World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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Assessment of serum electrolytes levels of obese individuals in Enugu southeastern, Nigeria

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World Journal of Advanced Research and Reviews, 2023, 19(01), 934–941

Publication history: Received on 30 May 2023; revised on 12 July 2023; accepted on 14 July 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.19.1.1342

Abstract

Objective: Obesity is a public health disorder characterized by an excessive accumulation of fat by affected individuals. The excess fat leads to degradation in a lot of body organs and functions. This study assessed the serum electrolytes levels of obese individuals in Enugu, Nigeria.

Methods: Ninety subjects of ages 20–65 years were recruited for this cross sectional study with thirty three obese subjects as test while controls were thirty overweight and twenty-seven normal weight subjects. Anthropometric indices were measured and body mass index (BMI) calculated. 5mls of blood was collected from each participant for the determination of serum electrolytes by ion selective electrode method, using a sensa core electrolyte analyser. Data was analysed using statistical package for the social sciences (SPSS) version 25 and results express as mean ± SD.

Results: The result shows a significant increase ($P < 0.05$) in mean ± SD of systolic blood pressure (SBP) (136.87 ± 17.47, 121.65 ± 14.06, 117.82 ± 6.42), diastolic blood pressure (DBP) (78.91 ± 8.83, 72.80 ± 8.40, 71.58 ± 7.80), BMI (33.09 ± 3.87, 27.62 ± 1.33, 21.55 ± 1.80), Sodium(Na^+) (144.08 ± 1.75, 142.50 ± 3.05, 139.11 ± 2.17) and a significant decrease ($P < 0.05$) of potassium(K^+) (3.91 ± 0.42, 4.07 ± 0.24, 4.33 ± 0.35) in the test and control subjects respectively. There exist positive correlations between SBP vs DBP, SBP vs Na^+, DBP vs Na^+ and a negative correlation between SBP vs K^+, DBP vs K^+, Na^+ vs K^+ in the test subjects.

Conclusion: This study suggests that Obesity predisposes an individual to electrolyte variations, hence, the need for regular electrolytes assessment in obese individuals to avert Kidney and Cardiac complications.

Keywords: Obesity; Serum electrolytes; Blood pressure; Enugu; Electrolyte variations

1. Introduction

Obesity is a medical condition in which excess body fat has accumulated to such an extent that it has a negative effect on health. People are classified as obese when their body mass index (BMI), a measurement obtained by dividing a

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person's weight by the square of the person's height is over 30 kg/m^2; the range 25–30 kg/m^2 is defined as overweight [1, 2]

Obesity was classified as a disease condition in 2013 by several medical societies, including the American Medical Association and the American Heart Association [3, 4]. In Africa, 18.4% of women and 7.8% of men on the continent live with obesity up from 12% and 4.1%, respectively in 2000. An indication of an upward trend in the rate of obesity [1, 5].

The prevalence of overweight and obese individuals in Nigeria is of epidemic proportions with 20.3%-35.1% overweight while 8.1%-22.2% was obese [6].

In 2020, it was estimated that there were 21 million and 12 million overweight and obese persons in the Nigerian population aged 15 years or more, with an age adjusted prevalence of 20.3% and 11.6% respectively. Obesity and overweight were also found to be higher among urban dwellers (14.4% and 27.2%) compared to rural dwellers (12.1% and 16.4%). [7]. Obesity has individual, socioeconomic, and environmental causes. Some of the known causes are diet, physical inactivity, automation, urbanization, genetic susceptibility, medications, mental disorders, economic policies, endocrine disorders, and exposure to endocrine-disrupting chemicals [1, 6-7]. In Nigeria, nutritional and epidemiological transitions driven by demographic changes, rising income, urbanization, unhealthy lifestyles and consumption of highly processed diets are among the leading contributors to overweight and obesity [8- 9]. In fact, the burden has extended to younger population age groups in the country with about 9% of children aged 5-9 years estimated to be obese or overweight [9-10]. Obesity and overweight are strongly linked with several cardio-metabolic disorders including high blood pressure, high blood glucose, insulin resistance, high blood cholesterols, coronary heart disease, stroke and cancers [7, 10 -13].

