Original Article

Characterization of Serum Electrolytes Levels and Lipid Profile among Young Obese Saudi Females

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Abstract

Background: A higher prevalence of electrolyte imbalance is observed among individuals who are obese when compared to the general population. It has been observed that obesity contributes to electrolyte imbalance, which is one of the conspicuous consequences of this physiological dysfunction. **Aim:** This study aims to evaluate serum electrolytes and lipid profiles among young obese Saudi females. **Methods:** The study was cross-sectional at Taibah University, Madinah, Saudi Arabia. The research included 350 obese females aged 20–25 with a body mass index (BMI) ≥30 kg/m^2. The study included students and employees aged 20–25 with a high BMI of 116 ≥30 kg/m^2. A total of three hundred fifty people volunteered to take part in this study. Volunteers received self-administered screening questionnaires to remove individuals who did not match the eligibility requirements. Participants were chosen using a random selection approach, with the additional criteria of having no pre-existing medical issues and a BMI ≥30 kg/m^2 based on submitted information. **Results:** The mean age of the females with obesity was 21 ± 10.3 years who had body mass index (BMI ≥30 kg/m^2). Approximately 28.57% of subjects had hypernatremia, 2.9% hyponatremia (P = 0.03), 28.57% hypokalemia, 2.8% hyperkalemia (P < 0.001), 30% hypomagnesemia, and 2.9% hypermagnesemia (P < 0.001), 2.3% hypochloremia, 10.8% hyperchloremia. (P > 0.05) Notably, these individuals also exhibited elevated levels of cholesterol (P = 0.04) and triglycerides (P < 0.001). There exists a correlation between BMI levels and the levels of fasting blood glucose, total cholesterol, and triglycerides (r = 0.53, P = 0.04, r = 0.56, P = 0.04, r = 0.55, 181 P = 0.02, respectively). The levels of Na^+ exhibit a positive correlation with BMI (r = 54, P = 0.03), whereas the levels of K^+ and Mg^{2+} demonstrate a negative correlation (r = −0.53, P = 0.02, r = −0.54, P = 0.04, respectively). **Conclusion:** Young females in Saudi Arabia who are obese may have greater levels of sodium (Na^+), decreased levels of potassium (K^+), and elevated levels of triglycerides and cholesterol Addressing these imbalances through targeted dietary and lifestyle interventions may be crucial for improving the health outcomes of these individuals.

Keywords: *Electrolytes, lipids, obesity*

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Introduction

Serum contains sodium (Na^+), potassium (K^+), chloride (Cl^-), and magnesium (Mg^{2+}) electrolytes[1], which are essential mediators in the metabolic processes and cellular function.[2] Furthermore, electrolytes are important in providing a balance of body fluids and a normal pH of body fluids. Electrolytes play vital roles in muscle contraction, and blood coagulation and as

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cofactors in proteins, enzymes, and vitamin structures.[2] Disturbance in the concentrations of these electrolytes is associated with diseases such as diabetes complications, high blood pressure, kidney failure, osteoporosis, and CVD.[3,4]

For example, the primary intracellular cation (K^+) plays a significant role in maintaining cell processes. An action potential is essential for potassium function, especially in excitable tissues like neurons and muscles.[5] The kidneys are largely responsible for maintaining proper serum levels of K^+.[6] Having a serum K^+ level below 3.5 mmol/L or hypokalemia is a common and serious electrolyte imbalance leading to alteration in the electrical conduction of the heart and even abrupt death.[5,7]

Sodium (Na^+), an extracellular fluid cation, is the electrolyte responsible for the correct distribution of water and osmotic pressure in bodily fluids. Various illnesses are linked to variations in normal serum sodium levels.[8] Dehydration, diarrhea, or inadequate water intake all cause an increase in sodium levels, which disrupts brain function and causes convulsions and anomalies in consciousness. Conversely, insufficient water excretion causes an increase in sodium levels, which causes brain edema and hypertension.[9]

