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Original Article

Evaluation of some biochemical parameters in patients with metabolic syndrome

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Abstract

The term "metabolic syndrome" indicates a collection of metabolic abnormalities that raises a person's risk of developing cardiovascular disease (CVD) and diabetes mellitus type w (T2DM). Hypertension, obesity, glucose intolerance, and dyslipidemia are all symptoms of MetS. The primary risk factor for DM development is insulin resistance (IR), which is the critical stage of metabolic syndrome. The current research sought to compare levels of IR in 3 study groups. The current research comprised 50 patients with metabolic syndrome, 50 cases with a minimum of 1 metabolic syndrome symptom as a pathological control, and 50 healthy controls. In the current research, various available kits were used to measure hemoglobin A1C (HbA1C), fasting insulin, fasting blood glucose, and lipid profile, which included the triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC), and high-density lipoprotein cholesterol (HDL) concentrations. The present investigation revealed highly significant differences across study groups; however, no significant differences were found when comparing the two genders of the same sub-groups.

Keywords: metabolic syndrome, insulin resistance, glucose intolerance, hypertension, lipid profile, type 2 diabetes.

Introduction

IR, obesity, impaired glucose tolerance or diabetes, hypertension, dyslipidemia, and hyperinsulinemia with low HDL and raised triglyceride concentrations were the initial components of the metabolic syndrome, as described by Reaven [1–4]. All of the aforementioned characteristics are atherosclerotic risk factors, making metabolic syndrome a substantial risk factor for coronary heart disease (CHD). A significant risk factor for T2DM was also supplied by the characteristics of overweight/obesity and IR [5, 6]. Metabolic syndrome increases the incidence of CHD and diabetes compared to simple obesity [7]. The metabolic syndrome is quite typical. Metabolic syndrome affects roughly 85% of people with T2DM and 32% of the general population in the United States [8, 9]. According to estimates, the illness affects 25% of adults in Latin America and Europe, and rates are rising in emerging East Asia [9]. The metabolic syndrome is largely influenced by hereditary variables, which also have an impact on each of the syndrome's separate components and the syndrome itself. The likelihood that someone would develop metabolic syndrome is considerably increased by a family history of T2DM, early heart disease, and hypertension [10]. Environmental factors, including inactivity and a sedentary lifestyle [11], as well as progressive weight gain from consuming an excessively high carbohydrate diet [12], considerably increase the chance of having metabolic syndrome. Other factors include smoking

and postmenopausal women [13]. Fat accumulation in the liver (fatty liver), which can cause inflammation and the development of cirrhosis, is linked to metabolic syndrome [14]. The kidneys may also be harmed since kidney impairment is subtly but undeniably indicated by microalbuminuria, which is the leakage of protein into the urine [15]. Obstructive sleep apnea [16], polycystic ovarian syndrome (POS) [17], a higher risk of dementia with aging, and cognitive impairment in the elderly [18] are additional issues connected to metabolic syndrome. A crucial metabolic syndrome component, which is the primary risk factor for the onset of DM [13, 19–21], is IR. Therefore, resistance to insulin's influence on lipid metabolism and carbohydrates can be the cause of glucose intolerance, hyperinsulinemia, hypertriglyceridemia, type 2 diabetes, and low HDL levels [2, 5, 22].

Material and methods

A total of 50 patients with metabolic syndrome (59.04 years, age range 38), 50 healthy controls (52.39 years, age range 33), and 50 pathological control subjects (52.06 years, age range 34) have been enrolled in the current study. The groups in the current study have been divided into two groups based on gender. The patients who took part in the study were gathered from the National Institute of Diabetes, Nutrition, and Metabolic Diseases (N.C. Paulescu), Bucharest, Romania. Initial diagnoses have been conducted through specialist physicians that have been depended upon the definition of the metabolic syndrome necessitating the existence of 5 criteria, which include elevated blood pressure (systolic ≥130 mmHg and/or diastolic ≥85 mmHg), decreased HDL-cholesterol (less than 40 mg/dL), elevated fasting glucose (≥100 mg/dL), elevated triglycerides (≥150 mg/dL) and elevated body mass index (BMI) >3022 and through several of clinical and laboratory tests specialist for metabolic syndrome. The people who served as pathological controls experienced at least 1 sign of the metabolic syndrome. The selection of healthy people as controls was based upon a number of factors, including no major surgical or medical illnesses in the past five years, no current medications, no hospital admissions, and a subjective assessment of good health as specified through a health questionnaire. Adult females that were not pregnant or nursing were also excluded from the control group. More so, the control group can be in the same age range as the patient's group, not drinking alcohol or smoking, and eating similarly. Weight (in kg) divided by the square of height (in m) is used for the determination of the body mass index (BMI). Using WHO criteria [23], overweight and obesity were categorized. In the case when a person's BMI was ≥30 kg/m^2, they were deemed obese, and with BMI ≥25 kg/m^2 and <30 kg/m^2, they were deemed overweight. An automatic blood pressure monitor was used to test blood pressure.

