Type of Article: Original Research

Title: Associations of Waist Circumference and Body Mass Index with the Prevalence Lifestyle-Related Diseases in an Aging Asian Population

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Clinical Question Box

In Chinese adults aged ≥60, is waist circumference or body mass index more strongly associated with lifestyle-related diseases?

Both waist circumference and body mass index are positively associated with the prevalence of lifestyle-related diseases. However, waist circumference shows a slightly stronger association with lifestyle-related diseases than body mass index among older Chinese adults. Optimal cut-off values of 87 cm for men and 81 cm for women demonstrate the strongest associations with lifestyle-related diseases.

ABSTRACT

Introduction: Lifestyle-related diseases (LRDs), including hypertension, dyslipidemia, and type 2 diabetes mellitus (T2DM), impose substantial public health burdens, particularly in aging Asian populations who may develop metabolic abnormalities at relatively lower levels of adiposity. Although waist circumference (WC) and body mass index (BMI) are widely used anthropometric indicators, their optimal thresholds and strength of association with LRDs remain uncertain among older Chinese adults.

Methods: A retrospective observational analysis was conducted in adults aged ≥60 years who underwent routine health examinations at a community hospital in Southeast China between April 2021 and December 2023. Associations between WC, BMI, and LRDs were examined, and receiver operating characteristic (ROC) analyses were performed to assess discriminatory accuracy and to identify sex-specific cut-off values.

Results: Among the 63,528 included participants, the prevalence of T2DM, dyslipidemia, hypertension, and overall LRDs burden was 27.4%, 39.2%, 69.2%, and 83.5%, respectively. Both WC and BMI demonstrated strong dose–response relationships with all LRDsWC yielded area-under-the-curve (AUC) values of 0.673 in all individuals (optimal cut-off 83 cm), 0.660 in men (87 cm), and 0.674 in women (81 cm). BMI showed AUCs of 0.650, 0.652, and 0.649, with corresponding cut-offs of 24.0 kg/m², 24.1 kg/m², and 23.8 kg/m² for any LRD. Although the predictive performance for individual diseases was modest, all associations were statistically significant ($p < 0.001$).

Conclusions: Higher WC and BMI are significantly associated with increased prevalence of hypertension, dyslipidemia, T2DM, and overall LRDs in older Chinese adults. Despite moderate discriminatory ability, WC and BMI remain practical first-line tools for cardiometabolic risk assessment.

Keywords: waist circumference, body mass index, lifestyle-related diseases, hypertension, dyslipidemia, type 2 diabetes mellitus

Introduction

The complex interplay between lifestyle and health is highly relevant to medical research and public health policy[1]. A healthy lifestyle, characterized by balanced nutrition, regular physical activity, abstention from tobacco use, and moderate alcohol consumption, correlates strongly with enhanced well-being and key indicators of healthy aging[2,3]. These lifestyle choices are directly linked to the incidence of chronic diseases, notably hypertension, dyslipidemia, and (T2DM)[4,5]. These conditions are typically classified as lifestyle-related diseases (LRDs) in Asian countries such as Japan[6,7]. LRDs not only shorten life expectancy but also diminish the quality of life due to complications such as heart disease, stroke, and kidney failure[8,9]. Research shows that more than 80 % of residents aged 60 years and older in China have LRDs[10]. These diseases, when accompanied by abdominal obesity, are components of the metabolic syndrome, a cluster of conditions that significantly heightens the risk of cardiovascular diseases[11].

These conditions are interconnected through a combination of genetic and environmental factors, creating substantial public health challenges because of their high prevalence and complex development and progression[12]. Lifestyle modifications play a critical role in mitigating risk factors, making early detection and management crucial for preventing serious complications[13]. These frequently encountered LRDs profoundly impact both individual lives and the broader healthcare system[14,15]. The escalating prevalence of these diseases underscores an urgent need for effective preventive measures. Screening for LRDs is an essential component of preventive healthcare and involves the use of tests or examinations to detect disease in asymptomatic individuals, facilitating early intervention and management[16].