The most prevalent anion found in the extracellular fluid is the chloride (Cl^-) ion.[10] Chloride ion concentrations are crucial for normal physiological functions including acid–base balance, the production of hydrochloric acid in the stomach, and the homeostasis of cellular electrolytes.[11]

Physicians frequently undervalue the significance of chloride alterations in clinical practice, although chloride is one of the key electrolytes recorded on the basic chemistry panel because it collaborates with additional electrolytes, such as sodium and potassium, to facilitate the equilibrium of acids and bases within the human body. Additionally, it facilitates the transportation of fluid into and out of cellular structures. In the event of a decrease in chloride levels, an individual can experience illness and dehydration. Elevated levels of certain substances in the body may indicate impaired renal function.[12]

The human body utilizes magnesium (Mg^{2+}) for various purposes. The mineral in challenge plays a crucial role in various physiological processes, such as muscle contraction, neuromuscular transmission, glycemic regulation, myocardial contraction, and blood pressure regulation. This is achieved through its function as a cofactor for over 300 enzymes.[13,14] Magnesium plays a crucial role in various physiological processes, including the synthesis of nuclear materials, energy generation, active transmembrane transport of ions, and bone development.[13,14] There exists a significant association between a deficiency in magnesium and a wide range of disorders. Based on a research investigation, individuals of African American and Caucasian descent with diminished levels of serum magnesium exhibited an elevated likelihood of experiencing an ischemic stroke.[15] The presence of hypomagnesemia has been associated with an elevated likelihood of developing diabetes mellitus (DM). Previous studies have demonstrated that minor deviations in electrolyte levels, specifically reduced levels of Mg^{2+}, possess the ability to serve as prognostic indicators for mortality in individuals with type 2 diabetes mellitus.[16]

Furthermore, Total cholesterol, HDL-C, LDL-C, and TG make up the typical lipid profile.[17] Cardiovascular disease risk is increased by hypercholesterolemia. Alterations in high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol, and triglyceride levels lead to dyslipidemia, which is linked to atherosclerosis.[17,18]

Electrolyte and lipid level abnormalities are frequently caused by various factors such as nutritional deficiencies, acid-base abnormalities, and medication.[3,4,18]

Obesity is a pathological state characterized by the excessive accumulation of adipose tissue in the body, resulting in detrimental health consequences. Individuals are categorized as obese if their body mass index (BMI), is calculated by dividing an individual's weight by the square of their height, ≥30 kg/m^2. The range of 25–30 kg/m^2 is designated as overweight.[19] In 2013, medical groups, such as the American Medical Association and the American Heart Association, officially designated obesity as a disease.[20,21] There have been reports indicating that obesity might have an impact on serum electrolyte levels.[20-22] Obese persons exhibit a greater incidence of electrolyte imbalance in comparison to the broader population. Obesity has been found to result in dysfunction of the Na^+/K^+–ATPase pump, leading to the occurrence of electrolyte imbalance as one of the observable outcomes of this dysfunction.[22,23] Obesity is associated with an alteration in water equilibrium, resulting in an elevation of the extracellular fluid to intracellular fluid ratio. Consequently, this results in changes in serum electrolyte levels, including sodium, chloride, potassium, and bicarbonate.[22,23]

According to research by the World Health Organization (WHO), the prevalence of overweight and obesity in the Kingdom of Saudi Arabia (KSA) is 68.2%, with women accounting for 69.2% and men accounting

for 67.5%.[24] Additionally, the report states that the prevalence of overweight and obesity among women is 33.7%, while among males it is 29.5%. A recent comprehensive study was conducted in several locations in the Kingdom of Saudi Arabia (KSA), yielding results that indicated a prevalence of obesity at 24.7%.[25] Nonetheless, this specific study group lacks evidence about the relationship between electrolyte levels and obesity. Hence, the main objective of this research was to evaluate the blood electrolyte concentrations (particularly sodium, potassium, magnesium, and chloride), along with glucose and lipid profiles, in a group of young obese Saudi female volunteers (with a BMI of 30 kg/m^2 or above) aged between 20 and 25 years. The selection of this specific age group and high body mass index (BMI) is based on a thorough examination of several interrelated factors that impact individuals, including the adoption of dietary changes that might potentially jeopardize their nutritional status and general health.[19,20] According to our knowledge, the present study is the first one that studies the relationship between serum electrolyte and lipids profile among obese young Saudi females, specifically in the Madinah region. The selection of sodium, potassium, magnesium, and chloride was based on their abundance as electrolytes and their substantial correlation with general well-being and various illnesses.

