The association of obesity and serum leptin levels with complete blood count and some serum biochemical parameters in Iranian overweight and obese individuals

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Abstract

Background: Obesity has been suggested to be well correlated with altered levels of complete blood count (CBC) parameters. In this study, the relationship of body mass index (BMI) and circulating leptin levels with CBC among obese and overweight adults was examined.

Methods: CBC and biochemical parameters, WBC and hematological profiles, leptin levels, related factors to liver, and kidney and lipid profiles were measured among 184 obese and overweight people aged 18–60 years. Statistical analysis was performed using SPSS software. To assess the normality of data, the Kolmogorov–Smirnov test was used. Logarithmic transformation was performed for some variables with non-normal distribution. The association between 2 quantitative variables was measured using bivariate correlation (Pearson or Spearman). Pearson correlations and multiple regression analysis were performed to assess the correlation between variables. Simple and multiple regression analyses were performed to predict some variables. P- value <0.05 was considered significant.

Results: Hematocrit, insulin, fasting blood sugar, uric acid, TG, LDL-C, VLDL-C, and ALT were positively correlated with BMI (p=0.041, r=0.149 for hematocrit; p≤0.001, r=0.520 for insulin; p≤0.001, r=0.363 for FBS; p≤0.001, r=0.309 for uric acid; p=0.015, r=0.189 for TG; p=0.030, r=161 for LDL-C; p=0.019, r=0.181 for VLDL-C; p≤0.001, r=0.299 for ALT), whereas urea and HDL-C were negatively correlated with BMI (p≤0.001, r=-0.368 for urea; p≤0.001, r=-0.297 for HDL-C). Moreover, LDL-C and insulin were positively correlated with leptin (P = 0.011, r = 0.194 for LDL-C, P = 0.013, r = 0.114 for insulin) and hematocrit, urea, creatinine, TG and VLDL-C were negatively correlated with leptin (p=0.040, r=-0.162 for hematocrit; p≤0.001, r=-0.305 for urea; p=0.007, r=-0.219 for creatinine; p=0.025, r=0.188 for TG; p=0.007, r=-0.218 for VLDL-C). Our analysis showed that white blood cell was positively correlated with leptin (β=17.36, p=0.048). Also, other CBC parameters had no significant correlations with BMI and leptin.

Conclusion: According to the findings of this study, BMI had a negative association with urea and HDL-C, while BMI had a positive association with insulin, hematocrit, FBS, uric acid, TG, VLDL-C, LDL-C, and ALT. Furthermore, leptin had a negative association with hematocrit, creatinine, and urea, TG, VLDL-C and a positive association with LDL-C and insulin among the participants of this study.

Keywords: Obesity, Overweight, Complete blood count, Leptinn

Introduction

Obesity is clearly a serious public health concern worldwide; and it has been estimated that the prevalence

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↑What is "already known" in this topic:
The relationship between obesity and high concentrations of leptin has been confirmed.

→What this article adds:
High concentrations of leptin and BMI may be associated with abnormal changes in biochemical parameters levels.

of overweight and obesity will increase to 25% and 32%, respectively, in 2030 (1). Obesity is characterized by hypertrophy and hyperplasia of adipocytes, which are proinflammatory states related to metabolic and cardiovascular disorders, such as type 2 diabetes, hypertension, atherosclerosis, dyslipidemia, and acute and chronic inflammatory processes (1). Leptin, as a 16-KD protein, is a hormone produced by adipocytes, which are directly related to the amount and percentage of body fat; this protein circulates in the body and leads to reduced body weight through appetite, depression, and increased metabolic activity. On the other hand, the systemic effects of leptin is apart from those related to energy homeostasis, including immune function regulation of neuroendocrine, hematopoietic, and reproductive system (2, 3).

Current data have proved that the immune response may be influenced by leptin. Therefore, the express of leptin receptors is regulated in human peripheral blood mononuclear cells, intermediating the leptin outcome on proliferation and activation (2). Leptin has a significant direct proliferative effect on hematopoietic stem cells in the early stages of hematopoietic development and can stimulate the differentiation of cells of erythrocytes and myeloid lineage (4-6).

White blood cells (WBC) are immune defense system cells that play an important role in the inflammatory process (7); WBC count has a positive association with insulin resistance, hypertension, and cardiovascular disease, while it is unclear whether these alterations can fall out in healthy obese individuals (8, 9).

