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Original Article

Interplay of adipokines in the pathogenesis of essential hypertension: A comparative cross-sectional in Ghana

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ABSTRACT

Background: The renin-angiotensin-system (RAS), endothelial dysfunction and sympathetic nervous system are mechanistic risk factors of hypertension. The study sought to elucidate the interplay of adipokines in the pathogenesis of essential hypertension.

Methodology: This comparative cross-sectional study recruited 200 confirmed hypertensive patients from the KATH and 50 age-matched normotensives. Participants' blood pressures, anthropometric and socio-demographic information were voluntarily obtained. Serum levels of adiponectin, leptin and resistin of the participants were quantified using the ELISA. Renal function, lipid profile and glycemic status of all subjects were also analyzed.

Results: Hypertensive patients showed a significantly higher anthropometric indices of adiposity compared to normotensives, CI ($p < 0.0001$), BAI ($p < 0.0001$) and AVI ($p = 0.002$). Adiponectin levels ($p < 0.0001$) were significantly lower in the hypertensive relative to the normotensives. Furthermore, significantly higher concentrations of serum leptin ($p = 0.016$) and the leptin-adiponectin ratio ($p = 0.001$) were observed among the hypertensive compared to the normotensives. The study further observed a direct association between serum leptin and weight ($r = 0.111$, $p = 0.022$), BMI ($r = 0.129$, $p = 0.009$) and WHtR ($r = 0.098$, $p = 0.045$) but inverse relationship with height ($r = -0.134$, $p = 0.006$) among the hypertensive. Serum leptin has a significant negative correlation with HDL-C among the hypertensive ($r = -0.174$, $p = 0.013$). The fully aOR for hypertension as predicted by resistin and adiponectin were 1.12 (95% CI, 1.02–1.25); $p = 0.019$) and 0.93 (95% CI, 0.91–0.95); $p = 0.0001$) respectively.

Conclusion: We found that elevations in serum levels of leptin and resistin, and low levels of adiponectin may play a role in the pathogenesis of essential hypertension. Therefore, adipokines may offer themselves as potential indices for early and accurate detection of high blood pressure. At the same time our present results also confirm the conclusions with respect to correlation of leptin and obesity. Further longitudinal studies in a larger population are warranted to investigate the physiological and pathological functions of adipokines in hypertension.

1. Introduction

Hypertension a global health concern has reached pandemic levels and is often associated with high morbidity and mortality rates that negatively impact on the public health and socio-economic conditions.[1] Essential hypertension has no specific underlying medical cause and accounts for nearly 90–95% of all diagnosed cases.[2] It has been confirmed that hypertension was the leading cause of cardiovascular mortality in 2013.[3] Increasing

Abbreviations: aOR, Adjusted Odds ratio; AVI, Abdominal Volume Index; BAI, Body Adiposity Index; BMI, Body Mass Index; CI, Conicity Index; ELISA, Enzyme-Linked Immunosorbent Assay; RAS, Renin-Angiotensin-System; WHtR, Waist-to-Height Ratio.

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urbanization in Africa has been identified as one of the leading risk factors of hypertension in recent times.[4] The highest estimated prevalence of hypertension in Africa has been pegged at 46% among adults, aged 25 years and above, while the Americans have the lowest prevalence of 35%.[1] Similarly, according to WHO 2014 annual report, outpatient (OPD) cases of hypertension in Ghana rose from 799,028 in 2011 to 830,620 in 2014 and is on record as the highest among the non-communicable.[5] In Ghana, hypertensive-associated renal disease is a common complication both in Kumasi and Accra.[6]

Hypertension has been shown to play a very active role in the incidence metabolic syndrome.[7] Metabolic syndromes is a group of conditions characterized by high risk for heart disease, hyperglycemia, raised triglyceride/and free fatty acids levels, low HDL-cholesterol concentration and excessive abdominal fat.[8] These conditions are associated with an increased or abnormal fat mass of adipose tissue as seen in obesity and dyslipidemia. Adipokines have been showed to contribute to the risk of hypertension, for example, elevated levels of leptin have been proposed to play a role in the pathogenesis of obesity-associated hypertension. Moreover, leptin is one of the major adipocyte hormones and a principal determinant of bodyweight, energy metabolism and the occurrence of obesity and its related disorders in human.[9] Adiponectin also contributes significantly to the risk factors of hypertension namely endothelium dysfunction (ED), renin-angiotensin-system (RAS) and sympathetic nervous system (SNS).[10] Most studies on hypertension in Ghana have mostly been on the behavioural and socioeconomic factors and other related diseases. This study sought to assess the interplay of adipokines in the pathogenesis of essential hypertension in a Ghanaian setting.

