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Weight-Adjusted Waist Index May Predict Hypertension Plus Hyperuricemia

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ABSTRACT

The weight-adjusted waist index (WWI) is a novel indicator that could estimate body fat and muscle mass. This study aimed to investigate the relationship between WWI and hypertension plus hyperuricemia (HTN-HUA). The data were obtained from the National Health and Nutrition Examination Survey (NHANES) database from 1999 to 2018. Logistic regression analyses were used to explore the association between WWI with HTN-HUA, hypertension (HTN) alone, and hyperuricemia (HUA) alone. Restricted cubic spline (RCS) analyses were employed to examine potential nonlinear associations. Receiver operating characteristic (ROC) curves were utilized to assess the predictive ability of WWI. A total of 16 294 participants were included, among whom 2280 (12%) were diagnosed with HTN-HUA, 5148 (28%) with HTN alone, and 1252 (9%) with HUA alone. WWI was significantly associated with HTN-HUA, HTN alone, and HUA alone after adjusting for potential confounders. Compared to the lowest quartiles of WWI, the odds ratios of the highest quartiles were 2.13 (95% confidence interval [CI]: 1.59–2.83) for HTN-HUA, 1.28 (95% CI: 1.08–1.5) for HTN alone, and 1.6 (95% CI: 1.18–2.16) for HUA alone. RCS analyses demonstrated a nonlinear association between WWI and HTN-HUA. The fully adjusted model, which included WWI, exhibited a moderate predictive ability for HTN-HUA (area under the curve [AUC]: 0.804, 95% CI 0.796–0.813). The association between WWI and HTN-HUA was more prominent among young individuals and those with normal weight. The study suggested that a significant and nonlinear association between WWI and HTN-HUA. WWI had the potential to facilitate the early detection of HTN-HUA.

1 | Introduction

In 2021, the global burden of hypertension (HTN) has reached 226 million disability-adjusted life years (DALYs), marking a 59.2% increase from 142 million DALYs in 1990 [1]. Despite a marginal 0.3% decline in the age-standardized DALYs rate over three decades, the burden of HTN has remained high, surpassing that of diabetes, hypercholesterolemia, and obesity [1]. HTN is a well-established risk factor for cardiovascular diseases, including stroke, coronary heart disease, and heart failure. An increment of 20/10 mmHg in-office blood pressure was associated with a 20% increase in cardiovascular events [2]. Hyperuricemia (HUA) has been reported to be related to HTN in various epidemiological studies [3, 4]. Approximately 25%–40% of hypertensive patients exhibited concurrent HUA [5]. The co-occurrence of HUA in individuals with HTN has been linked to a significant increase in the risk of developing cardiovascular diseases [6, 7]. Notably, the European Society of Hypertension and Chinese guidelines

for HTN have incorporated uric acid (UA) as a risk factor that influences cardiovascular risk in hypertensive patients [8, 9]. Thus, the identification of patients with hypertension plus hyperuricemia (HTN-HUA) is of great significance.

Over the past three decades, the global burden of obesity has been rapidly escalating [1]. It is widely acknowledged that obesity is strongly associated with HTN and HUA. Insulin resistance plays a pivotal role in the relationship between obesity and HTN as well as HUA [10, 11]. Additionally, the adipocytokine signaling pathway is implicated in the pathogenesis of these conditions [11]. Several studies have presented that surrogate indicators of insulin resistance might predict HTN-HUA, such as the metabolic score for insulin resistance (METS-IR), triglyceride glucose index with body mass index (TyG-BMI), and the ratio of triglyceride divided by high-density lipoprotein cholesterol (TG/HDL-C) [12, 13]. However, obtaining these parameters necessitates laboratory tests, which can be cumbersome. Anthropometric indicators may be more appropriate for the prediction of HTN-HUA [14]. The weight-adjusted waist index (WWI) is a novel indicator that could provide information about body composition. A high level of WWI is correlated to high body fat mass, low muscle mass, and low bone mass [15]. Although studies have shown associations between WWI and diabetes, HTN, and cardiovascular diseases [16, 17], its predictive value for HTN-HUA is yet to be determined. This study aimed to investigate the relationship between WWI and HTN-HUA in the American population using data from the National Health and Nutrition Examination Survey (NHANES) database.