Materials and Methods

Ethics approval statement

This study was approved by the Ethical Committee at the College of Applied Medical Science, Taibah University, Madinah (SREC/AMS 2019/34/CLD). All the participants signed an informed consent.

Study population

A cross-sectional analysis was performed among females at Taibah University, Madinah, Saudi Arabia, including both students and employees with the age range of 20–25 years who had a high BMI ≥30 kg/m^2. Three hundred and fifty volunteers agreed to participate in this study. A self-administered screening questionnaire was distributed to the volunteers to exclude those who did not meet the eligibility criteria. The participants were selected using a random sampling method, with the additional requirement of having no pre-existing medical conditions and having a BMI ≥30 kg/m^2 as indicated by the provided information. Data were collected from the participants in a systematic and non-invasive manner. The study included participants who had complete data and underwent blood sample collection. The exclusion criteria encompassed individuals who had received a diagnosis of cardiovascular disease (CVD), hypertension, diabetes, endocrine diseases, renal diseases, or were undergoing hormonal or vitamin treatments, as well as pregnant women.

Blood analysis

An aliquot (3 mL) of blood samples was collected in plain tubes and 1 ml of blood in Fluoride Oxalate (Grey Top) tubes from 10-hour overnight fasting women. Fasting Plasma glucose (FPG), lipid profile, and electrolyte concentrations (Na^+, K^+, Mg^{2+}, Cl^-) were measured. The serum was obtained from blood samples by centrifuging at 3000 rpm (Centrifuge Lab Desktop Centrifuge with 12 × 10 ML Place Rotor, 110 V Variable Speed 500–4,000 RPM Benchtop Centrifuge, USA) for 5 min at 37°C and used in this study, however, 1 ml for measuring FPG was kept and analyzed by immunoassay analyzer. Serum samples were kept in a −70°C freezer until used. The lipid levels were detected using the Cobas b 311 immunoassay analyzer according to the manufacturer's instructions (Roche Diagnostics, GmbH, Germany). Total cholesterol (TC), high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C), and triglycerides (TG) were determined enzymatically. The determinations of the electrolytes (Na^+, K^+, Mg^{2+}, Cl^-) levels for the samples were performed on a Beckman D×C 600 instrument (Beckman Coulter, Brea, California, USA) based on the recommended chemicals from the same company. The reference range for parameters is obtained from the references utilized at the laboratories of Madinah Hospital in the region of Madinah, Saudi Arabia [Table 1]. The National Cholesterol Education Program[26] for lipid profile and Tietz fundamentals of clinical chemistry and molecular diagnostics-E-book[27] for electrolyte abnormalities definitions were used to subgroup the study participants in Table 1.

Statistical analysis

GraphPad Prism 7 was used to analyze the data (GraphPad Software, CA, USA). The data was evaluated for normal distribution using Kolmogorov-Smirnov and Shapiro-Wilk statistical tests. A P value larger than 0.05 indicates that the data does not statistically depart from normality. This indicates the data's normal distribution. Participants were categorized into four groups based on their electrolyte and lipid profiles [Table 1], and Quantitative data were compared between the groups using a two-way analysis of variance (two-way ANOVA). and a P value of < 0.05 was used to indicate statistical significance. Data were presented as mean ± SD. An association between BMI and electrolytes and lipids was investigated using Pearson's correlation, and the P values 0.05 and 0.001 were taken into account as statistically significant, which have been

extensively documented in numerous studies within the existing literature.