Common screening methods for LRDs include blood pressure measurements, blood tests for lipid profiles and blood glucose levels, and anthropometric measures including WC, and BMI[17]. However, such anthropometrics have their inherent limitations. BMI is widely used because it is simple and non-invasive, but does not differentiate between fat mass and lean mass. Consequently, individuals with a high muscle mass may be misclassified as overweight or obese, while those with normal BMI but high visceral fat may be incorrectly considered healthy[18]. In contrast, WC offers a simple and cost-effective measure that directly reflects abdominal adiposity, a key predictor of hypertension, dyslipidemia, and T2DM[19,20]. WC is particularly valuable because visceral fat accumulation is more strongly associated with metabolic risk than overall body size REF. Nevertheless, WC also has disadvantages, such as measurement variability across examiners, is influence by posture or breathing, and a lack of universal cutoff points across different ethnic groups[21]. Additionally, there are potentially different cut-off values between Asian and Caucasian populations.[22]

This study aims to evaluate the associations of WC and BMI with LRDs, including hypertension, dyslipidemia, and T2DM. Given the limitations of each measure, the study further aims to compare their individual discriminatory ability for identifying metabolic risk among older Chinese adults.

Methods

Overview

This retrospective, observational study investigated outpatients who underwent medical checkups at a community hospital in Southeast China from April 2021 to December 2023. The study protocol was approved by the institutional review board of Hangzhou Linping District Hospital of Integrated Traditional Chinese and Western Medicine (approval no. 2024-l-009) and adhered to the provisions of the Declaration of Helsinki, as revised in Brazil in 2013. Informed consent was obtained from all patients through an opt-out option available on the hospital website, as authorized by the institutional review board at the participating facility.

Eligibility

The following were the inclusion criteria: (1) patients aged ≥ 60, (2) patients with recorded WC and BMI, and (3) patients for whom comorbidity data were available. The exclusion criteria were (1) patients with disabilities that made WC or BMI measurement infeasible, (2) patients with insufficient data, and (3) those who declined to provide informed consent.

Definitions

LRDs were defined as conditions in patients with a history of, or a current diagnosis of, hypertension, dyslipidemia, T2DM, or any combination of these disorders. Dyslipidemia was defined as triglycerides ≥150 mg/dL or high-density lipoprotein cholesterol (HDL-C) <40 mg/dL or low-density lipoprotein cholesterol (LDL-C) >140 mg/dL, hypertension as systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg, and diabetes as fasting plasma glucose ≥100 mg/dL or hemoglobin A1c ≥6.5%[17]. WC was measured by trained personnel using a non-elastic measuring tape at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, with participants standing upright. Blood pressure and laboratory measurements were obtained on a single occasion during the routine health check-up.

Outcomes

This study primarily aimed to determine the relationship between WC and BMI and LRDs. The secondary objectives were to establish WC and BMI cut-off values for identifying the prevalence of hypertension, T2DM, dyslipidemia, and LRDs in both Chinese adults patients aged ≥ 60 years.

Statistical analyses

Categorical variables were summarized as counts and percentages and continuous variables as means with standard deviations (SDs). All statistical tests were conducted using a two-tailed approach, with p-values <0.05 considered statistically significant. The “pROC” and “pheatmap” packages were used to generate heatmaps, construct ROC curves, and calculate the AUC for all evaluated outcomes. All analyses were performed using R software (version 5.4; R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Characteristics of enrolled patients

In total, 160,141 records were retrieved. After removing records with missing values, 63,528 individuals (31,472 men, 32,056 women) were included in the final analysis (Table 1). The median age of participants was 65.5 (7.6). Statistical analyses revealed significant differences between men and women in age, height, weight, BMI, WC, systolic and diastolic blood pressures, total cholesterol, HDL-C, and blood sugar. However, levels of triglycerides and LDL-C did not indicate any statistically significant differences. The distribution of all enrolled variables, illustrated using violin plots, is shown in Figures S1–S3. The overall prevalence of T2DM, dyslipidemia, hypertension, and LRDs in the study population was 27.4%, 39.2%, 69.2%, and 83.5%, respectively. Among males versus females, the prevalence of T2DM was 30.6% vs. 24.3% ($p < 0.001$), dyslipidemia 40.8% vs. 33.7% ($p < 0.001$), hypertension 68.3% vs. 70.2% ($p = 0.129$), and LRDs 84.4% vs. 82.6% ($p = 0.077$), respectively.