Obesity has also been reported to affect serum electrolytes. There is a higher prevalence of electrolyte imbalance in obese individuals compared to the general population. Obesity causes impairment in the Na+/K+-ATPase pump with electrolyte imbalance one of the manifestations of this impairment [11, 14]. Electrolytes such as sodium (Na+), potassium (K+), chloride (Cl-), and bicarbonate (HCO3-) play various vital roles in the body and are required for the optimal functioning of cells and organs [15-16]. Sodium is one of the major cations and functions in regulating the total amount of water in the body [14, 17]. It also plays a vital role in electrical communication in many systems, especially the nervous and muscular systems. However, potassium is responsible for regulating heartbeat and muscle function and is important for the overall functioning of the cell [18-19]. Chloride helps maintain a normal balance of body fluids [15]. Bicarbonate, on the other hand, plays a role in maintaining the blood pH levels, that is, acid-base balance [20]. Disturbances in these electrolytes pose a threat to the normal functioning of the cell. Disturbances, such as an increase or decrease in these electrolytes can lead to detrimental effects [21].

Sympathetic nervous system (SNS) over activity, especially in the kidneys, is an important mechanism linking obesity to hypertension. Some adipokine play important roles in elevating blood pressure [10]. Hyperinsulinemia caused by insulin resistance stimulates sodium reabsorption, enhances sodium retention and increases circulating plasma volume [22]. Hyperinsulinemia also stimulates both the renin-angiotensin-aldosterone system (RAAS) and the SNS, resulting in the acceleration of atherosclerosis through the hypertrophy of vascular smooth muscle cells, which contributes to increased peripheral vascular resistance [23]. Obesity is associated with increased RAAS activity despite volume overload, as the tissue RAASs are stimulated in obese hypertensive individuals [23].

Serum electrolytes such as sodium, potassium, chloride and bicarbonate are critical in allowing cells to generate energy, maintain the stability of their walls, and to function in general. They generate electricity, contract muscles, move water and fluids within the body, and participate in myriad other activities. [15-16]. Low levels of serum electrolytes can lead to seizures, weakness, abnormal heart rhythms, paralysis, coma and death in extreme cases. Cardiovascular disease and metabolic acidosis can be developed as a result of the imbalance in serum electrolytes [14]. Obesity causes a disturbance in water balance leading to an increase in the ratio of the extracellular fluid to the intracellular fluid. This subsequently leads to a decrease in serum electrolytes such as sodium, chloride, potassium and bicarbonate. Patients with severe obesity had serum sodium concentrations below or in the lower reference range [14]. There is paucity of information in this study population on the relationship between electrolytes levels and obesity, hence, this study aimed at filling this knowledge gaps.

2. Materials and methods

2.1. Study Design/Selection

This cross sectional study involved a total number of ninety (90) adult human volunteers aged (20-65 years) from Enugu metropolis. The study comprised of thirty-three (33) obese individuals as test subjects and thirty (30) overweight, twenty-seven (27) normal weight individuals as control subjects. Informed consent was obtained from each participant. Questionnaires were distributed and duly filled by the participants before commencement of the study.

2.2. Inclusion and Exclusion Criteria

2.2.1. Inclusion criteria for test group

Apparently healthy subjects with BMI of 30kg/m^2 and above, ages 20 - 65 years old

2.2.2. Inclusion criteria for control group

Apparently healthy subjects with BMI of 18.5 to 24.9Kg/m^2 and 25 to 29.9Kg/m^2 for Normal weight and overweight subjects respectively, ages 20 - 65 years old

2.2.3. Exclusion Criteria for both test and control groups

Subjects with presence of dehydration or over hydration. Individuals on diuretic therapy, pregnant women and hypertensive subjects.

