Waist circumference, blood glucose, serum myeloperoxidase, xanthine oxidase and oxidized low-density lipoprotein as determinants of blood pressure among adults with abdominal obesity

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Abstract. Obesity is a risk factor for increased blood pressure and diabetes, in which the relationship is mediated by the action of several pro-inflammatory mediators such as myeloperoxidase (MPO), xanthine oxidase (XO) and oxidized low-density lipoprotein (Ox-LDL). The present study aimed to evaluate the contribution of serum MPO, XO and Ox-LDL as determinants of blood pressure in adults with abdominal obesity. A total of 86 adults with abdominal obesity were recruited, then waist circumference (WC), fasting serum glucose (FSG), MPO, XO and serum Ox-LDL were measured. The contributions of these parameters to systolic blood pressure (SBP) and diastolic blood pressure (DBP) were then assessed. Multivariate analysis revealed that the determinant factors of SBP were WC, FSG, MPO and XO (β=0.418, 0.328, 0.282 and 0.248 respectively; all $P<0.05$; adjusted R^2=41.5%), while the determinants of DBP were FSG, WC and MPO (β=0.310, 0.284 and 0.274, respectively; all $P<0.05$; adjusted R^2=24.8%). In conclusion, MPO has a role as a determinant factor for SBP and DBP, whilst XO has a role as a determinant factor for SBP, and Ox-LDL does not have a significant role in blood pressure.

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Introduction

Obesity is a state marked by excessive body fat mass, which has become a global issue with increasing prevalence in recent decades (1). Fat deposition in intra-abdominal tissue causes a condition known as visceral/abdominal obesity, which is closely related to the incidence of metabolic and cardiovascular disorders (2,3). Obesity can trigger insulin resistance, oxidative stress and disrupt hemodynamics, which can ultimately lead to hypertension (4,5).

Myeloperoxidase (MPO) is a heme peroxidase enzyme found in monocytes and neutrophils that serves a role in oxidative and inflammatory processes through its role as a catalyst for the formation of hypochlorous acid. It has been reported to be associated with hypertension (6,7). Moreover, xanthine oxidase (XO) is an enzyme that has important role in purine metabolism, producing uric acid, which in turn serves a role in reactive oxygen species (ROS) formation that can trigger an increase in blood pressure (8-10). Furthermore, oxidized low-density lipoprotein (Ox-LDL) serves an important role in the process of atherosclerosis, reducing the amount of endothelial nitric oxide (NO) synthase, which leads to vasoconstriction (11,12).

The present research aimed to assess the combined contribution of MPO, XO and Ox-LDL as determinant factors of blood pressure in adults with abdominal obesity.

Materials and methods

Study design and participants. The present cross-sectional study was performed from October to December 2025. A total of 86 adult subjects with abdominal obesity were recruited [Asian population cut-off, waist circumference (WC) >90 cm in men and >80 cm in women] (13). The subjects of the study were residents enrolled in specialist medical programs and students in the master's program of Biomedical Sciences at the University of Hasanuddin (Makassar, Indonesia). Sampling

was performed at Hasanuddin University Hospital (Makassar, Indonesia) and laboratory tests were performed at Hasanuddin University Medical Research Center (Makassar, Indonesia). Subjects with a history of diabetes mellitus, current infection, inflammation, or who were taking cholesterol-lowering, uric acid-lowering or anti-hypertensive drugs were excluded from the study. The present study was ethically approved by the Health Ethics Committee, Medical Faculty, University of Hasanuddin (recommendation no. 812/2025; protocol no. UH25080659; approved on October 17, 2025).