The bone marrow, which is located throughout the skeletal mass, is one of the largest and most active tissues in the body. Although complex differentiation pathways originate with hematopoietic stem cells, the bone marrow produces billions of new leukocytes and erythrocytes each day (10).

High red blood cells and hematocrit have been assumed to contribute to insulin resistance by rheological shifts and disturbed tissue blood flow (11, 12). Also, red blood cell count, hematocrit, and hemoglobin have been reported to be positively associated with insulin resistance (13, 14).

Among obese individuals, the levels of WBC, which include neutrophils, eosinophils, monocytes and lymphocytes, might be important in assessing the development of inflammation or diseases (15).

Considering that the elevated leptin levels with obesity is widely interpreted as the evidence of leptin resistance and also taking into account the role of CBC parameters (WBC and platelet) in inflammatory and thrombose in obesity, this study was conducted to assess these interactions.

This study was conducted to assess the relationship of clinical, biochemical, and CBC parameters with serum leptin levels and BMI in overweight and obese individuals.

Methods
Participants
This cross sectional prospective study was performed among Iranians recruited from the Clinical Nutrition De-

partment at Iran University of Medical Sciences in Tehran, Iran. The main researcher described the study procedure and protocol, benefits, and risks to those willing to participate in the study; eligibility criteria were as follow: age 18- 60 years; voluntarily participation; signing an informed consent. Exclusion criteria were as follow: severe infectious or inflammatory diseases; cancers; secondary causes of obesity; pregnancy or lactation; evidence of severe hepatic or renal diseases; using medications or hormone therapy, including antihypertensive drugs, oral hypoglycemic and hypolipidemic agents; and using dietary supplements and insulin. The study group included 189 eligible Iranian males and females aged 18-60 years who were enrolled for the study. The participants were allocated into 3 groups based on their BMI (kg/ m²): normal group: 18.5<BMI<24.9; overweight: 25<BMI<29.5; and obese group: BMI >30. Dietary patterns of individuals were assessed using FFQ, 24-hour recall, and physical activity with PAQ questionnaires. Also, food intake and physical activity were assessed as confounding factors. Sample size was calculated using the below formula:

$$N = \left[\frac{Z\alpha + Z\beta}{C}\right]^2 + 3$$
$$Z\alpha = 1.960$$
$$Z\beta = 0.842$$

$$C = 0.5 * ln[(1 + r)/(1 - r)] = 0.203$$

$$r\ (correlation\ coefficient) = 0.2$$

Ethics statements
This trial was performed according to the principles of the Declaration of Helsinki and the study protocol was approved by the Ethics Committee of Iran University of Medical Sciences (IUMS) (Ethic number 94-02-27-26191). The study protocol was carefully explained to all participants before obtaining the informed consent. This study was registered on the Iranian website (www.irct.ir) for registration of clinical trials.

Assessment of anthropometric measures
Weight, height, hip, and waist circumferences were measured without heavy clothing and shoes; height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, using an automatic height-weight scale. Waist circumference measurement was taken midway between the lower rib margin and the superior iliac spine at the end of gentle expiration in a standing position, and hip circumference was measured at the widest part of the hip region; waist to hip ratio (WHR) was also calculated. BMI was computed as weight (kg) divided by height in meters squared (m²). Blood pressure (BP) was measured using a sphygmomanometer after participants had been in a relaxed state for at least 10 minutes.

Biochemical measurements
After obtaining consent from 184 individuals, fasting blood samples (20 mL) were obtained in vacutainer tubes with EDTA (Greiner VACUETTE EDTA) in the early morning after a 14-hour overnight fasting. Blood samples

were centrifuged and stored at -80°C before analysis at the IUMS reference laboratory.

The concentration of leptin was determined using a leptin ELISA Kit (e-bioscience, USA).

Serum triglyceride, high-density lipoprotein (HDL)-cholesterol, low-density lipoprotein (LDL) cholesterol, and glucose levels were determined using an enzymatic-colorimetric test. The levels of uric acid, urea, creatinine, BUN, and plasma concentrations of SGOT, SGPT, and ALP were measured by biochemistry methods (autoanalyzer BT1500, Biotecnica Co, Italy). CBC were counted by a Coulter counter (Coulter International Corporation, Miami, FL, USA).

