Leptin levels in type 2 diabetic and non-diabetic Sudanese women, and their relationship to obesity indexes and lipid profile.

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Abstract

Objectives: There is little data on the metabolic effects of adipocytokine Leptin (Lep) on diabetic patients in Sudan. The goal of this study was to investigate Lep levels in diabetes, diabetic hypertensive, and non-diabetic women and their association to the anthropometric measurements BMI, WC, and Lipid profile.

Materials and Method: During April 2012 and March 2013, a case-control study was conducted in Central Sudan. The study involved 222 women who met the inclusion criteria, they were divided into 3 groups; diabetic, diabetic hypertensive, and Non-Diabetic Hypertensive (NDNH) groups to estimate FBG, Glycosylated Hemoglobin HbA_{1C}, Lipid Profile (TC, TG, HDL-C, and LDL-C) and Lep levels. A15, a random access auto-analyzer biosystem, was used to analyze the samples. A questionnaire was completed, which included anthropometric and biochemical measurements. Following each participant's verbal agreement, venous blood was drawn after an overnight fast. The statistical analysis was done with the help of statistical software for social sciences (SPSS version 16, Chicago, IL, USA).

Result: Statistical analysis of diabetic and diabetic hypertensive patients revealed that; 86(38.74%) participants had age <50 years and 137 (61.71%) participants were with WC <88, in addition to that 58 (26.13%) women were overweight and 81 (36.49%) were obese. Only 32(14.41%) had high physical activity. Lep had a weak positive significant correlation with age (r=0.10, p=0.005), and SBP (r=0.16, p=0.026) and had a weak negative significant correlation with LDL-C (r= -0.15, p=0.033). It had weak positive non-significant correlation with WC (r=0.048, p=0.495). Analysis of variance reveal significant difference in mean of Age, WC, BMI, BMI\WC ratio, SBP, FBG, HbA_{1C}, HDL-C and Lep among the diabetic and diabetic hypertensive groups by ($p \leq 0.0001$), (p=0.017), (p=0.004), (p=0.001), ($p \leq 0.0001$), ($p \leq 0.0001$), (p=0.007), (p=0.027) and ($p<0.0001$) respectively. Post- hoc analysis showed that mean HDL-C differed significantly between the diabetic-hypertensive and NDNH groups by (p=0.029). Mean Lep/BMI ratio differed significantly between the diabetic hypertensive group and each of the diabetic group by (p=0.008) and the NDNH group by (p=0.001). Hochberg's post hoc test revealed that mean Lep concentration differed significantly between the diabetic hypertensive group and each of the diabetic and the NDNH groups all with (p=0.001).

Conclusion: Leptin mean concentration in Sudanese women's is correlated to anthropometric measurement BMI, WC, and HDL-C concentration.

Keywords: Leptin, Obesity, Lipid profile, Type 2 diabetes mellitus, Women, Sudan.

Abbreviations: T2DM: Type2 Diabetes Mellitus; DM: Diabetes Mellitus; CVD: Cardiovascular Disease; BMI: Body Mass Index; WC: Waist Circumference; HTN: Hypertension; p: Probability; FBG: Fasting Blood Glucose; HA_{1C}: Glycated Hemoglobin; Lep: Leptin; TC: Total Cholesterol; LDL-C: Low Density Lipoprotein Cholesterol; HDL-C: High Density Lipoprotein Cholesterol; TG: tri-glycerides.

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Introduction

Adipose tissue is now regarded as not just a purely inert body compartment for excess energy storage, but rather as an active endocrine and paracrine organ, secreting a large number of hormones, cytokines, and growth factors, collectively called Adipocytokines [1]. Some of them are synthesized exclusively or predominantly by adipocytes (e.g., adiponectin, leptin), while others originate from other sources (e.g., resistin, chemerin, proinflammatory cytokines). Adiponectin and Lep are of particular interest because of their role in the regulation of various physiological processes, including insulin responsiveness, glucose, and lipid metabolism, in addition to endothelial function, inflammatory response, and cytokine signaling [2].