Samples collection

After a fast of not less than 8 hours, venous blood samples of 5 milliliters were taken from healthy people and patients. Samples were centrifuged at 5000xg for 5 minutes after being allowed to clot at lab temperature. When not in use, sera were collected and kept at -18°C.

Methods

Fasting insulin was assessed using a sandwich-ELISA kit from the US company Calbiotech [24]. HbA1C values are determined with the use of kits from the USA-based Stan biolaboratory company [25, 26]. A kit from Spinract, Spain [27] was used to estimate fasting blood glucose with the use of the colorimetric approach. Using commercially available kits from the Bilbao company in France, researchers assessed the concentrations of TC, TG, HDL, and LDL-C to create the lipid profile.

Statistical analysis

The 26th edition of the SPSS has been utilized in order to conduct statistical analyses of the results that have been acquired in the current research. The outcome was presented as Mean±Standard Deviation (Mean±SD). The results of the 3 research groups and sub-groups based on gender differences were compared using the ANOVA. The person correlation test was used to compare the studied parameters. The results were statistically significant at a 5% probability ($p<0.05$).

Results and discussion

The 150 participants in this work were divided into three groups, including 50 patients with metabolic syndrome (the first group). The final group consisted of the healthy individuals who were chosen to participate in this study as control group depending on strict criteria that have been stated in the questionnaire that was developed by an expert. The second group consisted

Table 1: The age (year) in study groups according to their gender.

Subjects (n)	Gender (n)		Age (year) Mean±SD	Min–max age (year)	Age range (year)
Healthy control (50)	1	Female (24)	52.71±9.594	43–70	27
	2	Male (26)	5223±10.116	38–73	35
Pathological control (50)	3	Female (27)	52248±8.107	44–70	34
	4	Male (23)	51257±10.693	36–69	33
MS patients (50)	5	Female (30)	56273±72683	44–81	37
	6	Male (20)	62.50±9.512	38–71	33

Note: 1 – healthy female controls; 2 – healthy male controls; 3 – female pathological control; 4 – male pathological control; 5 – female metabolic syndrome; 6 – male metabolic syndrome. The average difference has been significant at the 0.050 level.

of 50 pathological control persons. With differences in gender, age, and BMI taken into account, this work compares the changes in IR values in patients with metabolic syndrome, healthy and pathological control, and examines the connections between these changes and other metabolic disorders in metabolic syndrome. The study samples were divided depending on gender to evaluate the most age-matched instances of metabolic syndrome in both sexes. The current work demonstrated that there has been no difference between females and males in the pathological and healthy control groups but that there has been a significant difference between the female and male subjects in the group with metabolic syndrome (p=0.033), as shown in Table 1. The current conclusion was consistent with a research that noted that metabolic syndrome prevalence increases with age, peaking in 6th decade for the males and 7th decade for the women 28. It was indicated that Mexican-American men were more likely to have metabolic syndrome when they were 40, 50, 60, or 80 years old or older. The development of IR, visceral adiposity, high blood pressure, dyslipidemias, and poor glucose metabolism are all directly related to the presence of obesity and overweight. Additionally, as people age, IR evolves, other hormonal changes occur, and visceral adipose tissue rises, all of which play a crucial role in the pathophysiology of metabolic syndrome [28].

