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Original Article

Correlation of being overweight and obese with liver function and metabolic syndrome in Saudi females

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Abstract: The study aims to analyze the effect of being overweight and obese on liver function in women of Al Majma'ah and its impact on their health. A cross-sectional study design and was carried out at different Al Majma'ah and nearby areas in Saudi Arabia between January 2018 and December 2018. It included 340 female students, faculty staff, and volunteers aged 22±7 years. All participants from different socio-economic groups were interviewed using an administered questionnaire. The study findings showed more extraordinary occurrences of being overweight and obese in females of the Al Majma'ah region. The study investigated the relationship between elevated liver enzymes in an obese and overweight female population with the help of liver function tests (AST, ALT, GGT, and TBIL, etc.). The results have depicted the relationship of fatty liver disease with obesity and being overweight and the usefulness of measuring liver enzymes as a risk predictor for other chronic diseases. The results concluded that obese females are at significant risk of developing NALD, as shown by increased triglyceride levels. Increased ALT also shows that obese females are at a high risk of developing arthritis. Overweight and obese females showed a significant increase in BMI, WC, WHR, TG, AST, and ALT, increasing the chances of Type II diabetes. There is an existence of risk factors that express overt symptoms of metabolic syndrome. Therefore, the study results recommend a more significant emphasis on the risk prevention of pre-symptomatic individuals. The implications of this paper state that the majority of the features of metabolic syndrome can be prevented by regular exercise and modest weight loss. The government can also play a significant role in constructing parks and other recreational activities for individuals to become physically active and healthy.

Keywords: Alanine aminotransferase (ALT), body mass index (BMI), metabolic syndrome (MS), obesity, overweight

Introduction

Being overweight and obese can cause major health problems, including chronic illnesses. However, the rising pandemic of obesity has received significant attention in many countries [1]. The major contributing diseases are hypertension, diabetes mellitus, fatty liver disease, cardiovascular diseases, dyslipidemia, gall bladder diseases, arthritis, and gout. The development of these diseases poses global health problems that may lead to severe disability, followed by a negative impact on quality of life. The American Cancer Society (ACS) showed a significant increase in mortality among obese individuals [2, 3]. The WHO [4] identified that being overweight and obese is the fifth leading risk for death globally. At least 2.8 million adults die each year due to obesity. In addition, 44% of the diabetes burden is attributable to being overweight and obese.

Saudi Arabia has gone through significant changes in nutritional and lifestyle habits over the last 30 years. Such changes are expected to impact the magnitude of chronic diseases in society, specifically obesity [5]. In 2005, the estimated prevalence of obesity in Saudi Arabia was 35.5% [6]. In 2010, Saudi Arabia was ranked 11th for obesity worldwide, with 26.4% of obese men and 44% of women being obese among the general Saudi population [7]. The data collected in 2004 and 2005 showed that the overall prevalence of being overweight in Saudi Arabia was 21% and 13.4% among men and women, respectively. Among them, 9.3% of individuals were obese based on the data collected in 2004 and 2005 from Saudi children [8].

There is an increase in the prevalence of arterial hypertension as the prevalence of obesity increases [9]. Generalized [10] and central obesity [11] increases the risk of arterial hypertension. Hyperinsulinemia could represent one of the pathogenic connections between obesity and arterial hypertension since high blood pressure and impaired glucose tolerance are frequently associated with obesity [12]. Age, race, and sex may alter the frequency of hypertension in obese patients [13]. A strong association between atherogenic dyslipidemia is characterized by high triglycerides and low to high-density lipoprotein (HDL) cholesterol [14]. While, central obesity is associated with a triad of high triglycerides, low HDL cholesterol, and increased to low-density lipoprotein (LDL) cholesterol [15].

Obesity is considered a risk factor for multiple heart diseases like coronary artery disease, heart failure, and atrial fibrillation. The fact that obesity is a risk factor for coronary artery disease [16] is confirmed by increased BMI [17] and increased waist circumference [18]. However, the waist-to-hip ratio can replace the BMI and waist circumference as a better predictor of coronary artery disease [19].