2.3. Ethical Considerations and Informed Consents

Ethical approval was duly obtained from the ethics committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu with Ref no: UNTH/HREC/2021/02/44. Written consent of willingness to participate in the study as subject was obtained from all the participants.

2.4. Anthropometric Measurements

2.4.1. Measurements of Body Mass Index (BMI)

The weight, height and BMI of the respondents were recorded. A digital weighing scale (HELMSON) was used to measure the body weight (kg). A stadiometer was used to measure height (m); and the BMI was calculated by dividing the weight (kg) by the square of height (m^2).

2.4.2. Measurements of Blood Pressure (BP)

A standardized automatic BP monitor (ANDON MODEL KD-595) was used to take the blood pressure measurements in two readings after the participants have been sat undisturbed for a minimum of five minutes and the average record was used.

2.5. Sampling Techniques

Venous blood was collected into appropriately labelled five millilitres (5mls) plain tube. Sample was allowed to clot and retract, centrifuged at 5,000 rpm and the supernatant (serum) was separated into another labelled vial and stored at -20^{0}C until analysed, and the analyses were carried out within 48 hours of collection. All analysis of the samples was done by the researchers at the laboratory of University of Nigeria Teaching Hospital Ituku-Ozalla Enugu.

2.6. Biochemical Analysis

Serum electrolytes: Sodium, potassium, chloride and bicarbonate were all estimated on each collected sample.

2.6.1. Serum electrolyte estimation

Estimation was done using sensa core ST- 100B electrolyte analyser, with the manufacturer's instructions duly followed.

2.7. Data Analysis

Data obtained from this study were analysed using the statistical package for social sciences (SPSS) for Windows Inc. Chicago, IL, USA. Student's independent T-test was used to calculate the difference between means and correlations were also done in all parameters. Results were recorded as mean ± standard deviation. P-value <0.05 was considered statistically significant.

3. Results

Table 1: Shows the anthropometric parameters of obese, overweight and normal weight subjects. The result from the table shows a significant difference ($P < 0.05$) in the mean ± standard deviation of systolic blood pressure (136.87 ± 17.47, 121.65 ± 14.06, 117.82 ± 6.42), diastolic blood pressure (78.91 ± 8.83, 72.80 ± 8.40, 71.58 ± 7.80) and BMI (33.09 ± 3.87, 27.62 ± 1.33, 21.55 ± 1.80) of obese, overweight and normal weight subjects respectively.

Table 1 Anthropometric parameters of obese, overweight and normal weight subjects

Groups	**Systolic blood pressure (mmHg)**	**Diastolic blood pressure (mmHg)**	**BMI (Kg/m^2**
Obese subjects N= 33	136.86 ± 17.47	78.91± 8.83	33.09 ± 3.87
Overweight subjects N= 30	121.65 ± 14. 06	72.80 ± 8.40	27.62 ± 1.33
Normal weight subjects N= 27	117.82 ± 6.42	71.58 ± 7.80	21.55 ± 1.80
F- ratio	10.808	4.554	89.353
P- value	0.000*	0.015*	0.000*

Values are given as mean ± standard deviation; * = significant values

Table 2 shows the electrolyte levels in Obese, Overweight and normal weight subjects. The result shows a significant difference ($P < 0.05$**)** in the mean ± standard deviation of Sodium (144.08 ± 1.75**,** 142.50 ± 3.05, 139.11 ± 2.17) and potassium (3.91 ± 0.42, 4.07 ± 0.24, 4.33 ± 0.35) of obese, overweight and normal weight subjects respectively. There was a non- significant difference ($P > 0.05$) in the mean ± standard deviation of Chloride (100.73 ± 1.71, 100.75 ± 3.16, 100.70 ± 1.57) and bicarbonate (23.69 ± 1.39, 24.15 ± 1.63, 23.52 ± 1.90) of obese, overweight and normal weight subjects respectively.

