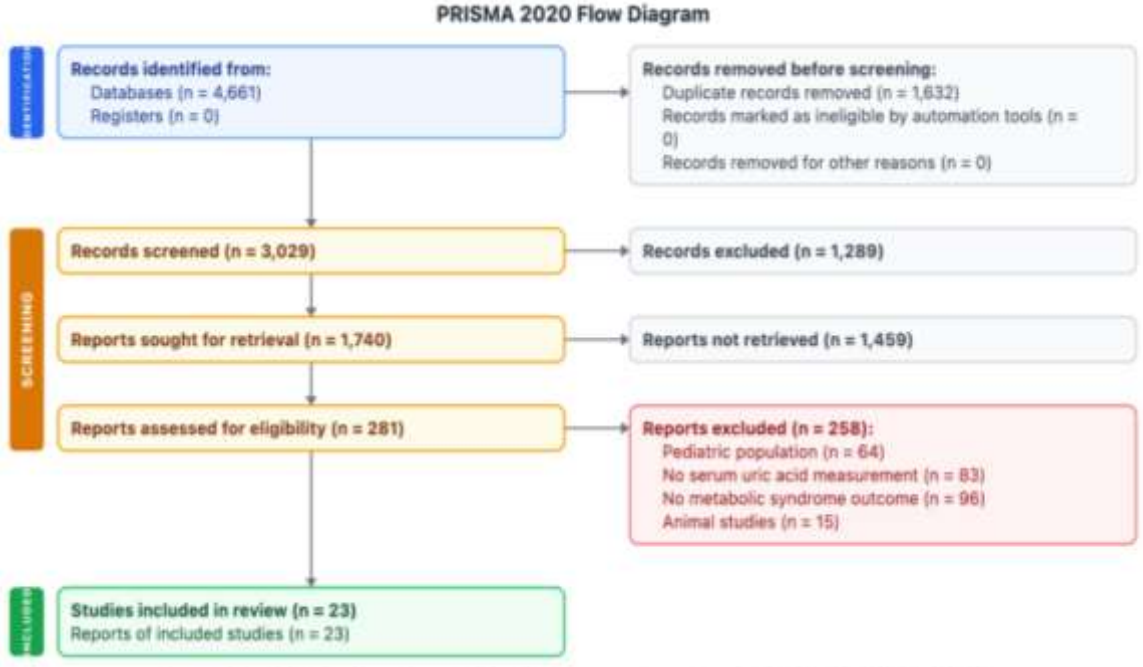

Table 1: Characteristics Of Eligible Studies Included In This Review

Study (Author, Year)	Country	Design	Sample (N)	Female %	Diagnostic Criteria for MetS	Analytical Methods for SUA	Significant SUA Threshold(s)	Outcome for Risk Stratification
Kim (2023)[13]	Korea	Cross-sectional	13,454	51.5%	NCEP ATP III	Uricase-based	≥6.0 mg/dL (High SUA)	Association with 5 MetS components
Norvik (2016) [14]	Norway	Longitudinal cohort	6,083	50.7%	NCEP-ATP III (revised)	Enzymatic colorimetric	Per 59 µmol/L (1 mg/dL) increment	7-year incidence of MetS
Zhang (2013) [15]	China	Longitudinal cohort	7,399	60.0%	IDF	Enzymatic	6.3 mg/dL (M); 4.9 mg/dL (F)	3-year prediction of future MetS