Statistical analysis

Statistical analysis was performed using SPSS software (Version 18.0; SPSS Inc. Chicago, IL, USA). To ensure the normal distribution of variables, the Kolmogorov–Smirnov test was used. Mean ± SD and median (Q1, Q3)

were calculated for variables with normal and non-normal distribution, respectively. The association between 2 quantitative variables was measured using bivariate correlation (Pearson or Spearman). Logarithmic transformation was performed for some variables with non-normal distribution. Pearson correlations and multiple regression analysis were performed to assess the correlation between the variables. P-value <0.05 was considered significant. Simple and multiple regression analyses were performed to predict some variables.

Results

A total of 184 participants aged 18-60 years [83 males (45.1%) and 101 females (54.9%)] participated in the study. Mean values of their age, weight, and BMI were 37.61±10.23 years, 80.36±17.62 (kg), and 29.42±5.71 (kg/m2), respectively. Baseline characteristics of participants are presented in Table 1.

Table 1. Baseline characteristics of the participants

Variable	Mean ± SD	Median (Q$_1$, Q$_3$)
Weight (kg)	80.36 ± 17.62	
Height (cm)		163 (158, 173.8)
BMI (Kg/m^2)	29.42 ± 5.71	
Waist circumference(cm)		91 (80.25 , 101.75)
Wrist (cm)		17 (15.5 , 18)
SBP (mmHg)		120 (110 , 120)
DBP (mmHg)		80 (75 , 80)
Hips (cm)	108.64 ± 11.62	
FBS (mg/dl)		75 (68, 83)
Urea (mg/dl)	27.61±9.84	
Creatinine (mg/dl)	0.92±0.16	
Uric Acid (mg/dl)	5.06±1.37	
Leptin (ng/mL)		9.4(4, 19.2)
Cholesterol (mg/dl)	182.33±37.43	
Triglyceride (mg/dl)		135 (100, 195)
HDL-C (mg/dl)	47.16±13.52	
LDL-C (mg/dl)	103.97±32.80	
VLDL-C (mg/dl)		27 (19, 39)
LDL-C / HDL-C	2.36±0.94	
TC / HDL-C	4.14±1.30	
SGOT(AST) (U/L)		23 (20, 28)
SGPT(ALT) (U/L)		19 (14, 25.25)
Alkaline phosphatase (U/L)		186(156.5, 221.5)

Body Mass Index (BMI), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Waist Circumference (WC), High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL), Very Low Density Lipoprotein (VLDL), Alanin Amino Transferas (ALT), Aspartat Amino Transferas (AST)

Table 2. Pearson correlation coefficients between complete blood count and some biochemical parameters with BMI and leptin

Variables	BMI		Leptin	
	r	P[1]	r	P[1]
WBC (×10^9/l)	0.129	0.081	0.160	0.055
RBC (×10^{12}/l)	0.109	0.144	-0.156	0.059
Hemoglobin (g/dl)	-0.049	0.523	-0.075	0.363
Hematocrit	0.149	0.041	-0.162	0.040
Platelet (×10^9/l)	-0.035	0.631	0.085	0.301
Insulin (mIU/l)	0.520	≤0.001	0.114	0.013
FBS (mg/dL)	0.363	≤0.001	-0.038	0.647
Urea (mg/dL)	-0.368	≤0.001	-0.305	≤0.001
Creatinine (mg/dL)	-0.041	0.581	-0.219	0.007
Uric Acid (mg/dL)	0.309	≤0.001	-0.068	0.401
Triglyceride (mg/dL)	0.189	0.015	-0.188	0.025
HDL-C (mg/dL)	-0.297	≤0.001	0.092	0.252
LDL-C (mg/dL)	0.161	0.030	0.194	0.011
VLDL-C (mg/dL)	0.181	0.019	-0.218	0.007
Alkaline phosphatase (IU/L)	0.052	0.492	-0.088	0.289
SGOT(AST)(U/L)	0.130	0.087	-0.077	0.346
SGPT(ALT) (U/L)	0.299	≤0.001	-0.043	0.599

[1] Obtained from Pearson's correlation analysis.