2 | Method

2.1 | Study Population

The NHANES is a periodic national survey conducted by the Centers for Disease Control and Prevention (CDC), to evaluate the health and nutritional status of the American population. The NHANES program was approved by the National Centers for Health Statistics (NCHS) Ethical Review Board, and informed consent was obtained from each participant in the NHANES program. The study data were collected from NHANES 1999–2018, encompassing data from ten cycles. The flowchart illustrating the selection of the study population is depicted in Figure 1. Participants under 18 years old ($n = 42\,112$) and pregnant women ($n = 1305$) were excluded. In addition, participants with missing data on WWI ($n = 6090$), HTN-HUA ($n = 8410$), or covariates ($n = 27\,105$) were excluded from the analysis. Finally, a total of 16 294 individuals were included in the present study.

2.2 | Data Collection

The study collected demographic, examination, laboratory, and questionnaire data from the NHANES dataset for analysis and evaluation. Age, gender (male/female), race (Mexican American/Other Hispanic/Non-Hispanic White/Non-Hispanic Black/Other races), marital status (married/other), education level (high school/less than high school/more than high school), and poverty-income ratio (PIR) were extracted from the demographic component of the NHANES dataset. The examination data comprised measurements including height, weight, waist circumference, systolic blood pressure (SBP), and diastolic blood pressure (DBP). Body mass index (BMI) was calculated as the body weight (in kilograms) divided by the square of the height (in meters), and WWI was determined by dividing the waist circumference (in centimeters) by the square root of body weight (in kilograms) [17]. The laboratory data included total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), UA, serum creatinine (Scr), fasting plasma glucose, and glycosylated hemoglobin. Considering the relationship between UA levels and renal function, the serum UA to Scr ratio (SUA/Scr) was calculated. Data regarding smoking status (current smoker/former smoker/non-smoker), alcohol consumption, and medical history including HTN and diabetes were obtained from the questionnaire component of the NHANES dataset. Diabetes was defined as a fasting plasma glucose level of ≥126 mg/dL, a glycosylated hemoglobin concentration of ≥6.5%, self-reported diabetes, or current use of insulin medication [18].

2.3 | Ascertainment of HTN and HUA

In the present study, HTN was defined as meeting one of the following criteria: a SBP level of ≥140 mmHg, a DBP level of ≥90 mmHg, self-reported HTN, or taking antihypertensive medications. HUA was defined as a UA level of ≥7.0 mg/dL in men and ≥6.0 mg/dL in women [12]. HTN-HUA was characterized as the coexistence of HTN and HUA in the study.

2.4 | Statistical Analysis

Participants were categorized into four groups (Q1, Q2, Q3, and Q4) based on the quartiles of the WWI, with the Q1 group considered as the reference group. Kolmogorov-Smirnov tests were used to examine the distribution of continuous variables. Continuous variables with a skewed distribution were depicted as median (interquartile range), and differences among groups were assessed using Wilcoxon rank-sum tests. Categorical variables were presented as number (percentage), and Chi-square tests were utilized to evaluate differences among groups. Univariate and multivariate logistic regression models were applied to investigate associations between the WWI with HTN-HUA, HTN alone, and HUA-alone. Model 1 was unadjusted for any variables. Model 2 was adjusted for age, gender, race, education level, marital status, and PIR. Model 3 was adjusted for age, gender, race, education level, marital status, PIR, BMI, smoking status, alcohol consumption, TC, LDL-C, Scr, and diabetes. Restricted cubic spline (RCS) analyses were conducted to explore potential nonlinear relationships between the WWI with HTN-HUA, HTN alone, and HUA-alone. Moreover, the receiver operating characteristic (ROC) curves were utilized to assess the predictive ability of the Model 3 for the presence of HTN-HUA, HTN alone, and HUA-alone. Finally, subgroup analyses were employed to assess group differences in the relationship between the WWI and HTN-HUA. Prespecified subgroups included gender group (male/female), age group (<40/40–64/≥65 years), race group (Mexican American/Other Hispanic/Non-Hispanic White/Non-Hispanic Black/Other races), smoking status group (current smoker/former smoker/non-smoker), BMI group (<25/≥25 to <30/≥30 kg/m^2), Scr group (<0.78/≥0.78 to <0.93/≥0.93 mg/dL),