2. Patients and methods

2.1. Study design and setting

A comparative cross-sectional study conducted among confirmed hypertensive patients from the Hypertension Unit of the Komfo Anokye Teaching Hospital (KATH), Ghana and age-matched normotensives from September 2012 to March 2014. KATH is a tertiary referral teaching hospital located in Kumasi, the regional capital of the Ashanti region in Ghana with a total projected population of 4,780,380 according to the Ghana Statistical Service, 2010. It is the second largest Hospital in Ghana. The geographical location of this teaching hospital, coupled with a well-defined road network makes this facility accessible to patients within the catchment area of the hospital.

2.2. Ethical consideration

This study was approved by the Committee on Human Research, Publication and Ethics (CHRPE) of School of Medical Sciences, KNUST and KATH. The subjects were adequately informed of the purpose, procedures, nature, risks and minimal discomfort of the study. Participants were coded and assured of strict anonymity, confidentiality and the freedom to exit or decline participation at any time without penalty.

2.3. Study population and subject recruitment

Using a simple random sampling technique, two 200 confirmed hypertension patients aged $\geq$ 30 years attending the Hypertension clinic, KATH and 50 age-matched normotensives. Participants who were all clinically stable voluntarily consented to the study. Individuals with secondary hypertension, diabetes, cardiovascular diseases, kidney or liver dysfunction as well as pregnant women were essentially excluded from the study. Participants' blood pressures and anthropometric as well as their socio-demographic and treatment information were voluntarily obtained.

2.4. Blood pressure measurement

Systolic and diastolic blood pressures of the study subjects were taken by two experienced senior nurses at the Hypertension clinic. Each participant was seated quietly and relaxed in an armchair with feet on the floor and arm supported at the heart level for at least 5 min. The brachial artery was located and mercury sphygmomanometer (Accoson, UK) with suitable cuff bladder size of 13 cm $\times$ 23 cm was used to encircle an upper arm of each participant. Cuff bladder which was connected to column of mercury with graduated scale, was inflated to exert pressure on the large brachial artery until the blood flow stopped and the pressure slowly released and, with the help of a stethoscope listened to the pulse for the determination of both systolic and diastolic pressures readings on the scale in millimeters of mercury (mmHg). Three measurements were taken for each participant at one-minute interval and then the average used as the mean systolic and diastolic pressures that were recorded into the data.

2.5. Anthropometric measurements

Body weight, expressed in 0.1-kg intervals, was measured at fasting state in the morning using automated scale. Portable Height Rod Stadiometers were used for body height to the nearest centimeters. The subject stood straight, with feet placed together and flat on the ground, heels, buttocks and scapulae against the vertical backboard, and arms loose and relaxed with the palms facing medially. Their heads were carefully positioned in the Frankfurt plane, with the lower margins of the orbit in the same horizontal plane as the upper margin of the external auditory meatus. BMI was calculated as body weight divided by height squared (Kg/m^2).