Table 3. Multiple regression analysis between complete blood count parameters with BMI and leptin

	BMI			Leptin		
	β	95% CI	P[1]	β	95% CI	P[1]
WBC (×10⁹/l)						
Crude	31.99	-4.65, 68.63	0.048	17.36	0.64, 34.08	0.042
Adjusted[2]	28.33	-6.91, 63.59	0.032	17.02	0.90,33.14	0.035
RBC (×10¹²/l)						
Crude	0.01	-0.004, 0.205	0.144	-0.006	-0.013,0.00	0.060
Adjusted	-0.001	-0.01, 0.009	0.892	-0.003	-0.008, 0.002	0.222
Hemoglobin (g/dL)						
Crude	-0.769	-3.12, 1.58	0.523	-0.508	-1.73, 0.71	0.414
Adjusted	-0.58	-2.97, 1.80	0.635	-0.386	-1.63, 0.86	0.542
Hematocrit (%)						
Crude	0.093	0.001, 0.186	0.045	-0.031	-0.075, 0.012	0.157
Adjusted	0.039	-0.024, 0.101	0.221	-0.004	-0.036, 0.027	0.786
Platelet (×10⁹/l)						
Crude	-328.61	-1710, 1052	0.631	152.77	-526, 832	0.659
Adjusted	-404.1	-1715, 907	0.547	-217.82	-872, 436	0.519

RBC: Red Blood Cell, WBC: White Blood Cell
[1] Obtained from multiple regression analysis.
[2] After controlled mutual effect of other biochemical indicators as covariates.

This study indicated that hematocrit, insulin, FBS, uric acid, TG, LDL-C, VLDL-C, and ALT were positively correlated with BMI (P = 0.041, r = 0.149 for hematocrit; p≤0.001, r=0.520 for insulin; p≤0.001, r=0.363 for FBS; p≤0.001, r=0.309 for uric acid; p=0.015, r=0.189 for TG; p=0.030, r=0.161 for LDL-C; p=0.019, r=0.181 for VLDL-C; p≤0.001, r=0.299 for ALT), whereas urea and HDL-C were negatively associated with BMI (p≤0.001, r=-0.368 for urea; p≤0.001, r=-0.297 for HDL-C). Moreover, LDL-C and insulin were positively correlated with leptin (p=0.011, r=0.194 for LDL-C; p=0.013, r= 0.114 for insulin), and hematocrit, urea, creatinine, TG, and VLDL-C were negatively correlated with leptin (p= 0.040, r= -0.162 for hematocrit; p≤0.001, r=-0.305 for urea; p=0.007, r = -0.219 for creatinine; p=0.025, r=-0.188 for TG; p=0.007, r=-0.218 for VLDL-C) (Table 2).

Simple linear regression analysis showed that among the CBC parameters, only hematocrit was positively correlated with BMI (β=0.093, p=0.045). However, this relationship did not remain significant after monitoring for other biochemical indicators (β=0.039, p=0.221). Also, simple linear regression analysis showed that white blood cell was positively correlated with leptin (β=17.36,

p=0.048). Similarly, this result was statistically significant for WBC (β=17.02, p=0.032) after adjusting for other biomarkers (Table 3).

Multiple regression analysis revealed that other CBC parameters had no significant correlations with BMI and leptin (Table 3).

Simple linear regression analysis revealed that among the biochemical measures in obese and overweight participants, serum urea and HDL-C were negatively correlated with BMI (β=-0.636, p≤0.001 for urea; β=-0.707, p≤0.001 for HDL-C) and serum insulin, FBS, uric acid, TG, ALT, LDL-C and VLDL-C levels were positively correlated with BMI (β=0.782, p≤0.001 for insulin; β=0.966, p≤0.001 for FBS; β=0.075, p≤0.001 for uric acid, β=2.85, p=0.014 for TG, β=0.563, p≤0.001 for ALT, β=0.925, p=0.034 for LDL-C; β=0.519, p≤0.010 for VLDL-C) (Table 4); these correlation continued to be significant even after controlling for other biochemical indicators (β=0.654, p≤0.001 for insulin; β=0.874, p=0.001 for FBS; β=-0.390, p=0.010 for urea), while the association of uric acid, TG, LDL-C, HDL-C, ALT and VLDL-C disappeared (Table 4).