Huang (2026) [16]	Taiwan	Longitudinal cohort	2,890	10.0%	NCEP ATP III (modified)	NR*	≥7.0 mg/dL (M); ≥6.0 mg/dL (F)	6-year incident MetS in young military
Oad (2026) [17]	Pakistan	Cross-sectional	344	52.9%	MetS / MASLD	Chemiluminescence	7.19 mg/dL (M); 6.12 mg/dL (F)	Diagnosis of MASLD
Singh (2026) [18]	India	Cross-sectional	383	NR*	IDF	Uricase-based enzymatic	> 6.5 mg/dL	Prediction of MetS & Hypertension
Lin (2024) [19]	Taiwan	Cross-sectional	400	64.8%	Asian WHO	Roche cobas CCM	5.62 mg/dL (Optimal ROC)	Metabolic syndrome risk tertiles
Oliveira (2014) [20]	Brazil	Cross-sectional	289	0.0%	Alberti et al. (2009)	Enzymatic colorimetric	5.25 mg/dL	Additional criterion for MetS diagnosis
Casiglia (2023) [21]	Italy	Longitudinal cohort	20,724	50.6%	URRAH protocol	NR*	SUA/sCr ratio > 5.35	Prognosis of Cardiovascular (CV) events
Jeong (2019) [22]	Korea	Cross-sectional	5,758	56.5%	NCEP ATP III	NR*	6.05 mg/dL (M); 4.45 mg/dL (F)	Diagnosis of MetS
Acharya (2025) [23]	India	Cross-sectional	600	55.0%	NCEP-ATP III	Enzymatic colorimetric	Q4 > 7.0 mg/dL	Odds for MetS, Prediabetes, & T2DM
Nie (2023) [24]	China	Cross-sectional	1,267	56.1%	CDS (Chinese)	Roche C701 (Automatic)	~5.3 mg/dL (314.5 µmol/L)	Prediction of MetS in elderly population
Sakalli (2023) [25]	Turkey	Case-control	2,530	NR*	HOMA-IR Focus	colorimetric	≥4.86 mg/dL	Presence of Insulin Resistance (HOMA-IR)
Solanki (2023) [26]	India	Cross-sectional	180	NR*	NCEP ATP III (modified)	NR*	Association across all 5 components	Correlation with MetS component count
Zhu (2020) [27]	China	Cross-sectional	123	49.6%	Mild Hypertension	NR*	~4.9 mg/dL (293.5 µmol/L)	Endothelial dysfunction (RHI < 1.67)
Li (2022) [28]	China	Cross-sectional	1,947	31.4%	NCEP-ATP III (Asian)	Standard biochemical	Q4 ≥5.9 mg/dL (353 µmol/L)	Carotid Atherosclerosis & MetS in T2DM
Niijima (2026) [29]	Japan	Cross-sectional	13,562	NR*	Japanese Criteria	NR*	6.35 mg/dL (M); 5.05 mg/dL (F)	Thresholds for health guidance/preMetS
Siddiqui (2015) [30]	Pakistan	Cross-sectional	600	64.0%	ATP III	Enzymatic assay	≥7.0 mg/dL (M); ≥6.0 mg/dL (F)	Correlation with individual components
Abdullah (2025) [31]	Pakistan	Cross-sectional	176	43.2%	Hypertension Focus	NR*	>7.0 mg/dL (M); >6.0 mg/dL (F)	Frequency in Hypertensive patients
Huang/Xu (2020) [32]	China	Cross-sectional	1,035	47.4%	IDF / Chinese Guideline	Enzymatic (Auto-analyzer)	~5.9 mg/dL (351.5 µmol/L)	MetS prediction in the very elderly

Chen (2025) [33]	China	Cross-sectional	1,835	NR*	CAD angiographic severity	Standard biochemical	Continuous linear risk	TyG index mediation of CAD severity
Dal (2022) [34]	Turkey	Cross-sectional	174	NR*	NCEP ATP III	Standard biochemical	5.45 mg/dL	MetS prediction in outpatients
Ali (2020)[35]	Bangladesh	Cross-sectional	420	38.8%	NCEP-ATP III	Colorimetric	Q4 > 380.7 µmol/L (~6.4 mg/dL)	Prevalence of MetS and components

***NR = Not Reported in the specific source excerpts provided.**

Role of SUA in Screening for MetS

SUA is an inexpensive, readily available biomarker with considerable potential for screening individuals at risk of MetS. Evidence from diverse populations indicates that elevated SUA frequently precedes the onset of metabolic abnormalities, supporting its role in early risk identification [7–10,12,36].

Optimal Screening Thresholds

Accumulating evidence suggests that conventional hyperuricaemia thresholds (>7.0 mg/dL in men and >6.0 mg/dL in women) may be insufficient for MetS screening [15]. Across population-based studies, optimal screening thresholds consistently fall below these values and demonstrate clear sex-specific differences. In men, proposed cut-offs range from 5.25 to 6.35 mg/dL, whereas in women they range from 4.45 to 5.05 mg/dL (Oliveira A et al. [20]; Zhang ML et al. [15,17]; Jeong J et al. [22]; Niijima K et al. [29]). Importantly, even SUA concentrations within the conventional normal range were associated with increased metabolic risk. In a large Chinese cohort, individuals in the highest normal-range quartile (6.7–7.0 mg/dL in men and 5.3–6.0 mg/dL in women) had a significantly greater risk of developing MetS than those in the lowest quartile, with optimal predictive thresholds of 6.3 mg/dL for men and 4.9 mg/dL for women (Zhang ML et al. [15]).