HC was measured at the level of maximal gluteal protrusion and waist circumference at the midpoint between the anterior superior iliac crest and the lowest rib using a tape measure while the subject stood with feet 25–30 cm apart. The tape measure was placed directly on the skin. Patients were allowed to breathe out normally and measurements were taken. The tape was held lightly so as not to compress the skin. WHtR and WHR were calculated as WC (cm) divided by Ht (cm) and HC respectively. Body Adiposity Index (BAI) was calculated as the size of the hips compared to the patient's height. $BAI = HipC(cm)\tilde{A} \cdot [Height(m)]^{1.5} - 18$

The conicity index (CI) was determined from the measurements of weight, height and waist circumference. $\text{Conicity index} = \frac{\text{Waist circumfrence(m)}}{0.109\times\sqrt{\frac{\text{weight(kg)}}{\text{height(m)}}}}$

Abdominal volume index (AVI) was derived from the measurements of waist circumference (WC) and hip circumferences (HC) $AVI = \frac{2[waistC(cm)]^2+0.7[waistC(cm)-hipC(cm)]^2}{1000}$

Visceral Adiposity Index (VAI) uses the study participant's waist circumference (WC), BMI, triglyceride (TG) and HDL-C levels

$$VAI\ for\ females = \frac{WC}{36.58} + (1.89xBMI)x\left(\frac{TG}{0.81}\right)x\left(\frac{1.52}{HDL}\right)$$

$$VAI\ for\ males = \frac{WC}{39.68} + (1.88xBMI)x\left(\frac{TG}{1.03}\right)x\left(\frac{1.31}{HDL}\right)$$

Atherogenic index (AI) utilizes triglyceride and HDL-C concentrations in the formula

$$AI = \log\left(\frac{[TG]}{[HDL - C]}\right)$$

2.6. Biochemical analysis

The stored frozen plasma and sera of blood samples of the participants were stalled to room temperature and analyzed quantitatively for various biochemical assays specifically glucose, creatinine, urea, total cholesterol, triglycerides and HDL-cholesterol on a chemistry auto-analyzer, COBAS INTEGRA® 400 *plus* automated chemistry analyzer (Roche Diagnostics GmbH, Mannheim, Germany) using the manufacturer's protocol. Serum levels of adiponectin, leptin and resistin of the participants were quantified using the enzyme-linked immunosorbent assays (ELISA).

2.7. Statistical analysis

Data was entered into Microsoft excel and analyzed using SPSS version 23. Continuous variables were expressed as mean ± SD for normal distributed data and median (inter-quartile range), while comparisons between confirmed hypertensive and normotensives were performed using parametric and non-parametric analysis where appropriate. Association of serum adipokines with clinical variables, anthropometrics, and blood lipid profiles among hypertensive were analyzed using partial Pearson correlation. *P-value* less < 0.05 were considered statistically significant.

3. Results

Serum adiponectin concentration was significantly lower in hypertensives than normotensives ($p < 0.001$). Contrary, serum leptin concentration was significantly higher in both systolic and diastolic pressures of hypertensives than the normotensive subjects ($p < 0.0001$). It was also observed that the mean resistin levels were higher in hypertensives though not statistically significant ($p = 0.2668$). The hypertension patients have higher serum concentrations of lipid profile parameters namely total cholesterol (TC, $p < 0.0001$), triglycerides (TG), LDL-C ($p < 0.0001$) and HDL-C ($p = 0.0427$) than the control subjects. Moreover, the serum urea levels ($p = 0.0378$) and fasting plasma glucose (FBG) concentration ($p = 0.0175$) of hypertensive subjects were significantly higher than the control subjects [Table 1].

Using non-parametric analysis, median BMI ($p < 0.0001$), conicity index ($p = 0.0297$), body adiposity index ($p < 0.0001$) and abdominal volume index ($p = 0.0010$) of the female hypertension subjects were statistically significant higher compared to their male counterparts. The median creatinine ($p < 0.0001$) and urea concentrations ($p = 0.0257$) were significantly higher in males compared to females. However, median TC ($p = 0.0022$), HDL-C ($p = 0.003$), LDL-C ($p = 0.0157$) were significantly higher in females compared to that of the male subjects. However, no statistical significant difference was observed between male and female in relation to the concentrations of adipokines ($p > 0.05$) (see Table 2).