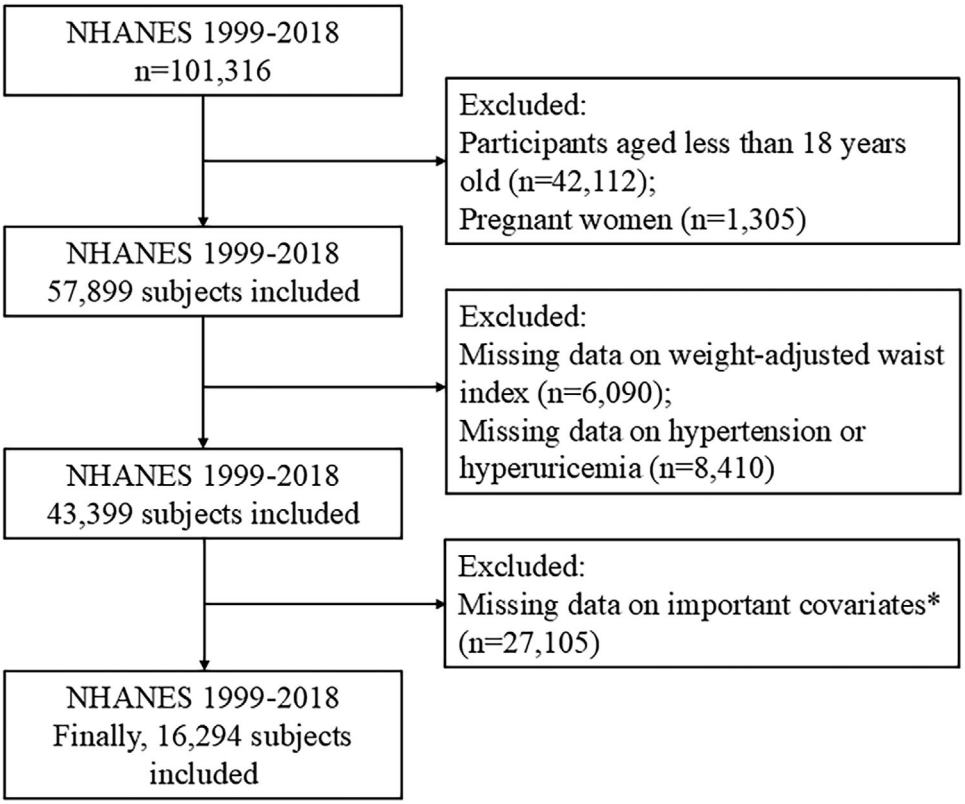

FIGURE 1 | Flowchart of the study population. *The covariates include age, gender, race, marital status, poverty-income ratio, education level, smoking status, alcohol consumption, body mass index, total cholesterol, low-density lipoprotein cholesterol, creatinine, and diabetes.

and diabetes group (yes/no). A p value less than 0.05 was regarded as statistically significant. Statistical analyses were conducted using R software (version 4.3.2).

3 | Results

3.1 | Baseline Characteristics

Baseline characteristics of the study population according to quartiles of WWI are shown in Table 1. The study involved 16 294 participants with a median age of 47 years, and females comprised 51% of the total participants. Within the participant cohort, 7428 individuals (40%) were identified with HTN, 3532 individuals (21%) with HUA, and 2280 individuals (12%) with concurrent HTN-HUA. With the increase of WWI, participants were more likely to be older, female, former smokers, and have lower levels of education and PIR. Moreover, compared to the lowest quartile group of WWI, the highest quartile group exhibited higher levels of BMI, SUA/Scr, and TG, and higher proportions of HTN, HUA, HTN-HUA, and diabetes.

3.2 | Associations between the WWI With HTN-HUA, HTN Alone, and HUA-alone

Table 2 presents the results of univariate and multivariate logistic regression analyses. In the unadjusted model (Model 1), WWI was significantly associated with HTN-HUA (odds ratio [OR]: 2.54, 95% CI: 2.36–2.74) and HTN-alone (OR: 1.78, 95% CI: 1.68–1.88). After fully adjusting for confounding factors (Model 3), WWI was significantly correlated with HTN-HUA (OR: 1.34, 95% CI: 1.19–1.5) and HUA-alone (OR: 1.29, 95% CI: 1.13–1.46). When WWI was regarded as a categorical variable, the risk of HTN-HUA increased with the rise in WWI (P for trends <0.001). Compared to the lowest quartile group of WWI, the highest quartile group was associated with the highest risk of HTN-HUA (OR: 2.13, 95% CI: 1.59–2.83) in Model 3. However, the third quartile group of WWI was linked with the highest risk of HTN-alone (OR: 1.43, 95% CI: 1.23–1.65) and HUA alone (OR: 1.62, 95% CI: 1.24–2.1) in Model 3. WWI exhibited a stronger association with HTN-HUA compared to HTN-alone and HUA alone.