Table 2 Serum electrolytes levels in obese, overweight and normal weight subjects

Groups	**Sodium (Na^+) (mmol/l)**	**Potassium ($K^{+)}$ (mmol/l)**	**Chloride ($Cl^{-)}$ (mmol/l)**	**Bicarbonate (HCO_3^-) (mmol/l)**
Obese subjects N =33	144.08 ± 1.75	3.91 ± 0.42	100.73 ± 1.71	23.69 ± 1.39
Overweight subjects N= 30	142.50 ± 3.05	4.07 ± 0.24	100.75± 3.16	24.15 ± 1.63
Normal weight subjects N= 27	139.11 ± 2.17	4.33 ± 0.35	100.70 ± 1.57	23.52 ± 1.90
F-ratio	21.785	6.932	0.002	0.741
P-value	0.000*	0.002*	0.998	0.481

Values are given as mean ± standard deviation; * = significant values

Table 3 shows the relationship between the BMI, SBP, DBP, Sodium ion (Na^+), potassium ion (K+), chloride and bicarbonate in obese subjects. There exist positive significant correlations ($P < 0.05$) in SBP vs DBP, SBP vs Na^+ and diastolic blood pressure vs sodium. There is also a negative significant correlation ($P < 0.05$) in SBP vs $K^{+,}$ DBP vs K^+ and sodium vs potassium, while there was no significant correlation between the other parameters ($P > 0.05$).

Table 4 shows the gender differences in BMI, Systolic and Diastolic blood pressures, sodium, potassium, chloride and bicarbonate in obese subjects. The result shows no significant difference ($P > 0.05$) in all the parameters among the male and female subjects.

Table 3 Relationship between BMI, SBP, DBP, Na^+, K^+, CL^-, HCO_3^- in obese subjects

Parameters N =33	r (Pearson)	P – values
SBP vs DBP	0.512	0.013*
SBP vs Na^+	0.563	0.005**
SBP vs K^+	-0.511	0.013*
SBP vs CL^-	0.085	0.698
SBP vs HCO_3^-	0.198	0.366
SBP vs BMI	0.165	0.451
DBP vs Na^+	0.575	0.004**
DBP vs K^+	- 0.654	0.001**
DBP vs CL^-	0.305	0.157
DBP vs HCO_3^-	0.235	0.281
DBP vs BMI	0.029	0.894
Na^+ vs K^+	- 0.605	0.002**
Na^+ vs CL^-	0.250	0.250
Na^+ vs HCO_3^-	- 0.119	0.590
Na^+ vs BMI	0.098	0.655
K^+ vs CL^-	- 0.410	0.052
K^+ vs HCO_3^-	0.136	0.536
K^+ vs BMI	- 0.092	0.677
CL^- vs HCO_3^-	- 0.073	0.741
CL^- vs BMI	0.185	0.398
HCO_3^- vs BMI	0.229	0.294

* correlation is significant at 0.05; ** correlation is significant at 0.01

Table 4 Gender differences in BMI, SBP, DBP, Na^+, K^+, CL^-, HCO_3^- in obese subjects

Groups	BMI (kg/m^2)	SBP (mmHg)	DBP (mmHg)	Na^+ (mmol/l)	K^+ (mmol/l)	CL^- (mmol/l)	HCO_3^- (mmol/l)
Male Subjects N = 10	32.54 ± 1.59	146.60 ± 22.71	82.80 ± 6.57	145.40 ± 2.19	3.7 ± 0.41	100.0 ± 1.87	23.40 ± 0.89
Female Subjects N = 23	33.33 ± 3.17	137.20 ± 16.54	80.60 ± 12.40	144.00 ± 1.87	4.0 ± 0.57	102.20 ± 0.45	23.20 ± 0.45
T- statistic	- 0.466	1.590	0.460	2.064	2.123	2.557	0.535
P- value	0.666	0.187	0.669	0.108	0.101	0.063	0.621