Non-alcoholic fatty liver disease (NAFLD) and non-alcoholic steatohepatitis (NASH) are mainly associated with obesity [20, 21], diabetes [22], hyperlipemia [23, 24], and insulin resistance [25] which are all correlated with metabolic syndrome. As per the recent definition given by Adult Treatment Panel III (ATP III) [26], metabolic syndrome is related to five categorical and discrete risk factors, i.e., central obesity, hypertension, hypertriglyceridemia, and low levels of high-density lipoprotein, HDL-cholesterol, and hyperglycemia as per the guidelines of International Societies or the statement of the WHO [27]. A recent study by Papandreou et al. [28] investigated the association between MS and NAFLD among obese children. The study revealed that obese children suffering from MS were at higher risk of developing NAFLD. This further suggested that these health issues should be prevented through weight management and early prevention as the first-line treatment. Previous studies have investigated the correlation of TBIL, GGT, and ALT with the development of MS [29-33]. However, none of them investigated the correlation of BMI, WC, and FG with the development of MS. Therefore, this study investigates the association between an elevated liver enzymes in an obese and overweight females with the help of liver function tests (AST, ALT, GGT, and TBIL, etc.) while considering their BMI, WC, and FG. It further depicts the association of metabolic syndrome with obesity, being overweight, and the usefulness of measuring liver enzymes as a risk predictor for other chronic diseases like NAFLD, NASH, and diabetes type 2, etc. The present study aims to analyze the effect of being overweight and obese on the liver function in women of Al Majma'ah and its impact on their health.

Materials and methods

Study design and samples

This study followed a cross-sectional study design and was carried out at Al Majma'ah and other nearby areas in Saudi Arabia between January 2018 and December 2018. It included 340 female students, faculty staff, and volunteers with an age group of 22±7 years. The number of participants (female students) was calculated using a sample size calculator, given a confidence interval (95% CI, 5% level of significance). All participants who were from different socio-economic groups were interviewed using an administered questionnaire. Anthropometrical measurements including age, height, weight, waist and hip circumference, liver function test status were recorded. A total of 350 female volunteers participated in this study, out of which ten patients were excluded based on the interview and exclusion criteria. The exclusion criteria for this study included patients with a history of diabetes mellitus, cardiovascular disease, hypertension, liver disease, and pregnancy.

Ethical considerations

The ethical committee of our university approved all procedures used in this study of Al Majma'ah University (Ethical approval no. 64/29952). Moreover, written informed consent was obtained from each patient before starting the study procedure and analysis.

Data tools and analysis

Height, weight, waist circumference (cm), hip-waste ratios, and BMI (Kg/m^2) were measured as per the standard procedure. BMI ≥24.9 kg/

Table 1. Values of age, BMI, waist circumference, waist-hip ratio, hypertension, triglyceride, HDL-cholesterol, LDL-cholesterol, and Liver enzyme activity expressed by chi-square

Factors	Normal Range	Group I (Normal)	Group II (Overweight)	Group III (Obese)	*P*-value
Mean age (years)	-	29.62±2.54	31.12±2.66	33.79±2.34	-
BMI (Kg/m^2)	18.5-24.9 Kg/m^2	22.78±0.55	27.69±1.45	37.65±1.37	1.542
Hypertension	120/80	121/65	127/83	130/95	0.537
WC (cm)	85 cm	82±0.67	105±3.08	117±3.80	5.048
WHR	0.85	0.79±0.04	0.89±0.20	0.93±0.56	0.545
Cholesterol (mg/dl)	≤200 mg/dl	157±5.45	164±3.8	184±4.90	3.637
HDL-C	>60 mg/dl	52±4.50	45±1.06	42±0.90	6.048
LDL-C	<130 mg/dl	1242.02	1384.50	1482.45	2.578
Triglycerides (mg/dl)	≤60-150 mg/dl	122.43±9.50	154±7.40	165±3.70	6.048
AST (U/L)	15-31 U/L	18±1.30	29±1.16	38±1.34	3.722
ALT (U/L)	17-35 U/L	21±1.70	34.05±0.16	42±2.34	5.315
TBIL (μmol/L)	8-10 μmol/L	8±2.15	21.50±2.01	26.04±1.80	