Lep is an adipocytokine hormone of 167 amino acids and a molecular weight of 16 kDa that is encoded by the obese gene and expressed in white adipose tissue [3,4]. Jeffrey M. Friedman discovered this hormone in mice in 1994 [5]. The circulating Lep reflects the degree of adiposity and its release from adipocytes signals to the brain to trigger the suppression of food intake and to boost energy expenditure, thus Lep is serving as an "apostate" [6]. Circulating Lep levels are positively correlated with fat mass [7] or BMI [8]. These levels range from 5 ng/ml to 10 ng/ml in healthy individuals and from 40 ng/ml-100 ng/ml in obese individuals [9]. A pathological state which includes inflammation, malignant transformation, low birth weight, and premature delivery has been linked to lower Lep levels [7]. On the other hand, prolonged fasting decreases Lep levels, whereas over-feeding greatly increases its levels [10].

Lep action is achieved by binding Lep to the neuropolypeptide Y in the arcuate nucleus and control the intake of food by interacting with the hypothalamic centers and brain stem neuronal circuits which are implicated in the regulation of feeding behavior and energy balance [11], either directly or by activating neuropolypeptide Y to decrease food intake, increase energy expenditure, influence glucose, and fat metabolism, or alter neuroendocrine function [12]. Neuropeptide Y is one of the major regulators of appetite and has an inhibitory effect with Lep [13]. Insulin and Lep signaling constitutes the adipoinsular axis, which contributes to the regulation of nutrient and energy balance in the body. This means that Lep suppresses insulin secretion in a negative feedback loop where insulin stimulates the release of Lep [14], so the expression of the Lep gene is correlated with insulin levels and increases after insulin infusion for several days [15]. Lep level is decreasing in low insulin state, such as experimentally induced diabetes [16] and regulation of its levels is by food compositions specifically intake of macronutrients such as carbohydrates [17] and micronutrients such as zinc [7]. So, insulin resistance occurs because of dysregulation of the adipo-insular axis [18]. Because Lep plays a key role in energy balance, glucose metabolism, and body weight management, is involved in pathways that influence the risk of cardiovascular disease (CVD) and DM [19].

High serum Lep concentrations were observed in the patient with T2DM [20], renal dysfunction [21], and obesity [22]. Furthermore, it has been proposed that the link between plasma Lep and diabetes is a symptom of underlying Lep resistance mediated by fat [23].

The degree of obesity was measured using anthropometric obesity indicators BMI and WC. The BMI of healthy people has a range of 19.5-25.5, overweight people have a range of 25-29.9, and obese people have a range of greater than 30 [24]. In addition to BMI, Waist Circumference (WC) data are utilized to indicate the risk of metabolic disease. The WC is the measurement taken halfway between the lower edge of the last perceptible rib and the top of the iliac crest as stated by WHO in 2008. Men's cut-off values are >102 cm, while women's cut-off values are >88 cm. Aside from genetic predisposition, the main causes of obesity are decreased physical activity and increased caloric intake. Obesity and overweight are characterized as abnormal or excessive fat accumulation that can be harmful to one's health. Obesity is a prominent risk factor for obesity-related health problems such as T2DM, hypertension, CVD, and insulin resistance [24], all of which result in deteriorating glycemic control [25].

DM is one of the world's most prevalent chronic disorders. According to the World Health Organization (WHO), T2DM now affects 387 million adults globally and is predicted to increase to 592 million adults in less than 25 years, which means one adult in ten is expected to effect by DM [26]. By 2030, the African Region is anticipated to have the highest proportionate growth in the number of adult diabetes (90.5%) of all WHO regions [27]. Sudan is part of the WHO's East Mediterranean area, and it was classified as a lower-middle-income country by the World Bank Income Groups in 2013 [28]. It has a medium prevalence of T2DM, accounting for 3.4% i.e. 75% of all diagnosed cases [29].