RCS analyses revealed nonlinear relationships between the WWI with HTN-HUA (p for nonlinear <0.001) and HTN alone (p for nonlinear <0.001) after fully adjusting for confounders (Figure 2). However, a positive linear correlation was observed between WWI and HUA alone (p for nonlinear = 0.131).

3.3 | Predictive Value of the WWI and the Fully Adjusted Model for the Presence of HTN-HUA

The area under the curve (AUC) values of the WWI for the presence of HTN-HUA, HTN-alone, and HUA alone were 0.69 (95% CI: 0.679–0.701), 0.628 (95% CI: 0.619–0.637), and 0.517 (95% CI: 0.501–0.533), respectively (Table 3). The cut-off value of WWI for discriminating HTN-HUA was 11.134, with a specificity of 59.1% and sensitivity of 69%. Furthermore, the fully adjusted model (Model 3) that included WWI yielded AUC values of 0.804

TABLE 1 | Baseline characteristics of the study population.

Characteristic	Overall, $N = 16\,294$	Q1 (WWI < 10.34), $N = 3420$	Q2 (10.34 ≤ WWI < 10.87), $N = 3655$	Q3 (10.87 ≤ WWI < 11.47), $N = 4284$	Q4 (WWI ≥ 11.47), $N = 4935$	*p* value
Age (years)	47.0 (33.0–60.0)	34.0 (26.0–45.0)	44.0 (33.0–54.0)	51.0 (39.0–62.0)	60.0 (47.0–70.0)	**<0.001**
Gender (%)						**<0.001**
Female	8104 (51%)	1397 (43%)	1629 (46%)	2065 (50%)	3013 (64%)	
Male	8190 (49%)	2023 (57%)	2026 (54%)	2219 (50%)	1922 (36%)	
Race (%)						**<0.001**
Mexican American	2682 (7.6%)	297 (4.4%)	561 (7.5%)	857 (9.9%)	967 (8.4%)	
Other Hispanic	1321 (4.9%)	198 (4.3%)	270 (5.0%)	373 (5.0%)	480 (5.4%)	
Non-Hispanic White	7701 (71%)	1600 (70%)	1710 (71%)	1965 (70%)	2426 (72%)	
Non-Hispanic Black	3192 (10%)	970 (14%)	745 (10.0%)	735 (9.0%)	742 (8.5%)	
Other races	1398 (6.3%)	355 (6.6%)	369 (7.0%)	354 (6.3%)	320 (5.3%)	
Marital (%)						**<0.001**
Married	8743 (57%)	1514 (48%)	2063 (61%)	2562 (64%)	2604 (56%)	
Other	7551 (43%)	1906 (52%)	1592 (39%)	1722 (36%)	2331 (44%)	
PIR (%)	3.04 (1.55, 5.00)	3.39 (1.74, 5.00)	3.36 (1.70, 5.00)	2.94 (1.56, 5.00)	2.41 (1.29, 4.21)	**<0.001**
Education (%)						**<0.001**
High school	3816 (24%)	742 (21%)	840 (23%)	1031 (25%)	1203 (27%)	
Less than high school	4057 (16%)	522 (10%)	701 (13%)	1161 (19%)	1673 (22%)	
More than high school	8421 (60%)	2156 (69%)	2114 (64%)	2092 (56%)	2059 (51%)	
Smoking status (%)						**<0.001**
Current smoker	3382 (21%)	890 (24%)	809 (22%)	838 (20%)	845 (18%)	
Former smoker	4307 (26%)	571 (18%)	853 (23%)	1270 (30%)	1613 (33%)	
Non-smoker	8605 (53%)	1959 (58%)	1993 (55%)	2176 (50%)	2477 (48%)	
Alcohol consumption (%)	14 183 (90%)	3092 (92%)	3278 (92%)	3731 (89%)	4082 (86%)	**<0.001**
BMI (kg/m^2)	28 (24, 32)	24 (22, 27)	27 (24, 30)	29 (26, 33)	32 (28, 38)	**<0.001**
WWI	10.87 (10.34, 11.47)	9.96 (9.67, 10.17)	10.63 (10.49, 10.75)	11.15 (11.01, 11.30)	11.88 (11.65, 12.21)	**<0.001**
SBP (mmHg)	119 (110, 129)	113 (107, 122)	117 (109, 127)	121 (111, 131)	125 (115, 137)	**<0.001**
DBP (mmHg)	71 (63, 77)	69 (63, 75)	72 (65, 78)	71 (65, 78)	70 (62, 77)	**<0.001**
TG (mg/dL)	104 (72, 151)	80 (58, 113)	101 (70, 146)	118 (81, 165)	125 (88, 176)	**<0.001**
TC (mg/dL)	191 (166, 218)	181 (159, 206)	194 (169, 220)	196 (170, 224)	194 (166, 222)	**<0.001**
LDL-C (mg/dL)	113 (91, 138)	106 (86, 129)	116 (94, 140)	118 (94, 143)	114 (90, 139)	**<0.001**
Scr (mg/dL)	0.84 (0.71, 1.00)	0.89 (0.75, 1.00)	0.84 (0.72, 1.00)	0.83 (0.70, 1.00)	0.80 (0.70, 0.99)	**<0.001**
UA (mg/dL)	5.40 (4.50, 6.40)	5.10 (4.20, 6.00)	5.40 (4.50, 6.30)	5.60 (4.60, 6.50)	5.70 (4.80, 6.70)	**<0.001**
SUA/Scr	6.32 (5.36, 7.44)	5.83 (5.00, 6.74)	6.25 (5.34, 7.25)	6.57 (5.53, 7.69)	6.83 (5.68, 8.07)	**<0.001**
Hypertension (%)	7428 (40%)	713 (18%)	1316 (32%)	2101 (46%)	3298 (63%)	**<0.001**
Hyperuricemia (%)	3532 (21%)	393 (11%)	626 (17%)	988 (23%)	1525 (32%)	**<0.001**
HTN-HUA (%)	2280 (12%)	140 (3.2%)	321 (8.5%)	623 (13%)	1196 (24%)	**<0.001**
Diabetes (%)	2822 (12%)	126 (2.2%)	346 (6.1%)	763 (13%)	1587 (28%)	**<0.001**