Anthropometry and laboratory tests. Patients fasted overnight for 8-10 h, then the following morning at 8 a.m., body mass index, WC, systolic blood pressure (SBP), diastolic blood pressure (DBP) and blood samples were assessed. Blood pressure was measured using a mercury sphygmomanometer (Rudolf Riester GmbH), after the subjects had been seated for 15 min. Fasting serum glucose (FSG) and 2-h oral glucose tolerance test examinations were performed using ABX Pentra 400 (Horriba, Ltd.), while serum MPO (cat. no. E-EL-H6244; Elabscience Bionovation Inc.), Ox-LDL (cat. no. E-EL-H6021; Elabscience Bionovation Inc.) and XO (cat. no. EH1036; FineTest®; Wuhan Fine Biotech Co., Ltd.) levels were assessed using ELISA.

Statistical analysis. The role of MPO, XO, Ox-LDL, WC and other parameters as determinant factors of SBP and DBP was assessed using multivariate linear regression analysis. Statistical power estimation performed via G*Power indicated that a sample size of at least 85 participants was required based on four input predictors. SBP and DBP were logarithmically transformed to normalize the data. Age, WC, FSG, Ox-LDL, XO and MPO were assessed as independent variables, while log SBP and log DBP were evaluated as dependent variables. A collinearity analysis was performed to assess and eliminate interfering variables. $P<0.05$ was considered to indicate a statistically significant difference. SPSS version 21 software (IBM Corp.) was used for analyses.

Results

A total of 86 research subjects consisting of 68 women (79.1%) and 18 men (20.9%) participated in the present study. The basic characteristics of the research subjects are presented in Table I. Preliminary bivariate analysis using Spearman's rank correlation (data not shown) identified four candidate variables displaying significant or marginal associations with SBP: WC, FSG, XO, and MPO ($r=0.528$, $P<0.001$; $r=0.306$, $P=0.004$; $r=0.277$, $P=0.010$; $r=0.189$, $P=0.081$, respectively), whereas Ox-LDL and age demonstrated no clear correlation with SBP ($r=0.098$, $P=0.369$; $r=-0.093$, $P=0.393$). Regarding DBP, significant or trend-level correlations were noted only for WC, FSG, and MPO ($r=0.391$, $P<0.001$; $r=0.229$, $P=0.034$; $r=0.193$, $P=0.076$, respectively), while Ox-LDL, age, and XO displayed no statistically meaningful relationships ($r=-0.200$, $P=0.854$; $r=-0.176$, $P=0.104$; $r=0.091$, $P=0.406$, respectively). Univariate linear regression analysis regarding the determinant factors of log SBP is shown in Table II. Multivariate linear regression analysis revealed that WC, FSG, serum MPO and XO levels were determinant factors, accounting for ~41% of the log SBP variability, as presented in Table III. Univariate linear regression analysis regarding determinant factors of log DBP is shown in Table IV. Furthermore, multivariate linear regression analysis revealed that FSG, WC and serum MPO levels were determinant factors accounting for 24.8% of the log DBP variability, as shown in Table V. A post hoc statistical power evaluation conducted in G*Power for the SBP model (incorporating 6 predictors, $R^2=0.415$, and an effect size $f^2=0.7094$) yielded a robust statistical power of 99.99%. Similarly, the power analysis for the DBP model (6 predictors, $R^2=0.248$, effect size $f^2=0.3298$) confirmed a statistical power of 98.46%. Gender-stratified regression analyses are shown in Tables SI-SIV. Sex-stratified subgroup analyses yielded disproportionately elevated standardized β coefficients among male participants; this outcome likely stems from reduced statistical

Table I. Basic characteristics of the subjects in the present study.