Material and Methods

Study subject, design, and area

In cross-sectional case-control research, 222 women subjects were enrolled. 74 participants were diagnosed as type 2 diabetics, 79 as diabetic hypertensive, and 69 as non-diabetic non-diabetic hypertensive or (control group). The participants came from both rural and urban locations in the Wad Madani city area, and they received their health care from the Abu A'gla health center. The research lasted from April 2012 through March 2013.

Inclusion and exclusion criteria

Participants who did not have a current infection or diabetic complications were included in this study. The non-diabetic non-hypertensive group consisted of apparently healthy individuals who volunteered to participate. If a subject failed to match any of the inclusion criteria, they were removed from the study.

Ethical approval

The Ethics Committee of the Ministry of Health granted the study ethical permission.

Study procedure

After informed consent, all patients and non-diabetic non-hypertensive participants provided biodata and anthropometric measurements (weight was measured in kilograms (kg) and heights in meters (m), and the Body Mass Index (BMI) was computed using the formula: BMI= (weight in kg)/(height in m^2). Using the A15, random access auto-analyzer bio system, plasma samples were evaluated for various biochemical parameters.

Statistical analysis

The statistical analysis was done with the help of Statistical Software for Social Sciences (SPSS version 16, Chicago, IL, USA). The mean and standard error of the mean was used to express all of the numerical data. The proportion of distribution of study participants was calculated using the Chi-square test. The strength of the relationship between two numerical variables was measured using correlation analysis. Analysis of variance was used to compare differences in the means of continuous variables between the research groups (ANOVA). To compare differences between the study groups, multiple

comparisons (post hoc tests such as Tukey HSD, Gabriel test, and Games Howell) were performed. P-values of ($p<0.05$) or less were considered significant.

Results

Table 1 showed that diabetic hypertensive women were aged with higher WC and BMI than diabetic and NDNH. 45.1% of the 50-year-old were NDNH, 36.9% were diabetic, and only 18.0% were diabetic hypertensive. However, 57.0% of participants over 50 years old were diabetic hypertensive, 29.0% were diabetic, and only 14.0% were NDNH. The difference ($p<0.0001$) was statistically significant. 53.3% of respondents with a normal BMI were NDNH, 26.7 percent were diabetic, and 20.0 percent were diabetic hypertensive, while 36.9% of people with an overweight BMI were diabetic, 32.1% were NDNH, and 31.0% were diabetic hypertensive. In the obese category, however, 42.6 percent were diabetic hypertensive, 32.4% were diabetic, and 25.0% were NDNH. The difference ($p=0.031$) was statistically significant. 47.1% of those with low physical activity were diabetic hypertensive, 39.2% were diabetic, and 13.7 percent were NDNH; 34.6% of those with moderate physical activity were diabetic, 33.8% were NDNH, and 31.6% were diabetic hypertensive, and 57.0 percent of those with high physical activity were diabetic, 34.3% were diabetic hypertensive. The difference ($p<0.0001$) was statistically significant.

Correlation analysis in table 2 revealed that Lep had a significant positive correlation with age, LDL-C, and SBP.FBG had a marginally significant correlation with TG ($r=0.13$, $p=0.064$), whereas, a weak positive non-significant correlation was observed with age, TC, LDL-C, SBP. FBG had a weak negative significant correlation with DBP ($r= -0.16$, $p=0.014$) and a negative weak non-significant correlation with BMI, HDL-C. HbA_{1C} showed a weak positive non-significant correlation with TC, TG, and LDL-C. It had a weak negative significant correlation with age ($r= -0.24$, $p=0.003$). HbA_{1C} showed a marginally significant weak negative correlation with SBP ($r= -0.15$, $p=0.061$), and a weak negative non-significant correlation with BMI, DBP, and HDL. Lep had a weak positive significant correlation with age ($r=0.10$, $p=0.005$), and SBP ($r=0.16$, $p=0.026$). It showed a weak positive non-significant correlation with DBP. Lep had a weak negative significant correlation with LDL-C ($r= -0.15$, $p=0.033$). It had a weak negative non-significant correlation with BMI, TC, TG, and HDL-C, and a weak positive non-significant correlation with WC.