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; HTN-HUA, hypertension plus hyperuricemia; LDL-C, low-density lipoprotein cholesterol; PIR, poverty-income ratio; SBP, systolic blood pressure; Scr, serum creatinine; SUA/Scr, serum uric acid to serum creatinine ratio; TC, total cholesterol; TG, triglyceride; UA, uric acid; WWI, weight-adjusted waist index.

TABLE 2 | Associations between weight-adjusted waist index with hypertension plus hyperuricemia, hypertension alone, and hyperuricemia alone.

		Model1		Model2		Model3	
		OR(95% CI)	*p* value	OR(95% CI)	*p* value	OR(95% CI)	*p* value
HTN-HUA							
Continuous WWI		2.54 (2.36–2.74)	<0.001	2.14 (1.95–2.36)	<0.001	1.34 (1.19–1.50)	<0.001
Categorical WWI							
	Q1	Reference		Reference		Reference	
	Q2	2.87 (2.23–3.69)	<0.001	2.36 (1.83–3.05)	<0.001	1.73 (1.32–2.28)	<0.001
	Q3	4.75 (3.71–6.09)	<0.001	3.38 (2.62–4.37)	<0.001	1.85 (1.39–2.45)	<0.001
	Q4	9.58 (7.7–11.9)	<0.001	5.84 (4.59–7.43)	<0.001	2.13 (1.59–2.83)	<0.001
	P for trends		<0.001		<0.001		<0.001
HTN alone							
Continuous WWI		1.78 (1.68–1.88)	<0.001	1.24 (1.16–1.32)	<0.001	1.04 (0.97–1.12)	0.275
Categorical WWI							
	Q1	Reference		Reference		Reference	
	Q2	1.87 (1.64–2.13)	<0.001	1.4 (1.22–1.6)	<0.001	1.28 (1.11–1.48)	<0.001
	Q3	2.85 (2.5–3.25)	<0.001	1.7 (1.48–1.95)	<0.001	1.43 (1.23–1.65)	<0.001
	Q4	3.86 (3.38–4.41)	<0.001	1.76 (1.53–2.03)	<0.001	1.28 (1.08–1.5)	0.004
	P for trends		<0.001		<0.001		0.002
HUA alone							
Continuous WWI		1.03 (0.94–1.12)	0.561	1.73 (1.54–1.93)	<0.001	1.29 (1.13–1.46)	<0.001
Categorical WWI							
	Q1	Reference		Reference		Reference	
	Q2	1.2 (0.97–1.49)	0.092	1.67 (1.33–2.08)	<0.001	1.27 (1.02–1.58)	0.035
	Q3	1.34 (1.09–1.66)	0.007	2.54 (1.99–3.25)	<0.001	1.62 (1.24–2.1)	<0.001
	Q4	1.07 (0.86–1.33)	0.557	3.03 (2.31–3.96)	<0.001	1.6 (1.18–2.16)	0.003
	P for trends		0.385		<0.001		0.002