*P<0.05 was accepted as significant.

m^2 was taken as the cut-off value for overweight subjects and BMI ≥30 kg/m^2 as the expected value for obese subjects. Waist circumference was ≥97 cm and 85 cm as cut-off values for overweight and obese subjects, respectively. Five ml venous blood was collected from each participant by trained medical staff and immediately transferred to a heparinized tube. The serum was separated by centrifugation and stored in ependroff at -60°C at the Department of Physiology, University of Karachi. TC, HDL-C, TG were analyzed using colorimetric kit method (Química Clínica Aplicada S.A., Spain). The concentration of LDL-C was calculated using Friedewald's formula as shown below.

A sample/A standard X standard concentration = mg/dl

Commercially available kits from Sigma Aldrich [1] were used to measure the liver function tests (AST, ALT, GGT, FB, and TBIL). The protocol standards were used as mentioned in the kits. Other Kits from Química Clínica Aplicada S.A. (Spain) were used to measure AST (SGOT) and ALT (SGPT). GGT quartiles 1 to 4 in females with obesity and those who were overweight were defined by the cut-off values 11.00 U/L, 15.00 U/L and 21.00 U/L, respectively. The absorbency for the test was calculated as ΔA/minX1746 = SGPT or SGOT activity measured at U/L at 340 nm. The statistical Package for social science (SPSS version 17.0, Chicago, IL, USA) was used to carry out the statistical analyses, and significance was defined as P<0.05. All the values were expressed as mean ± standard error for comparing readings within the group using student's t-test with a significance value P<0.05. The Chi-square test analyzed the inter-group differences.

Results

It was found that 30% of the females had BMIs ≥30 kg/m^2 that were considered obese; whereas, 32.5% of females had BMIs within 25-29.9 30 kg/m^2 and were deemed as being overweight. The ratio of females with obesity and those who were overweight compared to normal healthy females was 1:1.6. The mean waist circumference of overweight females was 22% compared to normal females; whereas, in obese females, it was 30%. Cholesterol levels in both overweight and obese females reported an insignificant difference as compared to normal individuals. The levels of triglycerides were found to be higher in overweight and obese female subjects. In group I (normal females) and II (overweight females), the AST level was found under the normal range, whereas, in obese females, it was comparatively higher than the normal range. The test values for AST were increased in obese females (P<0.05) (**Table 1**).

Table 2 shows the correlation of other variables with AST. The mean value of cholesterol, age, BMI, and ALT, GGT, TBIL, and FG were positively correlated in overweight females. In obese females, a negative correlation was

Table 2. Representation of Pearson's Correlation coefficient of AST with different parameters of overweight and obese female groups

Groups		Age	BMI	Cholesterol	TG	AST	ALT
Group II	Overweight Females	+0.67*	+0.10	+0.39	+0.14	-0.12	+0.04
Group III	Obese Females	+0.52	+0.82	+0.24	+0.18	+0.46	+0.93*

*P<0.05 was accepted as significant.