Moreover, simple linear regression analysis showed that

Table 4. Multiple regression analysis between some biochemical parameters with BMI and leptin

	BMI			Leptin		
	β	95% CI	P[1]	β	95% CI	P[1]
Insulin (mIU/l)						
Crude	0.782	0.615, 0.949	≤0.001	0.114	0.024, 0.204	0.013
Adjusted[2]	0.654	0.444, 0.863	≤0.001	0.093	0.003, 0.183	0.046
FBS (mg/dL)						
Crude	0.966	0.572, 1.36	≤0.001	-0.031	-0.217, 0.155	0.741
Adjusted	0.874	0.355, 1.39	0.001	-0.107	-0.308, 0.093	0.291
Urea (mg/dL)						
Crude	-0.636	-0.878, -0.395	≤0.001	-0.219	-0.340, -0.098	≤0.001
Adjusted	-0.390	-0.685, -0.094	0.010	-0.119	-0.227, -0.011	0.031
Creatinine (mg/dL)						
Crude	-0.001	-0.005, 0.003	0.587	-0.002	-0.004, 0.00	0.066
Adjusted	-0.001	-0.006, 0.004	0.693	0.00	-0.002, 0.002	0.811
Uric Acid (mg/dL)						
Crude	0.075	0.04, 0.109	≤0.001	-0.009	-0.027, 0.008	0.271
Adjusted	0.029	-0.012, 0.070	0.161	-0.005	-0.020, 0.010	0.511
Triglyceride (mg/dL)						
Crude	2.85	0.63, 5.07	0.014	-0.876	-1.81, 0.061	0.060
Adjusted	-0.109	-0.324, 0.542	0.612	0.085	-0.070, 0.24	0.280

Table 4. Cntd

HDL-C(mg/dL)						
Crude	-0.707	-1.04, -0.366	0.001	0.076	-0.095, 0.248	0.384
Adjusted	-0.368	-0.812, 0.076	.103	0.058	-0.108, 0.220	0.483
LDL-C (mg/dL)						
Crude	0.925	0.07, 1.78	0.034	0.488	0.08, 0.896	0.011
Adjusted	1.23	-0.045, 2.51	0.059	0.49	0.035, 0.945	0.033
VLDL-C (mg/dL)						
Crude	0.519	0.097, 0.942	0.010	-0.186	-0.367, -0.005	0.040
Adjusted	0.018	-0.104, 0.067	0.678	-0.020	-0.05, 0.01	0.193
Alkaline phosphatase (IU/L)						
Crude	0.525	-0.988, 2.03	0.499	-0.317	-1.05, 0.42	0.391
Adjusted	0.108	-1.05, 3.22	0.314	-0.039	-0.741, 0.819	0.928
AST(U/L)						
Crude	0.266	-0.260, 0.792	0.324	-0.042	-0.239,0.155	0.673
Adjusted	-0.066	-0.27, 0.138	0.527	-0.41	-0.114, 0.032	0.272
ALT(U/L)						
Crude	0.563	0.229, 0.898	0.001	-0.031	-0.187, 0.124	0.696
Adjusted	0.053	-0.261, 0.368	0.739	0.048	-0.064, 0.159	0.397

High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL), Very Low-Density Lipoprotein (VLDL), Alanin Amino Transferas (ALT), Aspartat Amino Transferas (AST)[1] Obtained from multiple regression analysis.
[2] After controlled mutual effect of other biochemical indicators as covariates.

serum WBC, insulin, and LDL-C levels were positively correlated with leptin (β=17.36, p=0.042 for WBC; β=0.114, p=0.013 for insulin; β=0.488, p=0.011 for LDL-C) and serum urea, creatinine, TG, and VLDL-C were negatively correlated with leptin (β=-0.219, p<0.001 for urea; β=-0.002, p=0.066 for creatinine, β=-0.876, p=0.060 for TG; β=-0.186, p= 0.040 for VLDL-C). These associations persisted to be significant even after controlling for other biochemical indicators (β=17.02, p=0.035 for WBC; β=0.093, p=0.046 for insulin; β=-0.119, p=0.031 for urea; β=0.498, p=0.033 for LDL-C); however, the related significant results for VLDL-C and TG disappeared (Tables 3, 4).

Multiple linear regression analysis demonstrated that BMI had no significant relationship with creatinine and alkaline phosphatase. In addition, non-significant differences were observed between serum leptin levels and either of HDL-C, alkaline phosphatase, uric acid, and FBS (Table 4).

Discussion

The aim of this study was to evaluate the relationship among clinical, biochemical, and CBC parameters with serum leptin levels and BMI in overweight and obese individuals.

This study indicated that BMI had a significant association with the levels of hematocrit, HDL-C, TG, and VLDL-C, insulin, ALT, LDL-C, FBS, uric acid, and urea.