Serum resistin and leptin concentrations showed significant and negative correlation with urea ($r = -0176$, $p = 0.013$) and HDL-C ($r = -0.174$, $p = 0.013$) respectively in both age and sex-adjusted models. Positive correlation was observed between leptin and triglyceride ($r = 0.012$, $p = 0.863$). Serum levels of resistin showed negative correlation with FBS ($r = -0.019$, $p = 0.785$), creatinine ($r = -0.089$, $p = 0.238$), TC ($r = -0.036p = 0.611$) and LDL-C ($r = -0.077$, $p = 0.278$) and CR ($r = -0.054$, $p = 0.444$). Leptin also has statistically insignificant and positive correlation with the biochemical variables and coronary indices [Table 3].

Table 1
Biochemical parameters and adipokines between hypertensive and normotensive.

Variables	Hypertensive patients (n = 200)	Normotensives (n = 50)	p-value
FBG (mmol/L)	5.9 ± 2.1	5.2 ± 0.71	**0.0175**
Serum creatinine (μmol/L)	70.1 ± 31.2	67.9 ± 18.5	0.6241
serum urea (mmol/L)	3.9 ± 1.7	3.4 ± 0.8	**0.0378**
TC (mmol/L)	5.5 ± 1.4	4.2 ± 1.0	**<0.0001**
TG (mmol/L)	1.3 ± 0.7	1.2 ± 0.7	0.3218
HDL (mmol/L)	1.5 ± 0.4	1.3 ± 0.5	**0.0427**
LDL (mmol/L)	3.4 ± 1.2	2.4 ± 0.9	**<0.0001**
Atherogenic Index	1.0 ± 0.7	1.1 ± 0.9	0.8054
Coronary risk	3.8 ± 0.1	3.2 ± 0.5	**0.0367**
SBP (mmHg)	150.0 ± 22.2	120.9 ± 10.2	**<0.0001**
DBP (mmHg)	90.1 ± 10.3	75.9 ± 8.3	**<0.0001**
Resistin (μg/l)	7.3 ± 0.25	6.7 ± 0.12	0.2268
Adiponectin (pg/mL)	157.3 ± 0.52	189.7 ± 0.87	**<0.0001**
Leptin (μg/L)	1.5 ± 0.07	0.9 ± 0.02	**<0.0001**
log(leptin)/ adiponectin	2.720–005 (−0.0004–0.0006)	−0.0003(−0.0005- - 9.8e−005)	**0.010**
Resistin/ adiponectin	0.05 ± 0.01	0.04 ± 0.004	**0.0030**
Leptin/ adiponectin	0.008 ± 0.006	0.004 ± 0.0008	**0.0010**
Anthropometric indices			
BMI (Kg/m^2)	28.9 ± 6.6	27.2 ± 11.8	0.2867
CI	1.27 ± 1.6	1.08 ± 1.8	0.4740
BAI	32.4 ± 7.7	24.5 ± 11.6	**<0.0001**
AVI	17.8 ± 6.0	12.5 ± 4.9	**<0.0001**
VAI	5.2 ± 0.3	3.0 ± 0.5	**<0.0001**

FBG: fasting blood glucose; TC: total cholesterol; TG: triglyceride; HDL: high density lipoprotein; LDL: low density lipoprotein, BMI = body mass index, CI = conicity index, BAI = body adiposity index, VAI = visceral adiposity index, AVI = abdominal volume index $p < 0.05$ was considered statistically significant.

As shown in Table 4, there was a significantly positive correlation between serum leptin and weight ($r = 0.111$, $p = 0.022$), BMI ($r = 0.126$, $p = 0.009$), and WHtR ($r = 0.098$, $p = 0.045$) among hypertension patients. Conversely, a weak, but significant negative correlation was observed between serum levels of leptin and height ($r = -0.134$, $p = 0.006$). No statistically significant correlations were observed for resistin and adiponectin with anthropometric indices ($p > 0.05$).