In table 3, the comparison of means between women groups showed statistically significant differences when we compared (age, weight, WC, BMI, and BMI/WC) and biochemical measures (FBG, HbA_{1C}, HDL-C, Lep and Lep/WC ratio).

There was a significant difference in age between the three groups ($p=0.0001$). When compared to the diabetic and NDNH groups (48.920.79 years and 46.480.86 years, respectively), the diabetic hypertensive group had a higher mean value (55.440.81 years). The three groups differed considerably in WC ($p=0.017$). When compared to the diabetic and NDNH groups (99.031.33 cm and 100.651.26 cm, respectively), the diabetic hypertensive group had the highest mean value (103.991.19 cm). The BMI of the three groups was significantly different ($p=0.004$). The diabetic hypertensive group (32.220.65 Kg/m^2) had the highest mean value (32.220.65 Kg/m^2), followed by the diabetic and NDNH groups (30.780.62 Kg/m^2 and 29.090.68 Kg/m^2, respectively. By ($p=0.001$), the BMIWC ratio demonstrated a

Table 1: *Cross-tabulation of women.*

Variable	Characteristic	women=222 (Sub-group)			p-value
		Diabetic (n=74)	Diabetic hypertensive (n=79)	NDNH (n=69)	
Age (years)	≤ 50 years	45(36.9%)	22(18.0%)	55(45.1%)	<0.0001
	>50 years	29(29.0%)	57(57.0%)	14(14.0%)	
WC(Cm)	≤ 88 women	9(39.13%)	7(30.43%)	7(30.43%)	0.064
	>88 women	65(65.66%)	72(36.18%)	62(31.16%)	
BMI (Kg/m^2)	<25 kg/m^2 Normal	8(26.7%)	6(20.0%)	16(53.3%)	0.031
	25 kg/m^2-29.99 kg/m^2 Overweight	31(36.9%)	27(32.1%)	26(31.0%)	
	≥30 kg/m^2 Obese	35(32.4%)	46(42.6%)	27(25.0%)	
Physical activity	Low	7(13.7%)	24(47.1%)	20(39.2%)	<0.0001
	Moderate	47(34.6%)	43(31.6%)	46(33.8%)	
	High	20(57.1%)	12(34.3%)	3(8.6%)	

NDNH: Non Diabetic Non Hypertensive, WC: Waist circumference, BMI: Body Mass Index, Cm: centimeter, Kg: kilogram, m: meter

Table 2: *Bivariate correlation analysis of women.*

Group		women (n=222)		
Variable		**FBG (mg/dl)**	**HbA_{1C}(%)**	**Lep(ug/L)**
Age (years)	r	0.008	-0.24	0.1
	p	0.911	0.003	0.005
WC(Cm)	r	-0.100	-0.094	0.048
	p	0.137	0.246	0.495
BMI (Kg/m^2)	r	-0.01	-0.14	-0.03
	p	0.884	0.091	0.662
TC (mg/dl)	r	0.05	0.03	-0.09
	p	0.488	0.723	0.186

TG (mg/dl)	r	0.13	0.06	-0.01
	p	0.064	0.484	0.886
LDL-C (mg/dl)	r	0.057	0.03	-0.15
	p	0.398	0.726	0.033
HDL-C (mg/dl)	r	-0.06	-0.01	-0.01
	p	0.378	0.929	0.852
SBP (mmHg)	r	0.08	-0.15	0.16
	p	0.264	0.061	0.026
DBP (mmHg)	r	-0.16	-0.11	0.07
	p	0.014	0.165	0.32