In this study, no significant associations were found between WBC and BMI among participants. Obesity is a chronic disease with multifactorial etiologies that accompanies nutrients accumulation, which can lead to the aggregation of excess energy in the form of fat mass (16). Contrary to our results, several lines of evidence have supported a positive link between WBC count and BMI (17, 18).

According to the results of this study, there was a poor positive correlation between BMI and hematocrit among participants, while no significant associations were observed between BMI and platelet counts. Farhangi et al (19) found that the levels of platelet counts were significantly higher among obese individuals compared to the non-obese; in fact, there is a current debate on whether obesity is accompanied with platelet activation (20). Higher concentrations of adipose tissue result in releasing inflammatory markers, which may contribute to atherogenesis and thrombosis through its effects on platelet activation (20).

The contradiction between the results of our study and those of previous ones might be due to the differences in BMI ranges and gender of participants. Differences in BMI may partly explain the differences of the observed associations between BMI and WBC. While the average BMI of obese participants in this study was 29.16 kg/m^2, the mean BMI of obese participants in the study of Neiman et al, who showed a positive correlation between WBC count and BMI, was 33.2 kg/m^2 (18).

On the other hand, this study revealed that leptin had no significant associations with hemoglobin, which do not support previous researches.

Tungtrongchitr and Toko (21, 22) reported a negative correlation between hemoglobin and serum leptin levels in overweight and obese males and females. Although bone marrow contains many adipocytes, their exact role is not clear (21). Considering the epidemiologic findings and related in vitro studies, leptin might play some roles in hematopoiesis in humans (5, 23).

Recent studies demonstrated that leptin might be able to accelerate arterial thrombosis, suggesting a mechanism for atherothrombotic disease in obesity (24, 25). Considering the existence of the long form of leptin receptor on the platelet membrane, it may be possible that leptin promotes the aggregation of human platelets through the activation of its receptor (26). Thus, the survey of leptin effects on platelet function may offer new insights into the mechanisms linking obesity and cardiovascular diseases.

In addition, a significant correlation was found between leptin and WBC in participants of this study; this result is in agreement with that of the previous studies (27, 28).

In obese individuals, the higher levels of WBC may be related to increased leptin concentration. Leptin may interfere in hematopoiesis, inflammation, or immunologic re-

action in humans (27).

In this study, BMI showed a significant association with the levels of TG, HDL-C, LDL-C, and VLDL-C, suggesting that total cholesterol and TG levels were correlated with WHR measure, which is considered as an index for body fat distribution and visceral adiposity (29). Numerous reports have shown that higher levels of abdominal fat have been associated with elevated plasma TG concentration and lower HDL-C levels (30-32). These associations could also help explain the association between regional body fat distribution and cardiovascular diseases. Recent prospective studies have indicated that body fat distribution is significantly associated with cardiovascular diseases (33, 34).

It has been suggested that the significant positive association between the levels of VLDL-C and BMI, which is associated with the excess abdominal fat, may indirectly be due to an increased free fatty acid (FFA) flux from the omental adipocytes to the liver (35, 36). Elevated plasma VLDL levels, followed by increased free fatty acid, has also been associated with a reduced hepatic extraction of insulin (37).

The present data indicated that the levels of serum ALT, urea, and uric acid had a significant correlation with BMI in obese and overweight individuals; in accordance with our results, previous findings also demonstrated the same correlation (38-40). Obesity and central body fat distribution were associated with hyperuricemia (41, 42). Li-ying (43) reported that elevated waist circumference could result in higher risk of hyperuricemia.

Although the exact mechanisms of the elevated serum uric acid in obesity have not been fully clarified (41), several reasons have been suggested (41, 44-46). First, the rise of uric acid due to impairment of urinary urate excretion can be an important factor underlying hyperuricemia in obesity (47). Second, insulin resistance may be another cause of high serum uric acid level as the presence of hyperinsulinemia may decrease the urinary urate excretion (45, 48). Last of all, the aggregation of visceral fat is closely related to the incremented production of uric acid (UA), which may lead to hyperuricemia in obesity (41).

The mentioned association in this study was stronger in females than in males in both overweight and obese participants, which was inconsistent with published findings in different countries, such as Thailand (Bangkok) and China (40, 49, 50).