Note: Model 1 was unadjusted; Model 2 was adjusted for age, gender, race, education level, marital status, and poverty income ratio; Model 3 was adjusted for age, gender, race, education level, marital status, poverty income ratio, body mass index, smoking status, alcohol consumption, total cholesterol, low-density lipoprotein cholesterol, creatinine, and diabetes.

Abbreviations: HTN, hypertension; HTN-HUA, hypertension plus hyperuricemia; HUA, hyperuricemia; OR, odds ratio.

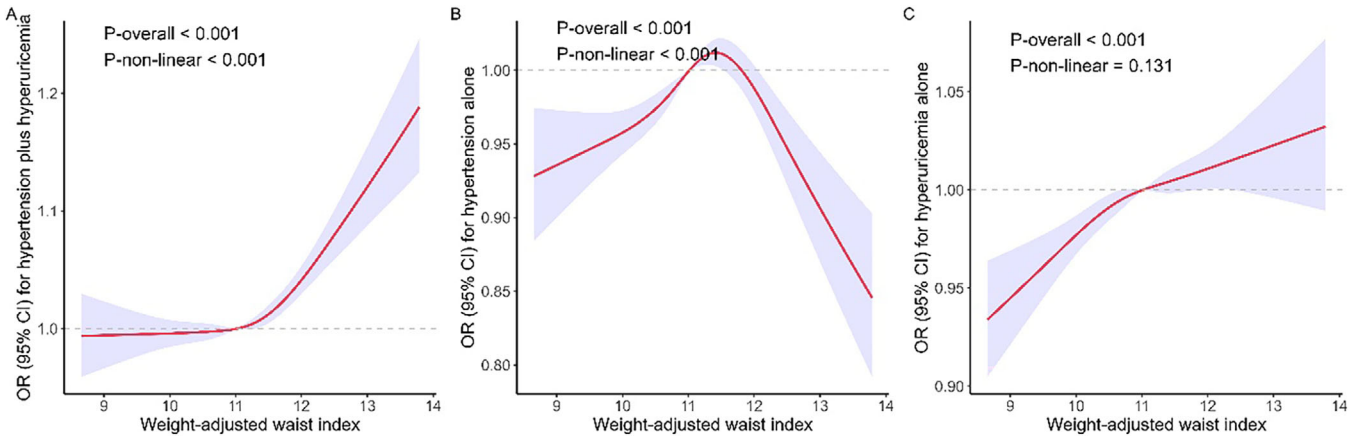

FIGURE 2 | The restricted cubic spine regressions between weight-adjusted waist index with hypertension plus hyperuricemia (A), hypertension alone (B), and hyperuricemia alone (C). CI indicates confidence interval; OR, odds ratio.

TABLE 3 | Receiver operating characteristic curves analysis of weight-adjusted waist index for the prediction of hypertension plus hyperuricemia, hypertension alone, and hyperuricemia alone.

	AUC	95% CI	Cut-off value	Specificity	Sensitivity
HTN-HUA	0.69	0.679–0.701	11.134	0.591	0.69
HTN alone	0.628	0.619–0.637	10.972	0.541	0.653
HUA alone	0.517	0.501–0.533	11.258	0.396	0.657

Abbreviations: AUC, area under the curve; CI, confidence interval; HTN, hypertension; HTN-HUA, hypertension plus hyperuricemia; HUA, hyperuricemia.

(95% CI: 0.796–0.813), 0.739 (95% CI: 0.73–0.749), and 0.554 (95% CI: 0.541–0.568) for the prediction of HTN-HUA, HTN-alone, and HUA alone, respectively.

3.4 | Subgroup Analysis

Subgroup analyses were performed to evaluate variations in the relationship between the WWI and HTN-HUA within predefined subgroups, such as gender, age, race, smoking status, BMI, Scr, and diabetes status (Figure 3). The results indicated that there were no significant differences in the correlation between WWI and HTN-HUA across different gender, race, smoking status, Scr, and diabetes subgroups. However, a stronger association between WWI and HTN-HUA was identified in participants aged less than 40 years and those with a BMI below 25 kg/m^2 compared to other respective groups.