The majority of MS patients were obese (BMI ≥30) in comparison to healthy controls (BMI ≤25), and they were identified as such because of their large waist circumferences, which are indicative of an accumulation of the lipid layer in the abdomen (i.*e.*, apple pattern). In the same groups of pathological control and MetS, the results revealed substantial variations in BMI between both genders (female and male), except for the control group (p=0.960). Except for males in the pathological control group who did not show a significant elevation when put to comparison with their correlatives in the healthy control group, the two genders in the MetS group showed statistically significant variation (p<0.05) in the case when put to comparison with their

Table 2: BMI (kg/m^2)of the study subgroups.

Subjects (n)	Gender (n)		BMI (kg/m^2) Mean±SD	Min–max BMI (kg/m^2)	BMI range (year)
Healthy control (50)	1	Female (24)	27.316±22493	232833–342637	6.804
	2	Male (26)	272268±2.362	212847–342628	8.781
Pathological control (50)	3	Female (27)	32.775±42884	472444–252951	21.049
	4	Male (23)	28.771±22766	252444–362198	11.198
MetS patients (50)	5	Female (30)	38.512±32998	312544–452444	13.500
	6	Male (20)	342957±22351	322444–442440	8.000

Note: 1 – healthy female controls; 2 – healthy male controls; 3 – female pathological control; 4 – male pathological control; 5 – female metabolic syndrome; 6 – male metabolic syndrome. The average difference has been significant at the 0.050 level.

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peers in the subgroups of pathological and healthy controls (Table 2). BMI and waist circumference measurements could be used to quantify obesity as a body fat marker, which might then be used to determine the risk of MetS [29]. Not just for the onset of MetS but for other cardiovascular risk factors as well, obesity appears to be the main underlying risk factor [30]. However, this result was not reported as an approximately 2-fold increase in the 10-year risk of coronary artery disease in the subjects who have [31] kg/m^2 BMI or higher when compared with the ones with BMI <21 kg/m^2 after adjustment for age [32]. The results of various works suggested that increasing body weight and BMI were related to an elevation of ischemic heart disease in numerous populations [33, 34]. The prospective cardiovascular study's findings showed that the BMI did not independently influence cardiovascular risk in multiple logistic regression analyses [35].

When the patient groups and the healthy control were compared with the use of the ANOVA test, the results of the current investigation showed significantly ($p<0.05$) different results. The research produced several distinct observations, such as: (1) levels of blood sugar in MS patients and pathological controls significantly increased as compared to healthy control subjects, although there have been no appreciable changes between the MetS group and the pathological group, as indicated in Table 3; (2) There were substantial differences

Table 3: Levels (Mean±SD) of sugar concentration (mg/dL), insulin secretion (mIU/L), HbA1c%, and lipid profile in serum of study groups.

Parameters	Healthy control (50) Mean±SD Min–Max range	Pathological control (50) Mean±SD Min–Max range	MS patients (50) Mean±SD Min–Max range
BloodGlucose (mg/dL)	107.605±15.593 70.402–129.572 59.17	241.582±81.129 89.00–421.015 332.0150	250.639±81.235 136.415–442 305.585
Systolic blood pressure (mmHg)	114.13±24.915 110–135 124	133.54±19.56 100–183 83	153.92±23.839 180–190 172
HbA1c%	4.544±0.647 3.500–5.600 2.100	8.742±1.671 4.525–12.000 7.475	9.403±1.462 5.900–12.000 6.100
Cholesterol (mg/dL)	184.042±38.448 79.829–266.826 186.997	198.392±50.607 120.000–325.157 205.157	225.806±42.038 154.581–340.015 185.434
Insulin (mIU/L)	12.223±6.593 0.068–25.291 25.223	28.379±16.824 5.864–75.917 70.053	37.935±21.893 6.291–86.436 80.145
Triglyceride (mg/dL)	143.330±40.237 74.870–215.520 140.650	179.919±84.007 60.969–350.541 289.572	283.756±90.106 118.920–598.110 479.190
HDL-C (mg/dL)	88.250±22.888 43.910–133.035 89.125	53.673±18.585 23.245–88.000 64.755	34.3917±7.49752 20.000–62.620 42.620
LDL-C (mg/dL)	71.615±33.189 25.532–126.492 100.960	111.065±50.810 22.912–236.526 213.614	135.312±44.970 62.547–248.695 186.148
vLDL-C (mg/dL)	28.398±7.799 16.483–43.103 26.620	35.395±16.498 12.193–70.108 57.915	56.606±18.031 23.784–119.621 95.837
Diastolic blood pressure (mmHg)	76.87±5.057 65–85 20	81.920±11.911 68–112 44	92.70±13.815 12–110 98

Note: 1 – healthy female controls; 2 – healthy male controls; 3 – female pathological control; 4 – male pathological control; 5 – female metabolic syndrome; 6 – male metabolic syndrome. The average difference has been significant at the 0.050 level.