After controlling for age, gender and BMI, the fully adjusted odds ratio (aOR) for hypertension as predicted by resistin and plasma adiponectin were 1.128 (95% CI, 1.020–1.247; $p = 0.019$) and 0.933 (95% CI, 0.909–0.953; $p < 0.0001$) respectively. This indicates that there was a 12.8% increase in the odds of having hypertension for each 1 μg/L increase in resistin and 6.7% decrease in the odds of having hypertension for each 1 pg/ml increase in serum adiponectin. Moreover, the fully adjusted odds ratio (OR) for hypertension as predicted by systolic and diastolic were 1.097 (95% CI, 1.05–1.14; $p < 0.0001$) and 1.13 (95% CI, 1.06–1.21; $p = 0.001$) respectively. This observation suggests that, there were 9.7% and 13.1% increase in the odds of having hypertension for each mmHg increase in systolic and diastolic pressures. However, none of the biochemical assays as well as the atherogenic index has any significant association with the risk of hypertension [Table 5].

4. Discussion

Adipokines are known to contribute to the regulation of varied biological processes, including inflammation, immune function and metabolic syndrome. They also play various important roles in vascular biology, hematopoiesis and cell proliferation as well

Table 2
Comparison of variables between male and female hypertensive subjects.

Variables	Female (n = 137)	Male (n = 63)	p-value
Blood pressure			
Systolic (mmHg)	150(≤140)	148(≤140)	0.3820
Diastolic (mmHg)	90(≤80)	88(≤80)	0.4561
Anthropometrics			
BMI (Kg/m^2)	30.41(24.41–37.29)	25.77(22.95–29.24)	**<0.0001**
CI	131.10(118.9–138.3)	126.00(117.50–133.90)	**0.0297**
BAI	35.89(30.45–42.49)	26.95(24.04–31.43)	**<0.0001**
AVI	18.53(14.53–22.9)	15.51(13.80–18.05)	**0.0010**
VAI	3.26(1.89–4.63)	3.13(1.76–4.50)	0.0600
Biochemical parameters			
FBS(mmol/L)	5.30 (4.82–6.12)	5.50(4.90–6.50)	0.3782
Creatinine (mmol/L)	60.00(53.00–70.00)	71.00(58.00–89.00)	**<0.0001**
Urea(mmol/L)	3.40(2.58–4.56)	3.87(3.04–4.89)	**0.0257**
TC(mmol/L)	5.43(4.68–6.23)	4.89(4.14–5.60)	**0.0022**
TG (mmol/L)	1.14(0.80–1.60)	1.09(0.78–1.46)	0.5114
HDL-C(mmol/L)	1.42(1.22–1.83)	1.28(0.97–1.56)	**0.003**
LDL-C(mmol/L)	3.40(2.65–4.05)	2.80(2.30–3.80)	**0.0157**
Cardiovascular risks			
Coronary risk	3.78(3.03–4.55)	4.23(3.05–4.91)	0.2278
Atherogenic index	(−)0.102(0.273)	(−)0.056(0.306)	0.2888
Adipokines			
Resistin(μg/L)	7.38(5.23–9.33)	7.04(5.58–8.02)	0.540
Adiponectin(pg/mL)	157.60(153.80–159.50)	156.70(152.60–159.30)	0.4578
Leptin(μg/L)	1.54(0.87–1.87)	1.32(0.87–1.26)	0.1371
Log([L]/[A])	0.00022(−0.00039–0.000167)	−005(−0.00043–0.000632)	0.0745
R/A	0.042(0.033–0.060)	0.042(0.034–0.052)	0.9618
L/A	0.007(0.006–0.012)	0.007(0.005–0.008)	0.1027

FBG: fasting blood glucose; TC: total cholesterol; TG: triglyceride; HDL: high density lipoprotein; LDL: low density lipoprotein, BMI = body mass index, CI = conicity index, BAI = body adiposity index, VAI = visceral adiposity index, AVI = abdominal volume index p < 0.05 was considered statistically significant, L/A = Leptin/Adiponectin, R/A = Resistin/Adiponectin.

as angiogenesis.[11] It was observed in this study that hypertensive subjects had significantly lower plasma concentration of adiponectin compared their counterpart normotensive. Furthermore, adiponectin levels were significantly associated with reduced odds for hypertension. This observation confirms the fact that low plasma levels of adiponectin impact a negative effect on cardiac output.[12] In addition, various studies have confirmed this observation.[13,14]