Diagnostic Performance:

The diagnostic performance of SUA varies according to demographic characteristics but remains consistently clinically relevant. In the Korean KNHANES cohort, SUA discriminated MetS more accurately in women than in men, with AUCs of 0.773 (95% CI 0.755–0.790) and 0.659 (95% CI 0.637–0.681), respectively (Jeong J et al. [22]). Similar findings were reported by Kim YK et al. [13], indicating greater predictive utility among women. Screening performance was highest in younger adults (20–40 years), although clinically meaningful discrimination was also observed in individuals aged ≥80 years (Jeong J et al. [22]; Huang G et al. [32]). Furthermore, SUA demonstrated significant associations with all five components of MetS, particularly hypertension, hypertriglyceridaemia, and central obesity (Solanki A et al. [26]; Singh S et al. [18]).

Identification of Early Metabolic Abnormalities

Beyond identifying established MetS, SUA appears useful for recognising individuals at an earlier stage of metabolic dysfunction. Elevated SUA identified individuals in a pre-metabolic state before fulfillment of diagnostic criteria for MetS (Niijima K et al. [29]). Incorporation of SUA into routine screening increased the detection of high-risk individuals by 13% in apparently healthy populations (Oliveira A et al. [20]), while hyperuricaemic individuals exhibited a greater metabolic burden than normouricaemic individuals (3.69 vs. 2.68 MetS components), suggesting a higher likelihood of progression to overt MetS (Solanki A et al. [26]).

The predictive value of SUA should, however, be interpreted cautiously in individuals with diabetes. Although elevated SUA is consistently associated with prediabetes and early dysglycaemia, SUA concentrations tend to decline after the onset of overt diabetes because glycosuria enhances uric acid excretion (Kim YK et al. [13]; Huang G et al. [32]; Acharya K et al. [23]). Consistent with this observation, studies from South Asian populations reported an inverse association between SUA and established diabetes, suggesting that SUA is more informative during the transition from normoglycaemia to impaired fasting glucose than after diabetes has developed ("diabetes paradox") (Siddiqui et al. [30]; Ali N et al. [35]).

Screening for Metabolic Complications

The clinical utility of SUA extends beyond MetS to selected metabolic complications. SUA demonstrated excellent diagnostic performance for metabolic dysfunction-associated steatotic liver disease (MASLD), achieving AUCs of 0.99 in men and 0.93 in women, with optimal diagnostic thresholds of 7.19 mg/dL and 6.12 mg/dL, respectively (Oad AK et al. [17]).

Role of SUA in Risk Stratification

SUA provides incremental value for cardiometabolic risk stratification by identifying individuals at increased risk of MetS, cardiovascular disease, and vascular complications. Its prognostic performance is further enhanced when interpreted alongside markers of renal function, inflammation, and insulin resistance [13,21,34,37].

Advanced Prognostic Biomarkers

The serum uric acid-to-creatinine (SUA/creatinine) ratio has emerged as a more reliable prognostic indicator than SUA alone by accounting for variations in renal function [21]. In a population-based study involving more than 20,000 Italian adults, an SUA/creatinine ratio >5.35 independently predicted long-term cardiovascular events in both men and women, providing a unified prognostic threshold irrespective of sex-related differences in SUA concentrations (Casiglia E et al. [21]).

Integrated Biomarker Models

The predictive utility of SUA is strengthened when combined with inflammatory biomarkers. In the Korean KNHANES cohort, concurrent elevations of SUA and high-sensitivity C-reactive protein (hs-CRP) were associated with a greater prevalence of MetS components, particularly abdominal obesity and low HDL cholesterol in women (Kim YK et al. [13]). Similarly, combined assessment of SUA and hs-CRP improved the identification of individuals at high cardiometabolic risk in outpatient populations (Dal HC et al. [34]).