Results

Sociodemographic characteristics/variable study participants data are shown in Table 2. The total participants of the current study were 350 female individuals (BMI ≥30 kg/m^2) aged between 20 and 25 years with a mean ± SD age of 21 ± 10.3 years. Among the study subjects, the total cholesterol (TC) as mean ± SD was 5.6 ± 3.0 mmol/l, the triglycerides (TG) as mean ± SD was 3.3 ± 1.13 mmol/l, the Na^+ level as mean ± SD was 150 ± 11.13 mmol/l, the K^+ level as mean ± SD was 3.2 ± 0.95 mmol/l, and the Mg^{2+} level as mean ± SD was 0.61 ± 0.43 mmol/l, whereas the other markers were at the normal levels [Table 2].

The majority of participants in the study (n = 350), specifically 234 individuals (66.9%), exhibited normal levels of electrolytes. The study showed that 116 females (33.1%) had alterations in their electrolyte concentrations. In Table 3, the data shows that out of the 350 participants, 28.57% had hypernatremia, 2.9% had hyponatremia, 28.6% had hypokalemia, 2.8% had hyperkalemia, 30% had hypomagnesemia, 2.9% had hypermagnesemia, 2.3% had hypochloremia, and 10.8% had hyperchloremia.

Table 4 demonstrates the lipid profile levels in study subjects. Significant differences in the mean values of total cholesterol and triglycerides were observed among the subgroups that were identified based on the levels of lipids [Table 1, method section) (P = 0.04 and < 0.001, respectively). A total of 45.7% (n = 160) of the subjects exhibited borderline high levels of total cholesterol, while 2.9% (n = 10) displayed high levels. Furthermore, it is worth noting that 28.6% (n = 100) of the participants exhibited borderline high levels of triglycerides, while 14.3% (n = 50) displayed high levels [Table 4].

According to the findings shown in Table 5, there exists an association between electrolyte levels, lipid profiles, FBG, and BMI in women who are classified as obese. The total cholesterol and triglycerides were found to be directly associated with BMI (r = 0.56, P = 0.04, r = 0.55, P = 0.02, respectively). Na^+ revealed a positive association with BMI (r = 54, P = 0.03); whereas K^+ and Mg^{2+} were negatively associated (r = −0.53, P = 0.02, r = −0.54, P = 0.04, respectively) with BMI.

Table 1: Criteria of subgrouping the study participants' normal reference range for parameters

Parameters	Reference range
Fasting Plasma Glucose (FPG) (mmol/L)	3.89–5.50
Study subgrouping	Definition
Hyponatremia	Serum sodium level <135 mmol/L
Hypernatremia	Serum sodium level >145 mmol/L
Hypokalemia	Serum potassium level <3.5 mmol/L
Hyperkalemia	Serum potassium level >5.0 mmol/L
Hypochloremia	Serum chloride level <98 mmol/L)
Hyperchloremia	Serum chloride level >107 mmol/L
Hypomagnesemia	Serum magnesium level <0.66 mmol/L
Hypermagnesemia	Serum magnesium level >1.07 mmol/L
Total Cholesterol (TC)	
Normal	<5.17mmol/L
Borderline	5.17–6.20 mmol/L
High	≥6.21mmol/L
Triglycerides (TG)	
Normal	<1.70 mmol/L
Borderline High	1.70–2.25 mmol/L
High	≥5.64 mmol/L
Low-density lipoprotein (LDL-C)	
Normal	<2.59 mmol/
Borderline High	3.36–4.13 mmol/L
High	4.14–4.90 mmol/L
Very high	>4.91 mmol/L.
High-density lipoprotein (HDL-C)	
High	≥1.55 mmol/L
Low	<1.3mmol/L

The parameter reference range is derived from the benchmarks employed in the laboratories of Madinah Hospital, situated in the Madinah region of Saudi Arabia

Discussion

Obesity induces changes in several organs inside the human body. To counteract these abnormalities, the body's homeostatic mechanism operates to uphold normal physiological functioning. This regulatory process is achieved by a feedback loop involving hormones