Variables	Mean ± SD	Median (min-max)
Age (years)	34.81±3.05	35 (28-42)
Height (cm)	157.19±7.10	156 (143-172)
Weight (kg)	69.17±11.02	68.70 (48.80-100.00)
BMI (kg/m^2)	27.88±3.29	27.60 (20.60-37.20)
WC (cm)	93.07±6.82	93 (81-106)
SBP (mmHg)	120.60±13.65	119 (94-158)
DBP (mmHg)	78.40±10.83	78 (52-100)
FSG (mg/dl)	95.31±10.98	94.20 (74.80-120.80)
OGTT (mg/dl)	111.45±25.27	108.20 (68.60-156.30)
XO (ng/ml)	1.25±0.80	1.02 (0.30-4.30)
MPO (pg/ml)	33.32±38.65	19.94 (7.01-205.02)
Ox-LDL (pg/ml)	1,660.73±880.75	1,455.52 (458.11-4740.39)

BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FSG, fasting serum glucose; OGTT, oral glucose tolerance test; XO, xanthine oxidase; MPO, myeloperoxidase; Ox-LDL, oxidized low-density lipoprotein.

Table II. Univariate linear regression analysis of the determinant factors of log systolic blood pressure.

Variables	B	Standard error	β	P-value	Adjusted R^2
Ox-LDL	-1.560×10^{-6}	0.000	-0.029	0.793	0.011
MPO	0.000	0.000	0.230	0.033	0.042
WC	0.004	0.001	0.531	<0.001	0.274
XO	0.016	0.006	0.264	0.014	0.059
FSG	0.001	0.000	0.279	0.009	0.067
Age	-0.001	0.002	-0.071	0.514	0.005

Ox-LDL, oxidized low-density lipoprotein; MPO, myeloperoxidase; WC, waist circumference; XO, xanthine oxidase; FSG, fasting serum glucose.

Table III. Multivariate linear regression analysis of the determinant factors of log systolic blood pressure.

Variables	B	Standard error	β	P-value	Adjusted R^2
Constant	1.725	0.076	N/A	<0.001	0.415
Ox-LDL	-5.261×10^{-6}	0.000	-0.097	0.274	
MPO	0.000	0.000	0.282	0.006	
WC	0.003	0.001	0.418	<0.001	
XO	0.015	0.005	0.248	0.007	
FSG	0.001	0.000	0.328	0.001	
Age	-0.002	0.001	-0.142	0.113	

Ox-LDL, oxidized low-density lipoprotein; MPO, myeloperoxidase; WC, waist circumference; XO, xanthine oxidase; FSG, fasting serum glucose; N/A, not applicable.

Table IV. Univariate linear regression analysis of the determinant factors of log diastolic blood pressure.

Variables	B	Standard error	β	P-value	Adjusted R^2
Ox-LDL	-1.160×10^{-5}	0.000	-0.167	0.124	0.016
MPO	0.000	0.000	0.217	0.045	0.036
WC	0.003	0.001	0.356	0.001	0.116
Age	-0.004	0.002	-0.191	0.079	0.025
FSG	0.001	0.001	0.233	0.031	0.043
XO	0.000	0.008	-0.004	0.97	0.012

Ox-LDL, oxidized low-density lipoprotein; MPO, myeloperoxidase; WC, waist circumference; FSG, fasting serum glucose; XO, xanthine oxidase.

Table V. Multivariate linear regression analysis of the determinant factors of log diastolic blood pressure.

Variables	B	Standard error	β	P-value	Adjusted R^2
Constant	1.632	0.111	N/A	<0.001	0.248
Ox-LDL	-1.247×10^{-5}	0.000	-0.180	0.075	
MPO	0.000	0.000	0.274	0.017	
WC	0.003	0.001	0.284	0.006	
Age	-0.004	0.002	-0.201	0.059	
FSG	0.002	0.001	0.310	0.006	
XO	0.002	0.008	0.032	0.751	

Ox-LDL, oxidized low-density lipoprotein; MPO, myeloperoxidase; WC, waist circumference; FSG, fasting serum glucose; XO, xanthine oxidase; N/A, not applicable.

power given the smaller male subgroup size, suggesting that these specific estimates should be interpreted with caution.