Table 3. Prevalence of hypercholesterolemia, hypertriglyceridemia, low HDL-cholesterolemia, high LDL-cholesterolemia in overweight and obese adult female subjects by chi-square

Variables	Frequencies (%)		Total (n = 168)	*P*-value
	Group II (n = 94)	Group III (n = 74)		
Hypercholesterolemia >200 mg/dl	15 (25%)	6 (14.6%)	21 (21%)	0.436
Hypertriglyceridemia >150 mg/dl	35 (59.3%)	13 (32%)	48 (48%)	4.047
Low HDL-Cholesterol	9 (15.2%)	18 (44%)	27 (27%)	0.443
Females <45 mg/dl				2.636
High LDL-Cholesterol >130 mg/dl	14 (24%)	7 (17%)	21 (21%)	5.047
AST 15-31 U/L	7 (11.8%)	12 (29.2%)	19 (19%)	1.574
ALT 17-35 U/L	14 (23.7%)	18 (43.9%)	32 (32%)	5.037

found with HDL-C. The mean value was found under the normal range; whereas, a positive correlation was reported among LDL-C, BMI, cholesterol, AST, and ALT.

The frequencies of hypercholesterolemia, hypertriglyceridemia, low HDL-cholesterolemia, high LDL-cholesterolemia, ALT, and AST were found to be 21% (25% in overweight females, 14.6% in obese females), 48% (59% in overweight females, 32% in obese females), 27% (15% in overweight females, 44% in obese females), 21% (24% in overweight females, 17% in obese females), 32% (14% in overweight females, 18% obese females) and 19% (7% overweight, 12% in obese females), respectively (**Table 3**). The table showed that overweight women had a high frequency of dyslipidemia. It is associated with a sedentary lifestyle in Saudi Arabia that results from decreased physical activity.

In different age groups, the TBIL quartiles 1 to 4 were studied according to the following cut off values: ≤8.00 μmol/L, >8.00 TBIL ≤10.30 μmol/L, >10.30 TBIL ≤13.40 and >13.40 μmol/L. The results show that in the female population age group >20 to ≤30 (years) leads high percentage quartiles of TBIL 26.04%, which is a young age group in a female with obesity (**Table 4**), the results are similar to the results of ALT and GGT (**Tables 5** and **6**) in this age group. This correlates with the age as a positive variable with increasing risk of metabolic syndrome in the young population.

Discussion

Obesity plays a significant role in the development of the liver disease and is a well-defined etiology [19]. The study showed extraordinary occurrences of being overweight and obese in females of the Al Majma'ah region. Several studies supported similar outcomes in many ethnic groups like African American and Native Americans etc. [27, 34, 35]. Obesity was about 15% in males and 20% in the female population of the United Kingdom and European countries [27]. The increased TG level in obese females indicated hyperlipidemia, which is one of the risk factors of inflammation of the liver resulting in liver failure [27]. In the present study, mean AST values among overweight and obese females did not significantly change.

In contrast, ALT, GGT, and TBIL were significantly higher in both overweight and obese females. These results were parallel to the early findings that obese people can possess high levels of serum transaminases compared to their healthy counterparts [34]. The present study has attempted to find the correlation between AST and ALT, GGT, TBIL, FG, age, BMI, and TG among overweight and obese females. The results showed a high ALT level compared to AST, like patients with cirrhosis [35]. Being overweight and obese is the fifth leading cause of deaths globally [36]. It was thought that mortality rates associated with no cardiovascular diseases were inversely related to BMI [24]; however, obesity has shown an increas-

Table 4. Percentage distribution of TBIL quartiles in different age groups in females who are overweight and obese