Table 4: Comparison the levels of HOMA-IR and FIGRA mong the study groups.

Parameters	Healthy control (50) Mean±SD Min–Max range	Pathological control (50) Mean±SD Min–Max range	MS patients (50) Mean±SD Min–Max range
HOMA-IR	3.009±1.566 0.76–7.78 7.02	16.978±12.398 2.580–50.56 47.98	23.154±17.616 2.900–67.363 64.463
Insulin/GlucoseRatio	0.114±0.061 0.033–0.26 0.227	0.131±0.0792 0.015–0.344 0.329	0.158±0.106 0.034–0.518 0.484

Note: 1 – healthycontrols; 2 – pathologicalcontrol; 3 – metabolicsyndrome. The average difference is significant at the 0.050 level.

between pathological control and MS patients, as can be seen in Table 3, and the fasting insulin level appeared to be considerably elevated (p=0.00) in samples of pathological control and MetS patients when compared to healthy individuals; (3) The current investigation notes substantial differences between pathological control and MS patients in terms of HbA1c levels when compared to similar values in the group of healthy individuals; (4) The research found that cholesterol levels and the vLDL-C had increased significantly in MS patient sera compared to the healthy and pathological controls but not in the sera of controls (p=0.2340 and p=0.1110, respectively); (5) In comparison to the healthy individuals group, serum samples from patients who have metabolic syndrome and pathological controls show a highly significant increase in the levels of TG, HDL-C, and LDL-C.

Low HDL is a hallmark of the metabolic syndrome, also characterized by increased TG levels. This is thought to result from a higher TG burden in the HDL particle, which is then hydrolyzed by hepatic lipase. The kidney filters a small HDL particle produced due to the loss of triglycerides, which lowers the levels of apolipoprotein (Apo) A and HDL. In addition to a rise in apo A loss, findings suggest that insulin could encourage apoA gene transcription [36]. As a result, decreased apo A biosynthesis could be related to IR states [37].

Levels of insulin resistance have been represented by HOMA-IR and fasting insulin/glucose ratio (FIGR). HOMA-IR values in the metabolic syndrome, pathological control, and healthy control groups were 23.154±17.616, 16.978±12.398, and 3.009±1.566, respectively. Independent ANOVA test results showed that IR in the MetS group was higher than those in pathological control and healthy control group, and differences have been found statistically significant at ($p<0.05$), as demonstrated in Table 4.

Outcomes of the current parameter showed there had not been any significant differences ($p>0.05$) between the two genders in the same group when HOMA IR was tested in the six study subgroups, as demonstrated in Table 5, on the other side; significant increases (p=0.000) were recorded when two genders of patients (male and female)were compared to their matching genders in the healthy group. Additionally, significant variations ($p<0.05$) were observed when the individuals

Table 5: HOMA-IR levels in the different study subgroups.

Subjects (n)	Gender (n)		HOMA-IR Mean±SD	Min–max BMI HOMA-IR	Range HOMA-IR
Healthy control (50)	1	Female (24)	22693±12397	0.758–5.711	4.953
	2	Male (26)	3.300±1.681	0.896–7.780	6.884
Pathological control (50)	3	Female (27)	14.853±10.662	22584–49.404	46.824
	4	Male (23)	192472±132998	3.640–50.560	46.920
MetS patients (50)	5	Female (30)	222777±182947	2.900–67.363	64.463
	6	Male (20)	232724±152869	5.500–60.900	55.400

Note: 1 – healthy female controls; 2 – healthy male controls; 3 – female pathological control; 4 – male pathological control; 5 – female metabolic syndrome; 6 – male metabolic syndrome. The average difference has been significant at the 0.050 level.