Discussion

Obesity is one of the main causes of hypertension, where the relationship between them is mediated by several factors, including increased oxidative stress (4). The present study demonstrated that in subjects with abdominal obesity, 41.5% of SBP variability was determined by serum MPO, XO, WC and FSG, while 24.8% of DBP variability was determined by serum MPO, WC and FSG. MPO had a slightly higher contribution to SBP variability than XO (β, 0.282 vs. 0.248). Moreover, Ox-LDL was revealed to have no direct contribution to either SBP or DBP.

The involvement of MPO in hypertension, coronary heart disease and cardiovascular disease has been reported in previous studies (6,14). Buljubasic *et al* (15) reported higher serum MPO levels in hypertensive adults compared with that in normotensive individuals. Another study in obese children revealed a positive association between serum MPO levels and SBP and DBP (r=0.357 and r=0.354, respectively; P<0.05) (16). MPO produced by infiltrating neutrophils in perivascular tissues can lead to the formation of ROS, which may cause vascular dysfunction. ROS also reduce the bioavailability of NO, thereby reducing the vasodilatory capacity of blood vessels and causing hypertension (17).

The impact of XO on blood pressure has also been reported in several studies. Serum XO levels have been reported to be positively correlated with SBP and DBP in adult populations (r=0.309 and r=0.180, respectively; P<0.01) (8). Other research has reported findings similar to the present study, showing an increase in SBP with increasing serum XO quartiles but finding no relationship between DBP and serum XO quartiles (18). Another study reported higher serum XO and MPO levels in subjects with age-related cataracts accompanied by hypertension compared with that in those without hypertension; however, the contribution of XO and MPO to hypertension in that study was not investigated (10). XO, which serves a role in the metabolism of purine to uric acid, can produce ROS byproducts, which cause endothelial and vascular dysfunction, suppress NO levels, and cause vasoconstriction and increased blood pressure (8,18).

Ox-LDL is a compound that is pro-oxidant, pro-inflammatory and pro-thrombotic, which can cause endothelial dysfunction and atherosclerosis (11). A study in an elderly population reported that Ox-LDL was associated with arterial stiffness (19). However, in line with the results of the present study, Harmon *et al* (20) reported that no association was found between Ox-LDL with SBP and DBP in the adult population. This suggests that although Ox-LDL serves a role in the early formation of atherosclerotic plaques, it is not directly related to increased blood pressure, especially among young adults, as in the subjects of the present study.

Studies that evaluate combined contribution of MPO, XO and Ox-LDL to SBP and DBP in abdominally obese population are lacking. Whilst the present study demonstrated the contribution of MPO and XO to blood pressure elevation, there are several limitations of the study that should be addressed. The cross-sectional study design only provides an overview of the association between variables and cannot prove a causal relationship between them; therefore, further longitudinal research is needed to establish a temporal or causal

relationship. Furthermore, the majority of the study subjects were women, thus the findings may reflect the biological conditions of women more prominently than that of men. Consequently, it is recommended that future studies perform separate analyses by sex with a more adequate sample size. Additionally, most of the variability in SBP (58.5%) and DBP (75.2%) is determined by other factors not analyzed in the present study, including genetic factors, diet, sodium intake, physical activity and alcohol consumption; therefore, in future studies, the effects of these factors should also be analyzed simultaneously. Multicenter studies involving different populations and a larger number of subjects are also needed to generalize the findings of the present study.

In conclusion, WC, FSG, MPO and XO were shown to be determinants of SBP, while FSG, WC and MPO were demonstrated to be determinants of DBP.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

LBK, NN, AA, and HR conceived, designed the study, wrote and edited the manuscript. LBK, WM, and SHY performed the investigation and data analysis. HR supervised the project.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by Health Ethics Committee, Medical Faculty, University of Hasanuddin, with recommendation number: 812/2025, protocol: UH25080659 (approved on 17th of October 2025). Written informed consent was obtained from all subjects involved in the study before participation.

Patient consent for publication

Not applicable.

Competing interest

The authors declare that they have no competing interests.

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