Table 2: Characteristics of the study participants

Parameters	Total participant=350	The normal reference range
Age (years)	21±10.30	-
FPG (mmol/L)	5.40±0.67	3.89-5.50
LDL-C (mmol/L)	2.40±1.50	<2.6
HDL-C (mmol/L)	1.74±0.71	>1.55
TC (mmol/L)	5.61±3.0*	<5.1
TG (mmol/L)	**3.31±1.13***	<1.7
Na^+ (mmol/L)	**150±11.13***	135–145
K^+ (mmol/L)	**3.21±0.95***	3.5–5.0
Mg^{2+} (mmol/L)	**0.61±0.43***	0.66–1.07
Cl^- (mmol/L)	101±18.83	98–107

Values were Mean±standard errors. *Bold values were considered abnormal values. References range acquired from Madinah Hospital labs in Madinah region, Saudi Arabia. FPG=fasting plasma glucose, TC=total cholesterol, TG=triglyceride, HDL-C=high-density lipoprotein, and LDL-C=low-density lipoprotein, Na^+=sodium, K^+=potassium, Mg^{2+}=magnesium, and Cl^-=chloride

Table 3: Grouping of study participants according to electrolyte level

Parameters	Total participant=350	*P*
Alteration in all electrolyte levels	Normal=234 (66.9%) Alterations=116 (33.1%)	0.03*
Na^+ (mmol/L)=150±11.13		
Hyponatremia	132±9.11, (*n*=10) (2.9%)	0.03*
Normal	145±11.14, (*n*=240) (68.57%)	
Hypernatremia	155±10.11, (*n*=100) (28.57%)	
K^+ (mmol/L)=3.21±0.95		
Hypokalemia	3.0±0.90, (*n*=100) (28.6%)	<0.001**
Normal	3.61±0.85, (*n*=240) (68.6%)	
Hyperkalemia	5.21±1.55, (*n*=10) (2.8%)	
Mg^+ (mmol/L)=0.61±0.43		
Hypomagnesemia	0.52±0.33, (*n*=105) (30%)	<0.001**
Normal	0.67±0.23, (*n*=235) (67.14%)	
Hypermagnesemia	1.1±0.54, (*n*=10) (2.9%)	
Cl^- (mmol/L)=101±18.83		
Hypochloremia	95±12.33, (*n*=8) (2.3%)	>0.05
Normal	100±11.33, (*n*=304) (86.9%)	
Hyperchloremia	110±20.23, (*n*=38) (10.8%)	

Data were indicated as the mean±(SD) and percent within parentheses for continuous variables. *P* values obtained from two-way ANOVA were *$P \leq 0.05$, **$P \leq 0.001$

Table 4: Grouping of study participants according to lipid profiles

Parameters	Total participant=350	*P*
LDL-C (mmol/L)=2.40±1.5		
Normal	1.20±1.5, 300 (85.7%)	>0.05
Borderline high	3.31±1.7, 35 (10%)	
High	4.14±1.9, 15 (4.3%)	
HDL-C (mmol/L)=1.74±0.71		
High	2.37±0.71, 330 (94.3%)	>0.05
Low	1.1±0.51, 20 (5.7%)	
TC (mmol/L)=5.60±3.0		
Normal	5.41±3.01, 180 (51.4%)	0.04*
Borderline high	6.21±2.11, 160 (45.7%)	
High	6.91±2.71, 10 (2.9%)	
TG (mmol/L)=3.31±1.13		
Normal	2.41±0.73, 200 (57.1%)	<0.001**
Borderline high	5.71±1.23, 100 (28.6%)	
High	1.61±0.53, 50 (14.3%)	