Moreover, plasma leptin levels of hypertensive subjects were significantly higher compared to the normotensives. This observation is plausible considering the biogenic role of leptin in the sympathetic nervous system.[15] Plasma leptin transverses the blood-brain-barrier and binds to its receptors in various regions of the central nervous system (CNS), including the hypothalamus and brainstem. Indeed, leptin has been shown to activate neural pathways that decrease appetite but increase SNS activity and energy expenditure.[16] Hyperleptinemia contributes immensely to hyperactivity of the sympathetic nervous system and subsequently increase in blood pressure.[17]

Various studies have also confirmed the contributory role of resistin in adipogenesis and inflammation.[18] Results from this studies showed that hypertensive subjects had higher levels of resistin compared to the normotensives. This finding is consistent with reports from a study conducted in Greece which demonstrated significant higher levels of resistin in patients with essential hypertension compared to normotensives.[19] Furthermore, plasma resistin was significantly associated with higher odds for hypertension after controlling for age, gender and BMI (Table 5). Several mechanisms contribute to the possible involvement of resistin in the pathogenesis of hypertension including inflammation.[20] As a pro-inflammatory adipokine, resistin is known to be actively involved in the vascular inflammation. It is of interest to also note that inflammation of the vascular wall plays an important role in the pathogenesis and progression of atherosclerosis, cardiovascular disease and hypertension.[21] It has been proven that essential hypertension is characterized by vascular wall inflammation which causes resistance to the blood flow. At the functional level, resistin induces the expression of the pro-inflammatory cytokines IL-6 and TNF-α, probably *via* the NF-κB pathway in the human mononuclear cells.[22]

However, that the antagonistic action of resistin on insulin signaling is achieved by the involvement of two signaling pathways. The first signaling pathway, serum resistin inhibits the AMPK signaling pathway in the liver and the muscle.[23] This action of resistin induces the expression of suppressor of cytokine signaling(SOCS) 3 in adipocytes, a signaling molecule noted for its antagonistic effect on insulin signaling.[24] Thus, the probability of hypertensive patients developing diabetes is enhanced by the high plasma concentration of resistin.[25,26]

It was further observed in this current study that, the hypertensive subjects with elevated levels of resistin were dyslipidemic with raised levels of serum TC and LDL-C as against the normotensive group. Studies have confirmed that resistin increases the intracellular availability of non-esterified fatty acids in human macrophages.[27] The contributory roles exhibited by resistin and leptin in the aetiogenesis of hypertension as proffered in this study, thus stresses the importance of including leptin and resistin to the routine repertoire of laboratory investigations for hypertensive patients.

We found a statistically significant and positive correlation between serum leptin concentrations and weight, BMI and WHtR.

Table 3
Partial Pearson correlation of serum adipokines with biochemical markers of hypertension.

Variables	Resistin (μg/l)		Adiponectin (pg/ml)		Leptin (μg/l)	
	r	*p-value*	r	*p-value*	r	*p-value*
FBS (mmol/L)	−0.019	0.785	0.105	0.140	0.029	0.687
Creatinine (μmol/L)	−0.089	0.239	0.044	0.533	−0.086	0.226
Urea (mmol/L)	−0.176	**0.013**	−0.058	0.416	−0.084	0.239
TC (mmol/L)	−0.036	0.611	0.054	0.444	0.068	0.336
TG (mmol/L)	0.092	0.197	0.076	0.286	0.012	0.863
HDL-C (mmol/L)	0.061	0.39	−0.053	0.457	−0.174	**0.013**
LDL-C (mmol/L)	−0.077	0.278	0.057	0.426	0.08	0.262
CR	−0.054	0.444	0.081	0.254	0.100	0.157
AI	0.550	0.455	0.080	0.261	0.026	0.712

CR: Coronary risk AI: Atherogenic index.
Correlation is significant at the 0.05 level (2-tailed). r: correlation coefficient; TC: total cholesterol; TG: triglyceride; HDL: high density lipoprotein; LDL: low density lipoprotein.

Table 4
Partial Pearson correlation of serum adipokines with anthropometric indices among hypertensive patients.