4 | Discussion

To our knowledge, this study is the first to explore the relationship between WWI and HTN-HUA. We found that WWI exhibited a significant positive association with the risk of HTN-HUA, where a one-unit increase in WWI was linked to a 34% increase in the risk of HTN-HUA after adjusting for potential confounders (OR: 1.34, 95% CI: 1.19–1.5). In addition, in the fully adjusted model, the highest quartile group of WWI was associated with a 2.13 times higher risk of HTN-HUA (OR: 2.13, 95% CI: 1.59–2.83) compared to the lowest quartile group. Furthermore, the RCS analysis demonstrated a nonlinear relationship between them. Subgroup analyses revealed a more robust correlation between WWI and HTN-HUA among young individuals and those with a normal weight. Importantly, the ROC analysis indicated the moderate predictive ability of the fully adjusted model, which incorporated WWI, for determining the presence of HTN-HUA.

The WWI was introduced as a novel adiposity index by Park et al., aiming to surpass traditional anthropometric indicators for predicting cardiovascular diseases [19]. The study illustrated the excellent predictive ability of WWI for the morbidity and mortality of cardiometabolic diseases [19]. In a cross-sectional study involving 602 older participants, the WWI was suggested as a suitable measure for evaluating both muscle and fat mass due to its positive association with fat mass and negative association with muscle mass [20]. In particular, the WWI was closely related to abdominal fat and muscle mass, and it could reflect the changes in abdominal composition with aging [21]. Moreover, in a cohort study with 5983 Korean adults, the WWI was proposed to have implications for bone health, indicating its potential as an integrated index for fat, muscle, and bone health [15]. Several studies have presented that the WWI was associated with the risk of HTN, diabetes, cardiovascular diseases, cardiovascular mortality, and all-cause mortality [16, 17, 22]. Additionally, in a recent study with 14 078 participants from a Chinese hypertensive population, a positive correlation was observed between WWI and HUA [23]. In the present study, we found a significant and nonlinear relationship between the WWI and HTN-HUA, which was notably stronger compared to the relationships between WWI with HTN alone and HUA alone.

Multiple mechanisms might be involved in the association between WWI and HTN-HUA. First, insulin resistance is the key process that links obesity to HTN and HUA. Insulin resistance can activate the renin-angiotensin-aldosterone system, leading to increased blood pressure through vasoconstriction and sodium retention. Furthermore, it can elevate UA levels by stimulating the synthesis of UA and impacting renal urate clearance [11, 13]. In addition, adipocytokines could induce insulin resistance through multiple signaling pathways, subsequently contributing to HTN and HUA. Moreover, obesity is intertwined with oxidative stress and chronic inflammation, triggering endothelial dysfunction and increased UA synthesis, both of which are associated with HTN and HUA [13].

In this study, subgroup analyses demonstrated variations in the relationship between the WWI and HTN-HUA across different age and BMI groups. Particularly, the association was more pronounced among young individuals (aged less than 40 years) and those with normal weight. In young individuals, a high level of WWI could signify an increased risk of HTN-HUA and the potential for future cardiovascular diseases. Even among individuals with normal weight, the distribution of body fat mass might have an important influence on the risk of HTN-HUA. Since WWI can be derived simply from weight and waist circumference measurements, it is essential to highlight the significance of WWI as a simple metric for evaluating the risk of HTN-HUA.

The present study represented the first investigation with a substantial sample size to examine the correlation between WWI and HTN-HUA. However, there were several limitations that warranted attention in this study. First, the study could not establish a causal relationship between WWI and HTN-HUA due to its cross-sectional design. Second, the study population was solely from the United States, which limited the generalizability of the findings to other populations. Finally, although we adjusted for several relevant covariates, there were still potential confounders that could influence the association between WWI and HTN-HUA.