Relationship between WC or BMI with LRDs

The heatmap between WC and LRDs is presented in Figure 1. WC was categorized as <80 cm, 80–89 cm, 90–99 cm, and ≥100 cm. As WC increased, the prevalence of T2DM, dyslipidemia, hypertension, and LRDs rose in both sexes. Among individuals with a WC ≥100 cm, the prevalence of T2DM, dyslipidemia, hypertension, and LRDs in males versus females was 35.5% vs. 41.9%, 46.4% vs. 40.5%, 83.3% vs. 89.6%, and 94.2% vs. 95.7%, respectively. The heatmap between BMI and LRDs is presented in Figure 2. BMI was categorized as <18 kg/m^2, 18–22.9 kg/m^2, 23–27.4 kg/m^2, and ≥27.5 kg/m^2. As BMI increased, the prevalence of T2DM, dyslipidemia, hypertension, and LRDs rose in both sexes. Among individuals with a BMI ≥27.5 kg/m^2, the prevalence of T2DM, dyslipidemia, hypertension, and LRDs in males versus females was 32.8% vs. 33.3%, 50.0% vs. 41.5%, 80.1% vs. 86.3%, and 92.6% vs. 93.0%, respectively.

Associations of WC and BMI with LRDs

Figure 3 displays the ROC curves of WC and BMI for predicting LRDs in males and females. The AUCs of WC for all individuals, males, and females were 0.673, 0.660, and 0.674, respectively, with corresponding cut-off values of 83 cm, 87 cm, and 81 cm. The AUCs of BMI for all individuals, males, and females were 0.650, 0.652, and 0.649, respectively, with corresponding cut-off values of 24.0 kg/m^2, 24.1 kg/m^2, and 23.8 kg/m^2. All groups showed statistically significant results, with p-values < 0.001.

Associations of WC and BMI wiht hypertension

Figure 4 furnishes the ROC curves of WC and BMI for predicting *hypertension* in males and females. The AUCs of WC for all individuals, males, and females were

0.650, 0.593, and 0.654, respectively, with corresponding cut-off values of 85 cm, 88 cm, and 81 cm. The AUCs of BMI for all individuals, males, and females were 0.635, 0.601, and 0.637, respectively, with corresponding cut-off values of 23.9 kg/m², 24.0 kg/m², and 23.7 kg/m². All groups showed statistically significant results, with p-values < 0.001.

Associations of WC and BMI with T2DM

The ROC curves of WC and BMI for predicting T2DM are shown in Figure S5. The AUCs of WC for all individuals, males, and females were 0.560, 0.556, and 0.563, respectively, with corresponding cut-off values of 88 cm in all groups. The AUCs of BMI for all individuals, males, and females were 0.552, 0.550, and 0.572, respectively, with corresponding cut-off values of 24.7 kg/m², 23.2 kg/m², and 25.7 kg/m². All groups showed statistically significant results, with p-values < 0.001.

Associations of WC and BMI with dyslipidemia

The ROC curves of WC for predicting *dyslipidemia* are shown in Figure S6. The AUCs of WC for all individuals, males, and females were 0.575, 0.600, and 0.546, respectively, with corresponding cut-off values of 85 cm in all groups. The AUCs of BMI for all individuals, males, and females were 0.585, 0.619, and 0.558, respectively, with corresponding cut-off values of 24.2 kg/m², 24.2 kg/m², and 24.7 kg/m². All groups showed statistically significant results, with p-values < 0.001.

DISCUSSION

In this large, population-based study of more than 63,000 adults, we demonstrated clear associations between increasing WC and BMI with a higher prevalence of LRDs, including hypertension, T2DM, and dyslipidemia. The high prevalence of metabolic abnormalities observed in this cohort, particularly in hypertension and LRDs, highlights an urgent need for more effective strategies for cardiometabolic risk detection in aging populations. While the relationship between adiposity and metabolic disease is well established, the present study adds important new evidence by identifying sex-specific WC and BMI cut-off values in a large Asian cohort. These cut-offs are lower than conventional international thresholds, reinforcing observations from previous studies that Asian populations develop metabolic complications at lower levels of adiposity[23-25]. Early identification using simple anthropometric measures may therefore facilitate timely lifestyle modification, risk-factor monitoring, and clinical interventions aimed at reducing long-term disease burden.