BMI: Body Mass Index, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, FBG: Fasting Plasma Glucose, HA_{1C}: Glycated Haemoglobin, TC: Total Cholesterol, LDL-C: Low Density Lipoprotein Cholesterol, HDL-C: High Density Lipoprotein Cholesterol, TG: triglycerides, Lep: Leptin, Kg: kilogram, m: meter, Cm: centimeter, mg: milligram, Dl: deciliter, ug: microgram, mmHg: millimeter of mercury

Group	**women (n=222)**			
Variable		**FBG (mg/dl)**	**HbA1C(%)**	**Lep(ug/L)**
Age (years)	r	0.008	-0.24	0.1
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WC(Cm)	r	-0.100-	-0.094-	0.048
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LDL-C (mg/dl)	r	0.057	0.03	-0.15
	p	0.398	0.726	0.033
HDL-C (mg/dl)	r	-0.06	-0.01	-0.01
	p	0.378	0.929	0.852
SBP (mmHg)	r	0.08	-0.15	0.16
	p	0.264	0.061	0.026
DBP (mmHg)	r	-0.16	-0.11	0.07
	p	0.014	0.165	0.32

statistically significant difference between groups. Women with diabetes and diabetic hypertension had significantly higher BMIWC (0.3121 0.005 and 0.3088 0.004) respectively than non-diabetic non-hypertensive women (0.28770.005). SBP was significantly different between the three groups (p=0.0001). In comparison to the diabetic and NDNH groups (118.650.90 mmHg and 114.641.63 mmHg, respectively), the diabetic hypertensive had the highest mean value (126.461.45 mmHg). F (2,219=3.601), (p=0.029) showed a significant difference in DBP between the three groups. When compared to the diabetic and NDNH groups (77.030.83 mmHg and 82.902.48 mmHg, respectively), the diabetic hypertensive group had the highest mean value (81.141.10 mmHg). The three groups differed considerably in FBG (p=0.0001). When compared to the diabetic hypertensive and NDNH groups (165.817.32 mg/dl and 87.572.13 mg/dl, respectively), the diabetic group exhibited a higher mean concentration (215.3410.97 mg/dl). The HbA_{1C} levels in the three groups differed considerably (p=0.007). When compared to the diabetic hypertensive group (7.35060.22%), the diabetic group had a higher mean value (8.380.31%). There were no significant variations in the mean of TC across the three groups (p=0.535). When compared to the diabetic and diabetic hypertensive groups (197.424.95 mg/dl and 192.324.69 mg/dl, respectively), the NDNH group had the highest mean concentration (200.335.86 mg/dl). The difference in mean HDL-C across the three groups was significant (p=0.027). When compared to the NDNH and diabetic groups (57.972.12 mg/dl and 52.681.85 mg/dl, respectively), the diabetic hypertensive group had the lowest mean concentration (51.131.58 mg/dl). The mean of the three groups differed considerably (p<0.0001). When compared to the diabetic hypertensive and NDNH groups (1.760.12 ug/L and 0.860.20 ug/L, respectively), the diabetic group had the greatest mean concentration (1.220.08 ug/L).

Multiple comparisons (Post Hoc Tests) of every two women groups uncover statistical differences. The Games Howell test revealed a significant difference in the mean of WC between diabetic and diabetic hypertensive patients (p=0.017). The NDNH group varied considerably from the diabetic hypertensive group in terms of mean BMI (p=0.003). FBG was significantly different between the diabetic hypertensive and NDNH groups (p=0.001), as well as between diabetic and NDNH (p=0.0001). The diabetic-hypertensive and NDNH groups had substantially different mean HDL-C (p=0.029). The diabetic hypertensive group's mean Lep/BMI ratio differed considerably from the diabetic group (p=0.008) and the NDNH group (p=0.001). The diabetic hypertensive group varied significantly from each of the diabetic and NDNH groups (all with p=0.001), according to the Hochberg post hoc test. The three groups had the same mean TC, LDL-C, and TG (Table 4).