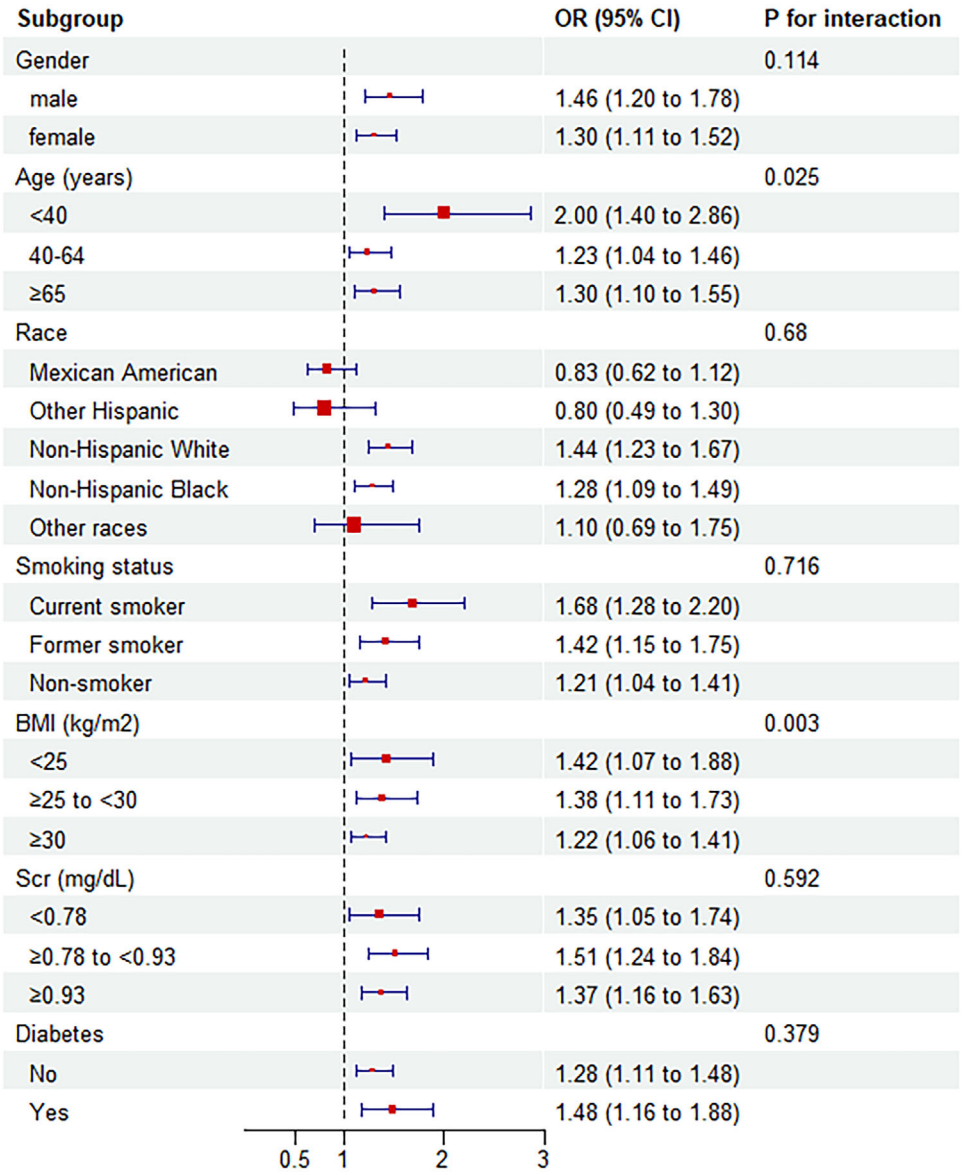

FIGURE 3 | Forest plot for subgroup analyses of the association between weight-adjusted waist index and hypertension plus hyperuricemia. BMI indicates body mass index; CI, confidence interval; OR, odds ratio; Scr, serum creatinine.

5 | Conclusion

In conclusion, the study suggested that WWI was significantly and positively associated with the risk of HTN-HUA, particularly among young people and those with normal weight. The study's results underscored the potential of WWI as a valuable indicator for the early detection of HTN-HUA and emphasized its role in preventive healthcare practices.

Author Contributions

Huanhuan Miao: conceptualization, formal analysis, and writing original draft. Zhanyang Zhou and Zheng Yin: investigation and methodology. Xue Li: data curation and software. Yuhui Zhang: methodology and review & editing. Yuqing Zhang and Jian Zhang: conceptualization and review & editing.

Ethics Statement

The program was approved by the National Centers for Health Statistics (NCHS) Ethical Review Board.

Consent

Informed consent was obtained from each participant.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data from the National Health and Nutrition Examination Survey are publicly available online (https://www.cdc.gov/nchs/nhanes/index.htm).

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