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Table 6: Levels of (FIGR) in the various study groups.

Subjects (n)	Gender (n)		FIGR Mean±SD	Min–max	Range
Healthy control (50)	1	Female (24)	0.103±0.553	0.029–0.194	0.165
	2	Male (26)	0.124±0.066	0.030–0.260	0.230
Pathological control (50)	3	Female (27)	0.123±0.070	0.03–0.31	0.278
	4	Male (23)	0.141±0.086	0.020–0.344	0.329
MetS patients (50)	5	Female (30)	0.148±0.996	0.034–0.420	4.386
	6	Male (20)	0.175±0.115	0.050–0.520	0.470

Note: 1 – healthy female controls; 2 – healthy male controls; 3 – female pathological control; 4 – male pathological control; 5 – female metabolic syndrome; 6 – male metabolic syndrome. The average difference has been significant at the 0.050 level.

with the same genders (healthy male with pathological control male and healthy female with pathological control female)in the two groups were compared together. Levels of HOMA-IR of men in the MetS group were not statistically different (p=0.269) from those in the pathological control group, while levels of HOMA-IR seemed to be statistically high (p=0.018)in the MetS female comparison to females in the pathological control group, as shown Table 5. Insulin represents the central glucose and lipid homeostasis regulator; it reduces the concentrations of blood glucose through the reduction of hepatic gluconeogenesis and glycogenolysis and the enhancement of the uptake of glucose into the striated muscles and adipocytes; in addition to that, it leads to the enhancement of the thesis of the triglycerides in the liver and adipose tissue, in addition to that, it leads to the increase of the breakdown of the circulating lipoproteins through the stimulation of the activity of the lipoprotein lipase in the adipose tissues, and suppresses lipolysis in adipose tissues as well as in the muscles [38].

When muscle, adipose, and liver cells do not respond to insulin as intended and circulating glucose levels remain high, IR develops, which results in pathology and the dysregulation of feedback mechanisms. Hyperinsulinemia is a compensatory measure for IR and a strong marker of T2DM [39]. Numerous common illnesses, including hypertension, metabolic syndrome, coronary artery disease, hyperlipidemia, and POS, are known to include IR as a contributing factor [40]. IR is the foundation for metabolic syndrome, which is caused by IR. Therefore, resistance to insulin's effects on carbohydrate and lipid metabolism can be the cause of glucose intolerance, hyperinsulinemia, hypertriglyceridemia, type 2 diabetes, and low HDL levels [41].

Fasting insulin: glucose ratio (FIGR) levels have been observed to be non-significant higher ($p<0.05$) in inpatient and pathological control groups than in those in the healthy subjects group, as demonstrated in Table 4. When the individuals who participated in the present study were compared based on their genders, ANOVA test results showed there was no significant variation among study subgroups when the FIGR were compared whether in the same group (male with female in the same group) or between the same-gender subgroups, as illustrated in Table 6.

In this case, when compared to the pathological and healthy control groups, patients with metabolic syndrome had a significantly higher level of HOMA IR. This finding points to the pathogenic nature of IR, particularly when all the combined strains of the syndrome are present in a single individual. Additionally, it was found that HOMA IR was more acceptable and accurate than FIGR for measuring insulin sensitivity, as FIGR yielded unacceptable and significant results when study groups were compared. This result was in agreement with a previous work that found HOMA to be more suitable for large epidemiologic studies and more accurate when compared to FGIR as an IR measure amongst adolescents and children. Compared to clamp studies [42], using HOMA is easier, less time-consuming, less expensive, and labor-intensive.

Conclusion

The metabolic syndrome, which includes dyslipidemia, visceral obesity, hypertension, and hyperglycemia, has emerged as one of the world's most pressing public health issues. The results of the current investigation showed that there were substantial correlations

between the symptoms of the metabolic syndrome and that IR, which is its core feature, has a pathogenic impact on the syndrome's other elements, including hypertension, hyperlipidemia, obesity and hyperglycemia.

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Conflict of interest

The authors declare no conflict of interest.

Ethics approval

The approval for this study was obtained from the Ethics Committee of the University of Bucharest, Faculty of Biology.

Consent to participate

Written informed consent was obtained from all participants in this study.

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