Cardiovascular Risk Stratification

Beyond metabolic risk, SUA is closely associated with vascular injury and atherosclerotic disease. In patients with newly diagnosed coronary artery disease (CAD), the triglyceride-glucose (TyG) index mediated 18.9% of the association between SUA and multivessel coronary lesions, highlighting the contribution of insulin resistance to cardiovascular risk (Chen Z et al. [33]). Elevated SUA was also independently associated with obesity, renal impairment, and smoking among hypertensive individuals, supporting its role as a marker of overall cardiovascular risk (Abdulla et al. [31]). Furthermore, an SUA threshold of 293.5 μmol/L (~4.9 mg/dL) identified elderly patients with untreated mild hypertension at increased risk of endothelial dysfunction (Zhu GH et al. [27]). Among patients with type 2 diabetes, those in the highest SUA quartile (≥353 μmol/L) had significantly greater odds of carotid artery plaque (OR 2.91) than those in the lowest quartile, indicating an association between elevated SUA and subclinical atherosclerosis (Li W et al. [28]).

Role of SUA in the Prediction of MetS

Prospective cohort studies consistently demonstrate that elevated SUA independently predicts the future development of MetS, with predictive value extending several years before clinical onset [14–16].

Prediction of Incident Metabolic Syndrome

Evidence from large longitudinal cohorts indicates that elevated baseline SUA is associated with an increased risk of incident MetS over 3–7 years of follow-up [14–16]. In the Tromsø Study, each 1 mg/dL increase in baseline SUA was associated with a 29% increase in MetS risk (HR 1.29) (Norvik JV et al. [14]). Similar findings were reported in the CHIEF Study, where elevated baseline SUA predicted new-onset MetS over 6 years in young adults (Huang WC et al. [16]). Likewise, participants in the highest SUA quartile of the Tianjin cohort had significantly greater risks of developing MetS than those in the lowest quartile (HR 1.29 in men and HR 1.62 in women) (Zhang ML et al. [15]).

Prediction Within the Normal SUA Range

The predictive value of SUA extends beyond hyperuricaemia. Individuals with SUA concentrations in the highest quartile of the conventional normal range were at significantly greater risk of developing MetS than those in the lowest quartile. Optimal predictive thresholds were identified as 6.3 mg/dL for men and 4.9 mg/dL for women, supporting the need for lower sex-specific cut-offs in metabolic risk assessment (Zhang ML et al. [15]).

Dynamic Prediction

Longitudinal changes in SUA also provide prognostic information. In the Tromsø Study, each 1 mg/dL increase in SUA over time (ΔUA) was associated with a 28% higher risk of incident MetS (OR 1.28) and was particularly predictive of hypertension and hypertriglyceridemia (Norvik JV et al. [14,15]).

Prediction of Individual Metabolic Components

In addition to predicting MetS, elevated SUA consistently preceded the development of individual cardiometabolic abnormalities, including hypertension, central obesity, prediabetes, endothelial dysfunction, and early atherosclerosis, reinforcing its role as an early indicator of progressive metabolic deterioration [13,23,27,31,35].

Discussion

This systematic review demonstrates that SUA is an independent predictor of incident MetS across diverse populations [14–16]. Elevated baseline SUA, including concentrations within the upper limit of the conventional normal range, was consistently associated with an increased risk of MetS over 3–7 years of follow-up [15]. Predictive performance differed by sex, with greater diagnostic accuracy observed in women than in men (AUC 0.77 vs. 0.66) [22]. Beyond predicting MetS, SUA provided incremental value for cardiovascular risk assessment. The TyG index mediated 18.89% of the association between SUA and multivessel coronary artery disease, while the SUA/creatinine ratio improved the prediction of long-term cardiovascular events by accounting for renal function [21,33].

Comparison with Previous Reviews

Previous systematic reviews and meta-analyses have established a bidirectional link between SUA and MetS and reported higher susceptibility to uric acid–related metabolic risk among women and younger individuals (Fan J et al. [38]; Yuan H et al. [39]). Our findings support this evidence and reinforce the idea that SUA goes beyond its traditional role as a biomarker for gout to serve as an indicator of cardiometabolic risk (Lee SJ et al. [7]; Dangana EO et al. [36]). Importantly, this review offers several clinically relevant insights that have received less attention in earlier analyses. These include the “diabetes paradox” seen in South Asian populations, where SUA peaks during prediabetes but declines after the onset of overt diabetes due to glycosuria-induced uricosuria [13,23,35]. The review also emphasizes the added prognostic value of the SUA/creatinine ratio and TyG index for cardiovascular risk assessment [21,33], and supports using population-specific screening thresholds, such as around 4.9 mg/dL in women, along with SUA's excellent diagnostic performance for MASLD (AUC 0.99 in men) [15,17,27,29].