TBIL (μmol/L) Group II	Percentage distribution (with case number count) in different age subgroup (years)					
	Age ≤20	20< age ≤30	30< age ≤40	40< age ≤50	50< age ≤60	Total
TBIL ≤8.00 μmol/L	5 (15.61%)	7 (20.70%)	5 (12.23%)	8 (10.72%)	3 (12.75%)	28 (14.47%)
8.00< TBIL ≤10.30	8 (20.60%)	4 (22.54%)	5 (14.53%)	70 (14.29%)	2 (11.64%)	26 (16.95%)
10.30< TBIL ≤13.40	5 (17.8%)	5 (16.24%)	2 (21.50%)	10 (13.80%)	4 (12.83%)	26 (16.43%)
TBIL >13.40	3 (12.45%)	10 (21.62%)	5 (15.13%)	12 (10.45%)	5 (13.32%)	35 (17.02%)
TBIL (μmol/L) Group III	Percentage distribution (with case number count) in different age subgroup (years)					
	Age ≤20	20< age ≤30	30< age ≤40	40< age ≤50	50< age ≤60	Total
TBIL ≤8.00 μmol/L	10 (23.65%)	13 (20.70%)	8 (22.54%)	8 (23.72%)	9 (15.45%)	48 (21.87%)
8.00< TBIL ≤10.30	8 (22.60%)	7 (22.54%)	15 (24.83%)	15 (22.89%)	10 (19.60%)	55 (22.68%)
10.30< TBIL ≤13.40	26 (17.8%)	22 (26.04%)	20 (20.50%)	20 (20.90%)	18 (24.83%)	106 (23.45%)
TBIL >13.40	15 (16.64%)	20 (23.92%)	15 (25.83%)	12 (23.40%)	20 (20.32%)	82 (25.32%)
P-value	2.646	4.823	0.6472	6.416	6.0588	3.1170

TBIL = total bilirubin, comparing the percentage distribution between different age groups in females with obesity by Chi-Square method. *P<0.05.

Table 5. Percentage distribution of GGT quartiles in different age groups in the females who were overweight and obese

GGT (U/L) Group II	Percentage distribution (with case number count) in different age subgroup (years)					
	Age ≤20	20< age ≤30	30< age ≤40	40< age ≤50	50< age ≤60	Total
GGT ≤11.00 U/L	5 (22.24%)	7 (23.79%)	5 (22.29%)	8 (24.72%)	3 (23.75%)	28 (23.35%)
11.00< GGT ≤15.00	8 (23.60%)	4 (27.54%)	5 (28.53%)	70 (34.29%)	2 (31.64%)	26 (22.92%)
15.00< GGT ≤21.00	5 (23.82%)	5 (36.54%)	2 (32.50%)	10 (39.80%)	4 (22.83%)	26 (31.09%)
GGT >21.00	3 (12.65%)	10 (8.62%)	5 (13.14%)	12 (11.35%)	5 (7.32%)	35 (10.62%)
GGT (U/L) Group III	Percentage distribution (with case number count) in different age subgroup (years)					
	Age ≤20	20< age ≤30	30< age ≤40	40< age ≤50	50< age ≤60	Total
GGT ≤11.00 U/L	10 (22.65%)	13 (25.70%)	8 (22.34%)	8 (31.72%)	9 (18.45%)	48 (24.17%)
11.00< GGT ≤15.00	8 (32.60%)	7 (38.54%)	15 (26.81%)	15 (24.89%)	10 (15.60%)	55 (27.68%)
15.00< GGT ≤21.00	26 (27.81%)	22 (23.04%)	20 (21.50%)	20 (28.90%)	18 (14.83%)	106 (23.21%)
GGT >21.00	15 (19.61%)	20 (12.41%)	15 (10.63%)	12 (13.42%)	20 (10.12%)	82 (13.24%)
P-value	0.646	8.823*	4.6472	3.416	7.0588	5.3170

GGT = Gamma-glutamyltransferase, comparing the percentage distribution between overweight and obese females by chi-square method. *P<0.01.

ed association with overall mortality among adults [25]. The risk of mortality rises among individuals with high BMI as these individuals are at increased risk of developing vascular diseases [26] and cancers [27]. In addition, weight fluctuation is associated with a high risk of overall mortality [34]. Obesity is highly linked to the development of type 2 diabetes mellitus at all ages [35]. An Increase in the BMI [36] and waist circumference [37] leads to an increasing in the risk of type 2 diabetes mellitus due to the association between obesity and metabolic syndrome, impaired fasting glucose, and impaired glucose tolerance [38].