Both WC and BMI showed clear dose–response relationships with LRDs. Visceral abdominal fat is metabolically active and contributes to insulin resistance, inflammation, and dyslipidemia.[26] Increasing WC-defined adiposity was associated with higher prevalence of T2DM, dyslipidemia, hypertension, and overall LRD burden in both sexes, consistent with established mechanisms involving visceral fat accumulation and adiposity-related activation of the renin–angiotensin–aldosterone system[27,28]. Notably, the increased prevalence of metabolic diseases at only mildly elevated WC and BMI levels underscores the need to reconsider screening thresholds for Asian populations[29].

Consistent sex-related differences were observed across anthropometric and biochemical indicators. Men exhibited higher BMI and a greater prevalence of LRDs, consistent with prior evidence of males accumulating more visceral adipose tissue than females, and androgens promoting central fat deposition[30,31]. Visceral adipose tissue is more metabolically active and exhibits higher lipolytic activity, leading to increased release of free fatty acids, hepatic insulin resistance, and secretion of pro-inflammatory cytokines—mechanisms that contribute to the higher metabolic burden observed in men[32,33]. Conversely, the predictive value of WC for the prevalence of T2DM and dyslipidemia did not differ significantly between sexes, possibly because WC captures both subcutaneous and visceral compartments and may therefore obscure sex-specific differences in fat distribution[34].

Although WC and BMI were statistically significantly associated with LRDs, their discriminatory performance was modest, with AUC values generally around 0.65 for prevalent LRDs and lower for individual metabolic conditions, indicating limited accuracy for individual-level prediction. Nonetheless, in real-world settings such as primary care, routine health checkups, and community-based screening programs, WC and BMI remain practical first-line screening measures due to their simplicity, low cost, and reproducibility. The sex-specific cut-off values identified in this study should therefore be interpreted as pragmatic reference points to identify individuals who may benefit from further metabolic evaluation or early lifestyle intervention, rather than as diagnostic thresholds. Given their modest discriminative ability, WC and BMI should be used in conjunction with other clinical risk factors, and future longitudinal studies incorporating additional metabolic biomarkers and more precise body composition measures may improve risk prediction.

Several limitations in this study should be acknowledged. First, the cross-sectional design precludes causal inference, and residual confounding from unmeasured factors cannot be excluded. Notably, although outcomes were defined as LRDs, no direct data on lifestyle behaviors such as diet, physical activity, smoking, or alcohol consumption were available, limiting our ability to assess their individual contributions. Second, this study was conducted at a single community hospital and included older adults who voluntarily attended routine health check-ups, which may represent a healthier or more health-conscious subset of the older population. This selection may have influenced the observed prevalence of LRDs, potentially leading to underestimation compared with the broader community-dwelling older population. Finally, both WC and BMI cannot differentiate between fat and lean mass or visceral and subcutaneous adiposity, thereby reducing their precision as indicators of metabolic risk.

Conclusion

Higher WC and BMI are significantly associated with increased prevalence of hypertension, T2DM, dyslipidemia, and LRDs. Although their predictive performance is moderate, they remain practical low-cost tools for early risk stratification. The sex-specific WC and BMI cut-off values identified in this study provide clinically relevant thresholds that may enhance metabolic risk assessment in Asian populations.

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Data availability statement: The raw data are available upon reasonable request to the corresponding author via email.

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Conflict of interest disclosure: The authors declare that they have no competing interests.

Ethics approval statement: This study protocol was approved by IRB of Hangzhou Linping District Hospital of Integrated Traditional Chinese and Western Medicine (approval no. 2024-l-009).

Authors' contributions: D.L. and N.S. contributed to the conception and design of the study, as well as to data analysis and interpretation. D.L. was involved in data acquisition. G.L. and S.S. contributed to the revision and critical review of the manuscript. All authors approved the final version of the manuscript, agreed on the journal to which it was submitted, and accept responsibility for all aspects of the work.

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Table 1. Baseline Characteristics of Enrolled Patients