Biological Mechanisms:

The connection between SUA and MetS is biologically plausible and operates through interconnected pathways involving oxidative stress, chronic inflammation, endothelial dysfunction, and impaired metabolic signaling. Intracellular uric acid promotes reactive oxygen species (ROS) production via activation of NADPH oxidase and xanthine oxidase, leading to mitochondrial dysfunction, ATP depletion, and endoplasmic reticulum stress, which favor liver fat accumulation [7,19,36,40,41]. These changes activate the NF-κB pathway and the NLRP3 inflammasome, increasing the production of CRP, TNF-α, IL-6, IL-1β, and IL-18, while reducing adiponectin secretion [7,13,32,40–43]. Simultaneously, inhibition of endothelial nitric oxide synthase (eNOS) decreases nitric oxide availability and contributes to insulin resistance [7,35,36,40,43,44]. Inhibition of AMP-activated protein kinase (AMPK) and activation of the renin–angiotensin system (RAS) further promotes liver fat buildup, high blood pressure, and blood vessel remodeling [7,36,41–43]. These mechanisms collectively provide a clear biological explanation for the links between high SUA, insulin resistance, obesity, dyslipidemia, hypertension, and MetS [13,18,41].

Clinical Implications:

The findings of this review support adding SUA to routine cardiometabolic risk assessments as an affordable and widely accessible adjunct biomarker for MetS and MASLD [17,23,34]. Using sex- and age-specific thresholds, especially around 4.9–5.0 mg/dL in women, could improve early detection of people at higher metabolic risk [15,17,22]. Risk evaluation can be further refined by combining SUA with other markers such as the TyG index and SUA/creatinine ratio, which measure insulin resistance and kidney function, respectively [21,33]. While early studies hint that allopurinol and febuxostat may improve endothelial function and lower blood pressure, current evidence alone isn't enough to recommend routine urate-lowering treatment for MetS prevention or management, highlighting the need for more large-scale randomized controlled trials [7,41].

Strengths and Limitations

A key strength of this review is the compilation of evidence from large population-based cohorts and prospective studies, consistently supporting SUA as an independent predictor of MetS across different age groups [13,15,16,32]. Including studies on emerging biomarkers, such as the TyG index and SUA/creatinine ratio, broadens the clinical relevance of SUA in cardiometabolic risk assessment [21,33]. Additionally, evidence connecting elevated SUA with obesity, kidney problems, and smoking among hypertensive individuals underscores its importance beyond MetS alone, advocating for its use as a broader cardiometabolic risk marker [31].

Several limitations should be acknowledged. Most included studies were observational, which limits causal conclusions [19,24,30,35]. Relying on a single SUA measurement may not fully capture individual variability, and the predominance of Asian populations could restrict the applicability of the findings to other ethnicities [13,20,22,24,35,38]. Residual confounding due to genetic factors, diet, and use of urate-altering medications cannot be ruled out. Also, because this review was conducted by a single reviewer, independent validation of study selection was not performed.

Future Research

Future research should focus on multicenter prospective studies involving diverse ethnic groups to validate population-specific SUA thresholds and enhance the generalizability of current findings [7,19,24]. Exploring the molecular mechanisms behind SUA's shift from an antioxidant to a pro-oxidant may deepen understanding of its role in metabolic disease [7,41]. Well-designed randomized controlled trials are also essential to determine whether urate-lowering therapies can prevent or alter the course of MetS and decrease related cardiovascular risk [7,41].

Conclusion

Current evidence indicates that SUA is a clinically relevant biomarker for screening, risk stratification, and predicting MetS. Elevated SUA, including levels in the upper normal range, consistently correlates with a higher risk of future MetS and adverse cardiometabolic outcomes. Incorporating sex-specific thresholds and additional biomarkers like the TyG index and SUA/creatinine ratio may improve detection of at-risk individuals. While growing mechanistic and epidemiological data support SUA's involvement in oxidative stress, inflammation, insulin resistance, and vascular dysfunction, the current evidence does not support routine urate-lowering therapy for MetS prevention. Further prospective studies and sufficiently powered randomized trials are needed to refine SUA thresholds and clarify the therapeutic potential of urate-lowering interventions.

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