Several researchers conducted studies to assess the relationship between leptin (gene production of obesity) and the cluster of hyperuricemia to elucidate the pathogenic mechanisms of the association of obesity with hyperuricemia. They found that serum uric acid concentration is independently related to serum leptin concentration (51, 52). However, they were unable to prove the mentioned association; it was specifically indicated that leptin could be a pathogenic factor responsible for hyperuricemia in obese patients (51, 52).

Furthermore, our findings are in line with previous studies which reported that ALT levels were more associated with BMI compared to AST levels (53-55). The most probable explanation for the relationship between serum ALT levels and BMI could be related to visceral fat (56). Visceral fat accumulation is the strongest predictor of the elevated ALT concentrations among all the anthropometric variables, including BMI, while visceral adipose tissue, VAT, is the main predictor of the elevated ALT concentrations in the context of non-alcoholic fatty liver disease (57).

In the Western New York Health Study, ALT was reported to be more highly correlated with BMI than AST, particularly among men and postmenopausal women (55). Moreover, Burns et al (54), who performed 2 cross sectional analyses among men and women, also found a greater effect of BMI on the levels of ALT compared with AST.

In this study, it was demonstrated that serum insulin levels in obese and overweight people were positively correlated with leptin. The findings of this study on the relationship between insulin and leptin was inconsistent with a previous study, which reported that leptin might play a role in modulating serum insulin levels and insulin resistance (58). In addition, Karen et al (59) demonstrated that insulin resistance is linked with augmented plasma leptin concentrations. Although Kraen et al reported that insulin did not markedly regulate leptin production, the chronically elevated plasma insulin concentrations may stimulate the obese gene (ob gene) expression and increase the leptin concentration as its protein product (59).

According to the results of this study, there was a positive correlation between the levels of leptin and LDL-C, while no related correlations were found in a study by Ahmadi et al (60). The main reason explaining these differences are various characteristics of target populations, including obese and non-obese participants, type of patients, and different age groups.

On the other hand, we found that the levels of TG and VLDL-C were negatively correlated with leptin, while some human published studies (61-63) reported that leptin levels were directly associated with TG. Furthermore, in the study by Murtadha and Sarha (64), leptin was reported to be positively correlated with TG and VLDL-C levels (65).

Many existing criteria, including genetic factors, such as pleiotropy (ie, shared genes) and nongenetic factors (ie, shared environment) (61, 66), clinical differences of patients (65), sex (64), and age (61) could be accountable for the correlated relationship between leptin and lipid levels.

Based on the results of this study, urea and creatinine had negative correlations with leptin in obese and overweight people, while a related positive correlation was found in the study by Ahmadi et al (60).

Johansen et al did not report any correlations between leptin levels and urea or creatinine among hemodialysis male patients (67). Differences in health and disease status of the population, methods, and the kits used to measure leptin and other biochemical parameters, various methods for measuring serum or plasma leptin levels, and measuring free serum leptin or leptin, which is bounded to receptors, may be responsible for different results.

The potential strength of this study was that all the participants were obese and overweight. This study had sev-

eral limitations. Firstly, because of the cross sectional nature of the study, there was no information about the causal relationship between variables, which needs to be elucidated in future prospective studies. Secondly, the final analysis was performed only among overweight and obese adults, indicating that these results cannot be extended to healthy-weight adults. Another limitation of this study was lack of a control group and only a descriptive study was conducted. Moreover, the blinding method was not used; thus, further controlled and blind studies with randomized design are required; cell line studies are also needed to confirm these correlations.

With regards to the increasing prevalence of obesity in the world and leptin resistance in obesity, more studies are urgently needed to clarify whether leptin has positive effects on the concentrations of CBC parameters and inflammation.

Conclusion

Despite some limitations in this study, the correlations of CBC, lipid profiles, liver, and kidney parameters with the measurements of BMI and leptin were shown.

Moreover, there were significant differences in the levels of hematocrit, insulin, TG, HDL-C, VLDL-C, LDL-C, FBS, ALT, urea, and uric acid. Leptin levels were significantly correlated with insulin, WBC, urea and creatinine, TG, VLDL-C, and LDL-C. Leptin serum levels could play an important role in the etiopathogenesis of comorbidities, which are associated with the incidence of obesity.

Consequently, as the rate of obesity and its comorbidities are increasing, focusing on such strategies may lead to promises for reducing the non-communicable diseases via improving the life style, which prevents the incidence of obesity. Yet, further studies are required to confirm our findings and determine possible underlying mechanisms.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Conflict of interest

The authors declare that they have no conflict of interest.

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