Items	Total	Male	Female	P-value
Age (years)	65.5 (7.6)	64.2 (6.9)	66.7 (8.1)	<0.001
Height (cm)	161.2 (9.0)	168 (6.0)	154.5 (5.9)	<0.001
Weight (kg)	63.8 (11.1)	70.1 (9.5)	57.4 (8.7)	<0.001
Body mass index (kg/m²)	24 .5(3.1)	24.9 (2.9)	24.1 (3.3)	<0.001
Waist circumference (cm)	85.6 (9.0)	88.6 (8.3)	82.7 (8.7)	<0.001
SBP (mmHg)	143 (19)	144 (18)	141 (19)	<0.001
DBP (mmHg)	80 (11)	83 (11)	76 (11)	<0.001
Total cholesterol (mg/dL)	152 (110)	150 (97)	154 (122)	0.004
Triglycerides (mg/dL)	196 (42)	198 (41)	195 (42)	0.341
HDL-C (mg/dL)	53 (13)	54 (13)	51 (13)	<0.001
LDL-C (mg/dL)	125 (34)	126 (34)	125 (35)	0.42
Blood sugar (mg/dL)	111 (28)	108 (27)	113 (28)	<0.001
T2DM				<0.001
Yes	17,424 (27.4%)	9,630 (30.6%)	7,794 (24.3%)	
No	46,104 (72.6%)	21,842 (69.4%)	24,262 (75.7%)	
Dyslipidemia				<0.001
Yes	24,914 (39.2%)	12,841 (40.8%)	12,073 (37.7%)	
No	38,614 (60.8%)	18,631 (59.2%)	19,983 (62.3%)	
Hypertension				0.129
Yes	43,993 (69.2%)	21,495 (68.3%)	22,498 (70.2%)	
No	19,535 (30.8%)	9,977 (31.7%)	9,558 (29.8%)	
LRDs				0.077
Yes	53,037 (83.5%)	26,562 (84.4%)	26,475 (82.6%)	
No	10,491 (16.5%)	4,910 (15.6%)	5,581 (17.4%)	

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; T2DM: Type 2 diabetes mellitus; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol

Figure 1. Heatmap of the Association Between Waist Circumference and Lifestyle-Related Diseases

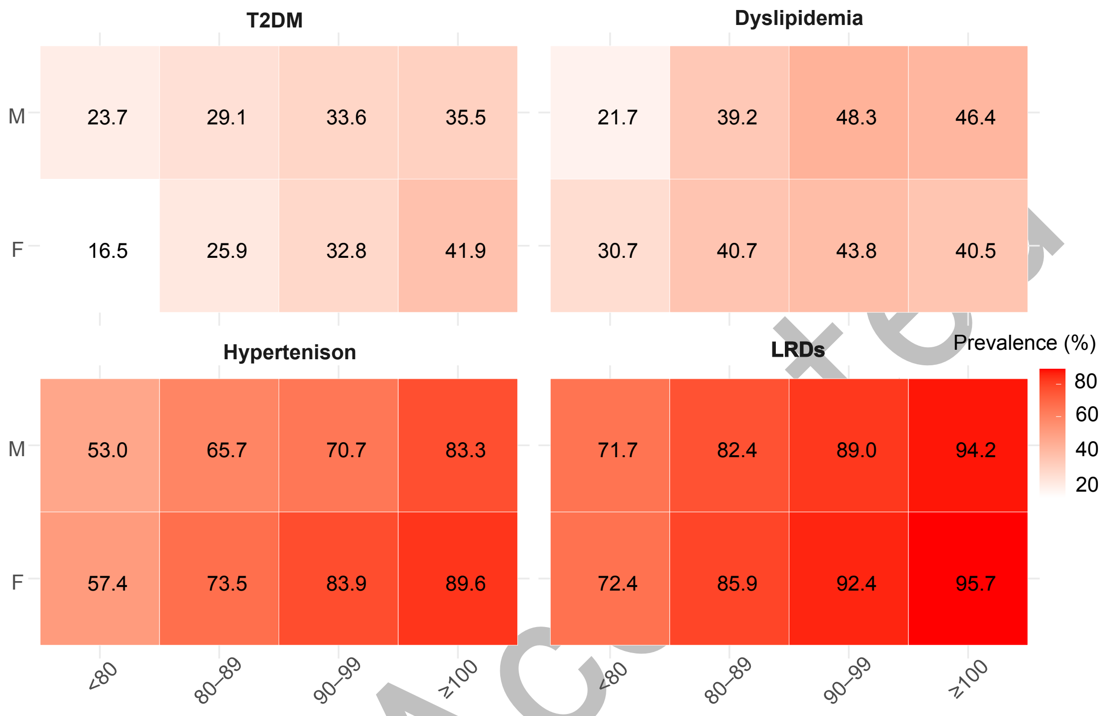


Figure 2. Heatmap of the Association Between Body Mass Index and Lifestyle-Related Diseases