Table 3: *Comparison of means of women.*

Variable	Minimum	Maximum	women=222 (Subgroup mean)			p-value
			Diabetic (n=74)	Diabetic-hypertensive (n=79)	NDNH (n=69)	
Age (years)	22	65	48.92 ± 0.79	55.44 ± 0.81	46.48 ± 0.86	<0.0001
WC (cm)	52	130	99.03 ± 1.33	103.99 ± 1.19	100.65 ± 1.26	0.017
BMI (Kg/m²)	17.31	49.98	30.78 ± 0.62	32.22 ± 0.65	29.09 ± 0.68	0.004
SBP (mmHg)	80	170	118.65 ± 0.90	126.46 ± 1.45	114.64 ± 1.63	<0.0001
DBP (mmHg)	30	130	77.03 ± 0.83	81.14 ± 1.10	82.90 ± 2.48	0.029
FBG (mg/dL)	46	409	215.34 ± 10.97	165.81 ± 7.420	87.57 ± 2.133	<0.0001
HbA_{1C} (%)	3.2	15	8.38 ± 0.31	7.3506 ± 0.22	-	0.007
TC (mg/dL)	75	316	197.42 ± 4.95	192.32 ± 4.69	200.33 ± 5.86	0.535
LDL-C (mg/dL)	32	216	105.45 ± 3.51	111.05 ± 3.36	107.62 ± 4.10	0.537
HDL-C (mg/dL)	15	97	52.68 ± 1.85	51.13 ± 1.58	57.97 ± 2.12	0.027
TG (mg/dL)	38	533	173.62 ± 10.35	162.96 ± 8.58	149.19 ± 9.44	0.203
Lep (µg/L)*	0.00001	9.81	1.22 ± 0.08	1.76 ± 0.12	0.86 ± 0.20	<0.0001
BMI\WC ratio	0.19	0.58	0.3121 ± 0.005	0.3088 ± 0.004	0.2877 ± 0.005	0.001

*Assay range: 0.3µg/L -8µg/L, NDNH: Non-Diabetic Non-Hypertensive, BMI: Body Mass Index, WC: Waist Circumference, FBG: Fasting Plasma Glucose, HbA_{1C}: Glycated Hemoglobin, TC: Total Cholesterol, LDL-C: Low Density Lipoprotein Cholesterol, HDL-C: High Density Lipoprotein Cholesterol, TG: tri-glycerides, Lep: Leptin, Cm: centimeter, Kg: kilogram, mg: milligram, dL: deciliter, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure mmHg: millimeter of mercury, ug: microgram

Group	**Diabetic(n=74)**			**Diabetic hypertensive(n=79)**			**Diabetic hypertensive(n=79)**		
Compared with	**NDNH(n=69)**			**NDNH(n=69)**			**diabetic (n=74)**		
Variable	**Mean Diff**	**SE**	**p-value**	**Mean Diff**	**SE**	**p-value**	**Mean Diff**	**SE**	**p-value**
WC (cm)†	-1.63	1.83	0.65	3.34	1.74	0.137	4.96	1.79	0.017
BMI (Kg/m²)†	1.69	0.92	0.165	3.13	0.94	0.003	1.44	0.9	0.249
FBG (mg/dl)§	127.77	11.18	<0.0001	78.24	7.72	<0.0001	-49.53	13.24	0.001
TC (mg/dl)†	-2.91	7.41	0.971	-8.02	7.29	0.614	-5.1	7.16	0.856
LDL-C (mg/dl)†	-2.18	5.25	0.967	3.43	5.16	0.88	5.6	5.07	0.61
HDL-C (mg/dl)†	-5.3	2.82	0.149	-6.84	2.65	0.029	-1.55	2.44	0.801
TG (mg/dl)‡	24.43	13.65	0.208	13.77	13.31	0.659	-10.66	13.16	0.803
Lep (µg/L)§	0.36	0.22	0.221	0.9	0.23	0.001	0.53	0.15	0.001
Lep/BMI ratio§	0.01	0.007	0.207	0.03	0.008	0.001	0.02	0.006	0.008
BMI/WC ratio	0.024	0.007	0.003	0.021	0.006	0.003	0.003	0.007	0.894