4. Discussion

Obesity causes alterations in some organs of the body, the body's homeostatic mechanism acts to maintain normal physiologic function and in essence control these alterations through the feedback mechanism, hormones and many organ systems in the body [10-12]. Fluid and electrolytes are regulated in the body through homeostasis. Cardiovascular disease and metabolic acidosis can be developed as a result of the imbalance in serum electrolytes [14]. This study in table 1 shows that Obese and overweight individuals had an increased blood pressure compared with normal weight individuals ($P < 0.05$). Both the systolic and diastolic blood pressure of Obese and overweight individuals were progressively increased from that of normal weight individuals with the average obese population being hypertensive while the average overweight individuals had elevated blood pressure. This is likely as a result of increased visceral adiposity where excess fat accumulate within and around the kidney causing physical compression of the kidney. The activation of the renin angiotensin aldosterone system as well as sympathetic nervous system activation due to the excess fat also leads to an increased blood pressure. This finding agrees with previous studies by [23-25], where Obesity induced hyperinsulinemia were found to stimulate sodium reabsorption, retention and over increase in circulating plasma volume, while stimulating the renin angiotensin aldosterone system and over activity of the sympathetic nervous system which results in acceleration of atherosclerosis through the hypertrophy of vascular smooth muscles.

The result presented in table 2, showed a significant progressive increase ($P < 0.05$) in serum sodium levels of normal weight, overweight and obese individuals although the increase remained within the normal range. This could be attributed to the increased reabsorption and retention of sodium caused by obesity induced hyperinsulinemia [7, 23]. This finding is in agreement with the previous study by [7] but not in line with the study by [14] who reported a lower serum sodium concentration among obese patients. Furthermore, serum potassium levels showed a gradual decrease from normal weight to overweight and lastly to obese individuals ($P < 0.05$). This was attributed to the increased activity of aldosterone which has been reported to cause an increase in potassium secretion at the distal convoluted tubule [26] as well as the increase in the ratio of the extracellular fluid to the intracellular fluid and just like serum sodium level; this decrease was also maintained within the normal range. No significant difference was found between chloride and bicarbonate serum levels between the two groups ($P > 0.05$).

This study also assessed the relationship between the different parameters in the obese individuals. There exist a significant ($P< 0.05$) positive correlation between SBP vs DBP, SBP vs Na^+ and DBP vs Na^+ while a negative correlation ($P< 0.05$) existed in SBP vs K^+, DBP vs K^+ and Na^+ vs K^+. This showed that an independent increase in systolic blood pressure in obese Individuals was associated with an increase in diastolic blood pressure, sodium and in diastolic blood pressure vs sodium levels. Again an independent decrease in potassium was associated with an increase in systolic blood pressure, diastolic blood pressure and sodium. This finding is in line with previous studies by [23, 27] where increase in sodium level was associated with subsequent increases in systolic blood pressure and diastolic blood pressure and also with the work of Reyhane *et al* [28], who reported a positive correlation between electrolytes and BMI.

This study also assessed the gender differences in electrolytes parameters (table 4) among the obese individuals and found that there exist no variations between the male and female electrolytes levels in obese individuals. This implies that these parameters are not influenced by gender.

5. Conclusion

This study observed that there were increased serum sodium levels and decreased serum potassium levels in obese individuals when compared to overweight and normal weight subjects. It also showed that the serum electrolytes levels of obese individuals are not gender dependent. Again, this study also observed that systolic blood pressure and diastolic blood pressure were significantly raised in obese individual when compared to both overweight and normal weight individuals. The study then concludes that there were variations in some electrolytes levels and both systolic and diastolic blood pressure in obese subjects compared to the normal subjects. Therefore, Obesity predisposes an individual to electrolyte variations; hence, obese individuals need regular evaluation of their serum electrolytes to avert kidney and cardiac complications.

Compliance with ethical standards

Acknowledgements

The authors wish to appreciate all the participants and everyone who contributed in any way to the success of this research work.

Disclosure of conflict of interests

The authors declare no conflict of interest, financial or otherwise.

Statement of ethical approval

Ethical approval was duly obtained from the ethics committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu with Ref no: UNTH/HREC/2021/02/44.

Statement of informed consent

Informed consent was obtained from all participants in this study before commencement.

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