Data were indicated as the mean ± (SD) and percent change in parentheses for continuous variables, *P* value obtained from one-way ANOVA. *$P \leq 0.05$, **$P \leq 0.001$. TC=total cholesterol, TG=triglyceride, HDL-C=high density lipoprotein, and LDL-C=low-density lipoprotein

and multiple organ systems. The body maintains the balance of fluid and electrolytes through the process of homeostasis. The development of cardiovascular disease and metabolic acidosis can occur due to an imbalance in serum electrolytes in obese persons. The individuals involved in this study exhibited modifications in their electrolyte concentrations. In the study, it was found that 28.57% (*n* = 100) of the subjects exhibited hypernatremia, 2.9% (*n* = 10) had hyponatremia, 28.6% (*n* = 100) had hypokalemia, 2.8% (*n* = 10) showed hyperkalemia, 30% (*n* = 105) were diagnosed with hypomagnesemia, and 2.9% (*n* = 10) exhibited hypermagnesemia. Approximately 45.7% (*n* = 160) of the participants had borderline high total cholesterol readings, while 2.9% (*n* = 10) demonstrated high levels of cholesterol. 28.6% of participants (*n* = 100) had borderline high triglyceride levels, while a significant proportion (14.3%, *n* = 50) displayed triglyceride values classified as high.

First, the fact that 28.57% of current study individuals had hypernatremia is important because it suggests that even small increases in the amount of sodium in the blood may make the serious effects on the heart worse.[28,29] Having a high sodium intake is associated with an increased chance of hypertension and cardiovascular illness.[30,31] Small but persistent elevations in serum sodium have been seen in response to increased salt consumption over the course of several days in randomized controlled studies.[28-32] Previous investigations have demonstrated a positive relationship between serum sodium and blood pressure.[33-35] It has been hypothesized that a rise in serum sodium causes a rise in blood pressure by increasing the amount of extracellular fluid in the body (by promoting thirst and antidiuresis). Blood pressure is positively correlated with serum sodium regardless of extracellular volume status, as shown in some previous studies carried out by He, Aburto, and Adrogué, *et al*., studies.[36-38] However, in the present investigation, the blood pressure was not assessed.

Further data from animal and *in vitro* research indicates that serum sodium content directly affects the blood arteries. Elevated levels of sodium in the bloodstream cause the vascular endothelium to become rigid by inhibiting the synthesis of nitric oxide and promoting the enlargement of vascular smooth muscle cells.[38]

Second, hypokalemia was present in 28.6% of individuals, which is a significant percentage. The most prevalent cation in the human organism is the potassium ion. Potassium in the interstitial space is tightly regulated by uptake from the environment, transfer within the body, and elimination through the kidneys.[36-38] About 90% of the potassium consumed by an average individual is taken and excreted by the kidneys. A meta-analysis study carried out on randomized controlled studies revealed that raising potassium consumption lowered blood pressure in adults by 3.49 mmHg on the systolic side and 1.96 mmHg on the diastolic side.[36-38] Adrogué *et al*. (2007) found a correlation between high sodium

Table 5: The correlations between BMI and electrolytes and lipids

Parameter	BMI (≥30 kg/m^2)	
	r	*P*
FPG (mmol/L)	0.53	0.04*
LDL-C (mmol/L)	0.13	0.07
HDL-C (mmol/L)	0.15	0.06
TC (mmol/L)	0.56	0.04*
TG (mmol/L)	0.55	0.02*
Na^+ (mmol/L)	0.54	0.03*
K^+ (mmol/L)	-0.53	0.02*
Mg^{2+} (mmol/L)	-0.54	0.04*
Cl^- (mmol/L)	0.13	0. 06

P-values were obtained from Pearson's correlation; Starred values point to a significant level *$P \leq 0.05$, **$P \leq 0.00$. FPG=Fasting Plasma glucose, TC=total cholesterol, TG=triglyceride, HDL-C=high density lipoprotein, and LDL-C=low density lipoprotein, Na^+=sodium, K^+=potassium, Mg^{2+}=magnesium, Cl^-=chloride

intake and poor potassium intake and the development of hypertension.[38] In this study, the relationship between blood sodium and serum potassium amounts and BP ranges in both genders. The overall figures indicate that both men's and women's serum Na levels increased, and their serum potassium levels decreased as their blood pressure increased. Evidence suggests that the interplay between sodium and potassium ions is crucial to the onset of hypertension via several different processes.[36-38] Blood potassium and sodium levels may rise in response to an increase in both nutrients consumed through food.[36-38] Even though some studies suggest that the ratio of sodium to potassium is more essential than either electrolyte alone, greater potassium consumption may be the method by which serum potassium lowers blood pressure. Additionally, it is thought that potassium ions can cause peripheral resistance to be lowered, thereby affecting blood pressure.[36-38] This is achieved by relaxing the smooth muscles that line the blood vessels. Consequently, changing people's lifestyles and raising awareness about the link between increased sodium and hypertension and its consequences may go a long way toward preventing this disease.