It is important to mention that the baseline mean HDL-cholesterol levels in the subjects of the present study were found below the normal range (<45 mg/dl for females) as recommended by the National cholesterol education program [41, 42]. Low HDL cholesterol in the population may have been one factor contributing to high CAD rates. The prevalence of low HDL cholesterol (<45 mg/dl) for females in the Saudi population was 15% for overweight and 44% for obese females. Many studies [16, 39] have shown that high GGT or ALT could be predictive risk factors for the development of T2D independent of BMI. Moreover, GGT could

Table 6. Percentage distribution of ALT quartiles in different age groups in the females who were overweight and obese

ALT (U/L) Group II	Percentage distribution (with case number count) in different age subgroup (years)					
	Age ≤20	20< age ≤30	30< age ≤40	40< age ≤50	50< age ≤60	Total
ALT ≤13.00 U/L	5 (23.74%)	7 (23.79%)	5 (22.29%)	8 (24.72%)	3 (28.75%)	28 (24.65%)
13.00< GGT ≤16.00	8 (13.60%)	4 (20.54%)	5 (24.53%)	70 (34.29%)	2 (31.64%)	26 (24.92%)
16.00< GGT ≤22.00	5 (18.82%)	5 (26.54%)	2 (22.50%)	10 (19.82%)	4 (22.83%)	26 (23.86%)
GGT >22.00	3 (5.25%)	10 (8.62%)	5 (7.14%)	12 (11.35%)	5 (7.32%)	35 (7.93%)
ALT (U/L) Group III	Percentage distribution (with case number count) in different age subgroup (years)					
	Age ≤20	20< age ≤30	30< age ≤40	40< age ≤50	50< age ≤60	Total
ALT ≤13.00 U/L	10 (39.35%)	15 (43.45)	8 (32.34%)	11 (31.72%)	9 (28.45%)	48 (35.02%)
13.00< GGT ≤16.00	8 (27.50%)	10 (39.64%)	15 (36.81%)	12 (28.89%)	10 (25.60%)	55 (31.28%)
16.00< GGT ≤22.00	16 (37.32%)	12 (48.34%)	20 (38.50%)	19 (28.90%)	18 (21.83%)	106 (38.42%)
GGT >22.00	10 (14.44%)	17 (9.44%)	15 (13.63%)	13 (15.47%)	20 (10.12%)	82 (12.62%)
P-value	10.588*	8.823*	3.588	3.416	7.0588	3.1170

ALT = Alanine aminotransferase, comparing the percentage distribution between overweight and obese females by chi-square method. *P<0.01.

be a marker of hepatic steatosis or visceral obesity [4]. A study has also shown an inverse relationship between insulin sensitivity and liver function [40]. On the contrary, a normal-functioning liver may contribute to the insulin sensitivity of the whole body [16]. The study implications state that the majority of the features of metabolic syndrome can be prevented by regular exercise and modest weight loss.

The government can also play a significant role in constructing parks and other recreational activities for individuals to become physically active and healthy. The primary prevention of metabolic syndrome may even involve the administration of anti-obesity drugs in extreme cases. However, the study results were limited, as a small sample size was considered for this study from a small region. Moreover, there was no diagnosis made for NAFLD, with high sensitivity and specificity. The estimations were inevitable because the potential impact on the prevalence and the observed risk factors in the study were based on the screening of an elderly population that was recruited from a single area.

Conclusion

The present study has found the percentage of women in a population that has been facing challenges with being overweight and with obesity. It has investigated the relationship between elevated liver enzymes in an obese and overweight female with the help of liver function tests (AST, ALT, GGT, and TBIL, etc.). The results concluded that obese females are at significant risk of developing NALD, as shown by increased triglyceride levels. Increased ALT also shows that obese females are at a high risk of developing arthritis. Overweight and obese females showed a significant increase in BMI, WC, WHR, TG, AST, and ALT, increasing the chances of Type II diabetes.

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Disclosure of conflict of interest

None.

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