	Resistin (μg/l)		Adiponectin (pg/ml)		Leptin (μg/l)	
	r	p-value	r	p-value	r	p-value
Weight (kg)	−0.066	0.35	0.06	0.398	0.111	**0.022**
Height (m)	−0.071	0.32	−0.066	0.353	−0.134	**0.006**
BMI (kg/m^2)	−0.043	0.545	0.081	0.256	0.126	**0.009**
WC (cm)	−0.019	0.789	−0.01	0.885	0.005	0.942
Hip C (cm)	−0.032	0.657	−0.028	0.694	0.037	0.600
WHR	0.015	0.828	0.002	0.982	−0.051	0.472
WHtR	−0.003	0.964	0.008	0.905	0.098	**0.045**
BAI	−0.005	0.949	0.006	0.931	0.043	0.545
CI	0.030	0.670	−0.065	0.362	−0.100	0.161
AVI	−0.028	0.690	−0.011	0.872	−0.005	0.945
VAI	0.042	0.565	0.08	0.124	0.019	0.543

Correlation is significant at the 0.05 level (2-tailed). r: correlation coefficient. BMI: Body mass index; WC: waist circumference; Hip C: hip circumference; WHR: waist-to-hip ratio; WHtR: waist-to-height ratio BAI: Body Adiposity index CI: Conicity index AVI: Abdominal volume index; VAI: Visceral adiposity index.

Table 5
Regression analysis model of the risk of hypertension using adipokines, coronary and biochemical indices.

Variables	Adjusted OR	95% CI for OR	P-value
Systolic blood pressure	1.10	(1.05–1.14)	**<0.0001**
Diastolic blood pressure	1.13	(1.06–1.21)	**0.001**
FBS(mmol/L)	1.11	(0.72–1.72)	0.646
Creatinine(mmol/L)	1.00	0.97–1.02)	0.953
Urea(mmol/L)	1.50	(0.92–2.41	0.099
TC(mmol/L)	2.36	(0.002–233.51)	0.710
TG(mmol/L)	0.39	0.01–3.85)	0.423
HDL(mmol/L)	1.16	(0.01–126.5)	0.952
LDL(mmol/L)	0.67	(0.007–67.0)	0.865
AI	1.20	(0.92–2.06)	0.780
Age (per year)	1.026	(1.002–1.051)	**0.035**
Gender (female)	0.616	(0.321–1.181)	0.145
BMI (kg/m^2)	1.085	(1.021–1.142)	**0.005**
WHR	14.612	(0.874–24.42)	0.062
WHtR	0.031	(0.002–1.616)	0.085
CI	1.025	(0.99–1.06)	0.104
BAI	1.057	(0.99–1.13)	0.091
AVI	1.098	(0.94–1.28)	0.240
Resistin ((μg/L)	1.128	(1.020–1.247)	**0.019**
Adiponectin(pg/mL)	0.933	(0.909–0.958)	**<0.0001**
Leptin(μg/L)	0.908	(0.657–1.253)	0.556

OR: Odds ratio; CI: confidence interval. Statistical significant difference ($p < 0.05$).

This finding is in good agreement with observations in other numerous studies that have reported that leptin concentration is closely associated with BMI. Moreover, leptin also plays a significant role in the regulation of feeding behaviour and arterial hypertension.[28]

Although, the findings of this study are novel, there were some limitations. Despite our extensive effort to rule out confounding factors which may interfere with the adipokines such as adiponectin, resistin and leptin, there may be possible unforeseen confounders which were not controlled. In addition, this was a cross-sectional comparative study conducted with small sample size which limited our ability to explain the causal correlations between adipokines and hypertension. However, we are confident in our findings will be a baseline for further probing.

5. Conclusion

We found that elevations in serum levels of leptin and resistin, and low levels of adiponectin may play a role in the pathogenesis of essential hypertension. Therefore, adipokines may offer themselves as potential indices for early and accurate detection of high blood pressure. At the same time our present results also confirm the conclusions with respect to correlation of leptin and obesity. Further longitudinal studies in a larger population are warranted to investigate the physiological and pathological functions of adipokines in hypertension.

Conflict of interest

We have no conflict of interest to declare.

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