The third noteworthy result was that 30% of participants in this study had hypomagnesemia. The role of magnesium in human physiology is broad and essential. Magnesium is essential for a wide range of cellular processes, including those involving ATP production, kinases, ion channels, neuromuscular excitability, cell permeability, regulation of ion channels, mitochondrial function, cellular proliferation, apoptosis, and immunity.[37,38] Remarkably, hypomagnesemia has received less attention in the medical literature than hyponatremia, hypokalemia, and hypocalcemia, given that magnesium is the second most abundant intracellular cation and the fourth most abundant extracellular cation in the body. Additionally, atrial and ventricular arrhythmias, heightened sensitivity to digoxin toxicity, and sudden death can all result from hypomagnesemia and its associated hypokalemia. Alterations in glucose homeostasis, hypertension, atherosclerosis, osteoporosis, and other end-organ damage are some of the long-term adverse complications associated with hypomagnesemia.[38,39] Since a chronic hypomagnesemia state has been associated with a variety of micro- and macrovascular complications, it is advised to increase magnesium intake through diet and/or supplementation.

The most important and conclusive finding was that most of the individuals who participated in the study had slightly high levels of triglycerides and cholesterol. The typical lipid profile consists of total cholesterol, HDL-C, LDL-C, and TG.[17] It is used as a screening tool to determine the risk of CVD. According to recommendations made by the National Institutes of Health, an individual's lipid profile should be measured while they are fasting once every five years.[18] The presence of hypercholesterolemia is associated with an increased risk of cardiovascular disease. Dyslipidemia is caused by changes in a number of lipid levels, including high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total cholesterol, and triglyceride levels. It is common knowledge that atherosclerosis and dyslipidemia are fundamentally linked to one another.[17,18] In addition, our current study revealed that blood glucose was directly related to total cholesterol and triglycerides. The association between dyslipidemia and type 2 diabetes has only been established lately. Higher triglyceride (TG) levels were found to be significantly associated with the onset of diabetes in a large prospective study of middle-aged adults in the United States.[36-38] High levels of total cholesterol (TC) and triglycerides (TG) were identified as independent risk factors for the onset of type 2 diabetes in a Korean population cohort study.[36-38]

There is a consensus throughout the scientific and clinical communities that obesity represents a significant public health concern in the current century. The global prevalence of obesity has exhibited a notable increase in recent decades, irrespective of factors such as gender, age, and the level of development of a nation. Obesity, as defined by a body mass index (BMI) equal to or more than 30 kg/m^2, is consistently and significantly associated with an increased risk of developing cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), and death due to CVD. The relationship between the propensity for obesity and the atypical levels of sodium,