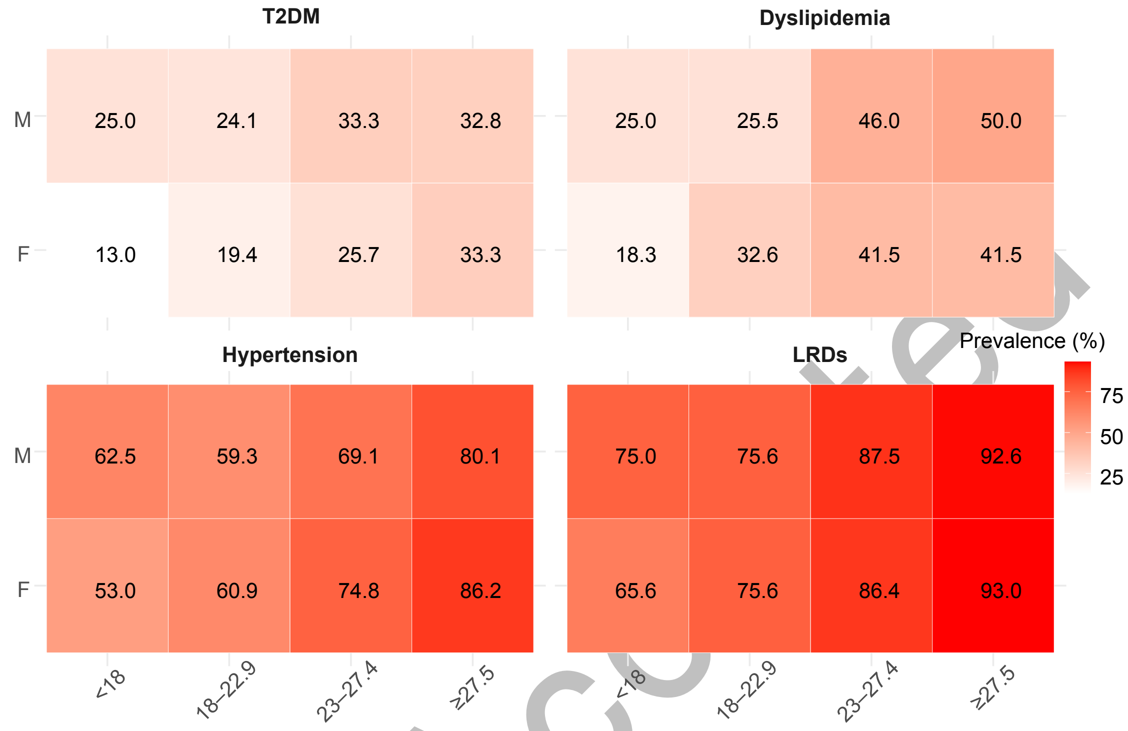
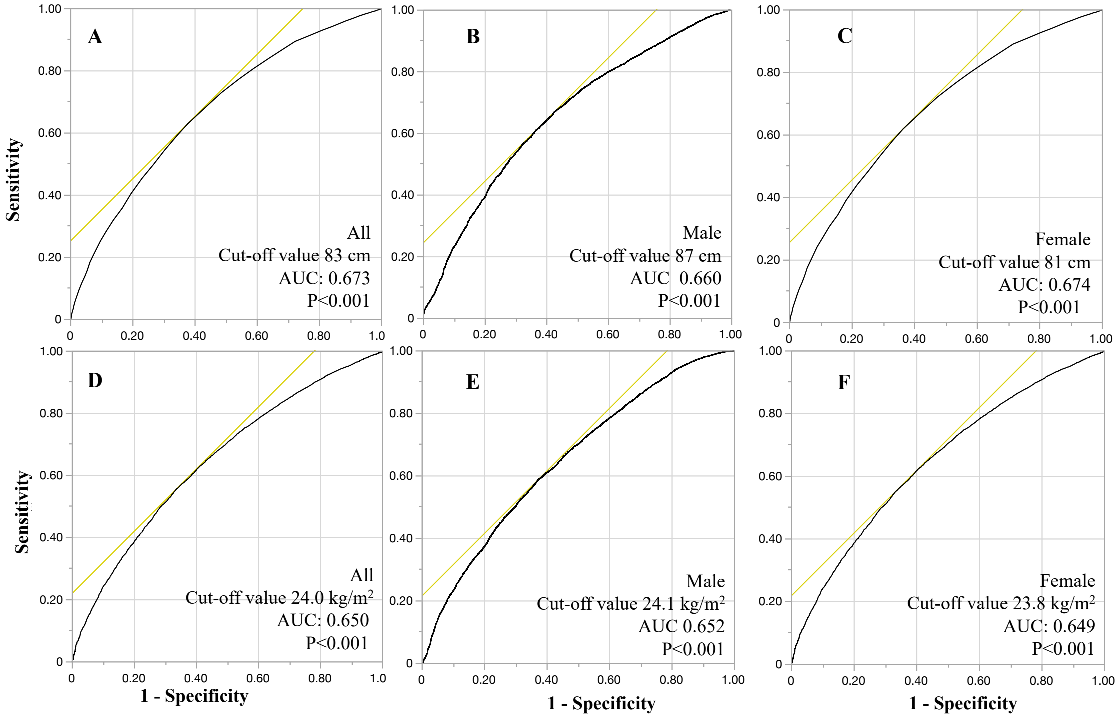
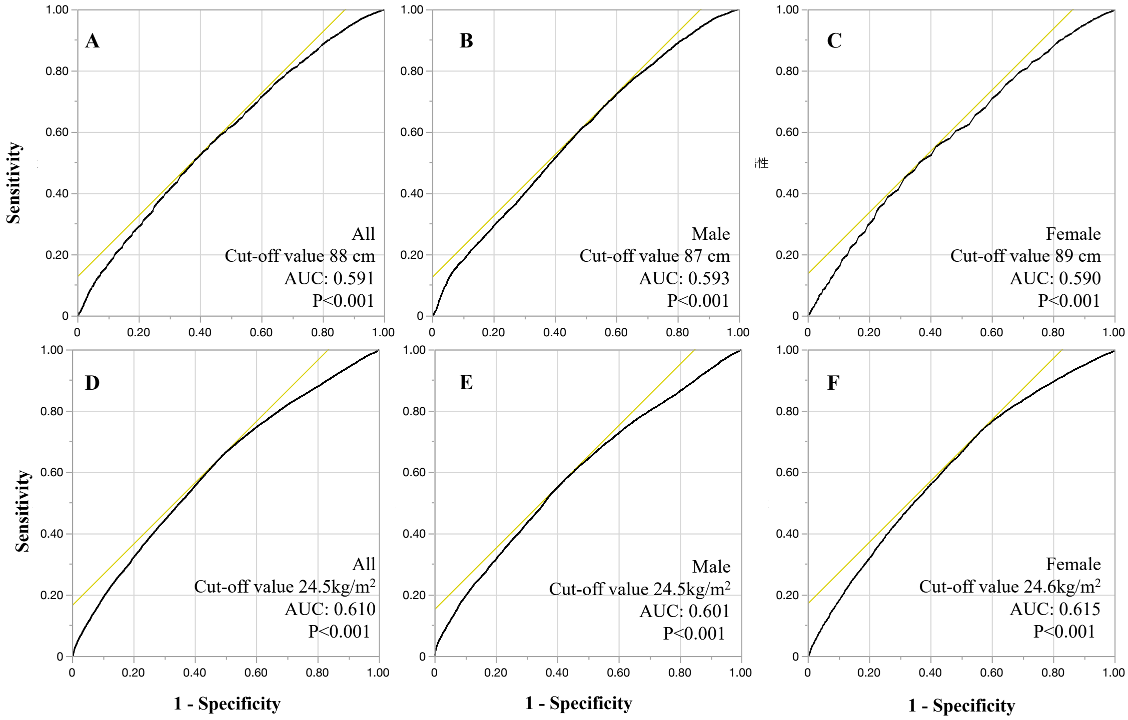


Figure 3. ROC Curves for Waist Circumference and Body Mass Index in Predicting Lifestyle-Related Diseases



Panels A, B, and C show the association between waist circumference and lifestyle-related diseases in all individuals, males, and females, respectively. Panels D, E, and F show the association between body mass index and lifestyle-related diseases in all individuals, males, and females, respectively.

Figure 4. ROC Curves for Waist Circumference and Body Mass Index in Predicting Hypertension



Panels A, B, and C show the association between waist circumference and hypertension in all individuals, males, and females, respectively; Panels D, E, and F show the association between body mass index and hypertension in all individuals, males, and females, respectively.