§Games Howell, †Tukey HSD, ‡Hochberg, NDNH: Non-Diabetic Non Hypertensive, BMI: Body Mass Index, WC: Waist Circumference, FBG=Fasting Plasma Glucose, TC=Total Cholesterol, LDL-C: Low Density Lipoprotein Cholesterol, HDL-C: High Density Lipoprotein Cholesterol, TG: tri-glycerides, Cm: centimeter, Kg: kilogram, m= meter, mg: milligram, dL: deciliter, ug: microgram.

Discussion

In this study, we looked at data to see if there were any correlations between different parameters in the three groups (diabetic, diabetic-hypertensive, and NDNH). The outcome reveal that diabetic hypertensive women were aged with higher WC, BMI, and moderate physical activity than diabetic and NDNH groups. This finding was consistent with previous research by Sowers [30], which found that women are more likely than men to develop T2DM and that the risk factor for the emergence of diabetes complications like dyslipidemia in diabetic hypertensive women include aged >50 years [31] beside the increased in WC, BMI, and moderate physical activity [32]. With strong statistical significance, also diabetic hypertensive women were found to be older than diabetic and NDNH participants, suggesting that the incidence of HTN in diabetic patients increases with age. This finding is consistent with Harris, et al., 1995, who found that the incidence of HTN in T2DM patients increases by 40%-60% from the age of 45 to 75 years [33].

In the current study, the mean concentrations of TC, TG, and LDL-C were altered with non-statistical significance in the lipid profile concentrations. Between the diabetic hypertensive and NDNH groups, HDL-C concentrations were significantly lower, despite a considerable increase in blood pressure mean (SBP and DBP). Furthermore, FBG showed a considerable increase in mean concentration in diabetes and diabetic hypertensive groups, while HA_{1C} exhibited good control in both. The findings in table 4 showed that diabetic hypertensive women had a significant increase in Lep, Lep/BMI ratio and BMI/WC ratio mean concentration when compared to diabetic and NDNH groups indicating that increase in Lep concentration was correlated with increased risk of diabetes complication e.g. hypertension, dyslipidemia, and insulin resistance; those finding appeared in the significant decrease in HDL-C concentration and increased in SBP and DBP. Those findings were supported by [16], who find that Lep levels may rise in low insulin conditions. In addition, predicted the development of T2DM in the presence of high Lep concentrations [34]. Therefore, high levels of Lep in diabetic hypertensive women than in diabetic women may be due to a longer duration of DM and an increase in age, and that the presence of HTN is one of the manifestations of high levels of Lep in Sudanese women, and that HTN may indicate a women tendency to improve diabetic complications

in the presence of other independent factors such as the family history of diabetes [35]. Case-control research conducted in Sudan found that circulating Lep levels were lower in diabetic participants (men and women) than in controls of the same age and BMI, and that women had higher mean concentrations than males, and that BMI was strongly linked with circulating Lep levels. The mean BMI of patients and control subjects, on the other hand, did not differ [36].

Conclusion

Leptin means concentration in Sudanese women is correlated to anthropometric measurement BMI, WC, and HDL-C concentration.

Recommendations

- More research is needed, and insulin resistance assessment provides accurate and precise data
- Dietary restriction and frequent exercise are recommended for research participants to reduce their weight, BMI, and WC
- Get your HbA_{1C} and lipid profile checked regularly to avoid serious diabetes complications

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Conflict of interest

None.

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