potassium, calcium, phosphate, and iron is a topic of significant relevance, particularly in populations such as Saudi Arabia. However, this area of research remains largely unexplored. According to reports, a significant proportion of the global population experiences obesity and its associated health issues, including hypertension and renal failure. These disorders are directly linked to the intracellular concentrations of electrolytes in affected individuals.[40,41] In addition, it is worth noting that various populations exhibit distinct dietary patterns. Specifically, Saudi individuals are recognized for their elevated intake of high-calorie foods that are abundant in sodium and deficient in potassium.[42,43] Therefore, the investigation of the relationship between blood electrolytes, specifically sodium and potassium, and obesity outcomes has significant importance in the field of public health. Many possible processes might potentially contribute to the observed association between obesity and electrolyte concentrations. Several studies have revealed a potential association between elevated sodium levels and reduced potassium levels and obesity, maybe due to an increase in calorie consumption. As a result, the correlation between sodium and obesity has primarily been acknowledged as being attributed to indirect downstream processes that are associated with increased calorie consumption. Nevertheless, some research has presented contrasting findings, indicating that the association between sodium levels and obesity indices is unaffected by caloric intake.[44,45] An alternative mechanism indicated by previous research suggests that an elevated sodium level may lead to the deposition of adipose tissue and disrupt lipid balance inside the body. For example, a higher accumulation of adipocytes was reported in rats who were fed a high-salt diet compared to the control group that received an equivalent diet. Additionally, another study documented an increased absorption of glucose and the accumulation of lipids inside adipose tissue in rats that were fed a high-sodium diet.[46,47] It is important to acknowledge that our study aligns with the findings of previous studies conducted on diverse groups. Consequently, obese people must undergo routine assessments of their blood electrolyte levels to prevent potential renal and cardiac issues.

In addition to implementing routine screenings for glucose, electrolytes, and lipids to reduce the risk of dyslipidemia, diabetes, and cardiovascular disease in young obese females, it is important to take into account the findings of this study to implement an appropriate educational program to change the lifestyles of young obese females and to raise awareness about the relationship between electrolytes and lipids and the risk of disease.

The present study encountered several limitations

The cross-sectional design of the study prevented the establishment of a cause-and-effect relationship. The availability of data was constrained to a solitary measurement of serum. However, our study was the inaugural attempt to evaluate the occurrence of different electrolyte irregularities among young obese Saudi females, serving as the principal aim of this research article. To effectively support the adoption of regular blood screenings as a significant intervention, it is imperative to utilize larger sample sizes and undertake investigations that encompass data collection from diverse sources. Additional research is necessary to assess the potential vulnerability of individuals with diabetes to the onset of complications associated with blood pressure and renal function. The present study encountered a constraint in terms of sample size when assessing the prevalence of electrolyte abnormalities. Consequently, forthcoming studies with more extensive sample sizes must corroborate our findings.

Conclusion

Saudi young females with obesity exhibit significantly elevated levels of cholesterol and triglycerides, along with increased sodium levels and reduced levels of potassium and magnesium. This study proposes that there is a need to target educational campaigns toward young females to enhance their understanding of the potential health implications related to alterations in lipid and electrolyte levels, as well as the diseases that can arise as a result of such changes, including diabetes and cardiovascular disease. The elevated sodium levels could be indicative of excessive salt intake or altered renal function, both of which are associated with higher blood pressure. The reduced potassium levels may further exacerbate cardiovascular risks, as potassium is essential for maintaining normal heart function and counteracting the effects of sodium on blood pressure. Increased triglycerides and cholesterol levels are well-known markers for cardiovascular risk, signaling a potential predisposition to atherosclerosis and other lipid-related disorders. This lipid profile suggests that these young females might be at an elevated risk for early onset of cardiovascular diseases.

The institution should strive to enhance its health promotion endeavors by fostering an environment that fosters therapeutic lifestyle modifications, encompassing weight management, heightened physical activity, and alterations in one's eating habits. A substantial emphasis in dietary recommendations for young females should be placed on reducing the consumption of foods that are rich in cholesterol, saturated fat, and sodium.

Author contributions

SM (The 1st author): Manuscript writing (Introduction, Methodology, Discussion). WM (Co-author): Laboratory work, Data entry, statistical analysis, writing part of the introduction, methodology, the result, and discussion sections. All authors read and approved the final manuscript.

Ethics approval statement

This study was approved by the Ethical Committee at the College of Applied Medical Science, Taibah University, Madinah (SREC/AMS 2019/34/CLD). All the participants signed an informed consent.

Informed consent statement

Participants must provide consent to participate in the study experiment, and their involvement is entirely optional. Every participant provided their signature on the informed consent document.

Declaration of Helsinki

The study was conducted according to the principles of the Helsinki Declaration.

Data availability statements

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Conflicts of interest

There are no conflicts of interest.

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