Evaluation of Magnesium and Potassium levels in Diabetic and Hypertensive subjects attending Federal Medical Centre, Keffi-Nigeria.

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***Abstract*: Diabetes and hypertension are diseases that affect people all over the world. This study was carried out at the Department of Medical Out-Patient of Federal Medical Centre, Keffi. It was aimed at assessing the Magnesium (Mg) and Potassium (K) levels in the blood of diabetics and hypertensive patients respectively. Magnesium and Potassium were determined using test kits produced by Teco diagnostics (USA). Blood samples were collected by venous puncture from one hundred and twenty (120) patients evenly distributed among Diabetic and hypertensive patients on gender basis. The result showed a low level of magnesium in diabetic patients in a range of 0.40-0.00mmol/l to the expected magnesium concentration range of 1.3-2.5mmol/l. The potassium level in hypertensive was within the normal range of 3.25- 1.55mmol/l compared to the expected concentration range (3.40-5.30mmol/l). This study showed high level of deficiency of magnesium in diabetics but normal level of potassium in hypertensive individuals. Though, further studies using larger sample size is advocated to substantiate these findings, magnesium potassium aspartate should be included in the supplements or fortified foods from time to time to increase the amount of magnesium and potassium intake of patients. Importantly, Health care providers should consider monitoring serum magnesium levels periodically in patients especially the elderly to provide medical assistance where necessary.**

***Key words*: Diabetic, hypertensive, serum concentration, magnesium, potassium**

I. INTRODUCTION

Statistical evaluation on diabetes mellitus and hypertension worldwide continue to soar high up to what could be termed as an epidemic situation. It is fair to say that they are part of the most common chronic diseases around the globe as they are usually accompanied with health complications (WHO, 2017).

Diabetes mellitus is a disease of abnormality in glucose metabolism involving the destruction of alpha and beta cells of the pancreas resulting to the type 1 and 2 respectively. It is a chronic metabolic disease that is characterized by elevated levels of blood glucose, which can result **in** damage to the heart, blood vessels, eyes, kidneys and nerves. The danger is that diabetes mellitus can progress to **life-threatening** complications (Sunday *et al*., 2022).

Hypertension, also known as high blood pressure is a cardiac medical condition in which the systematic arterial blood pressure is elevated (Carrtero and Oparil, 2000). Hypertension can be caused by heredity and a variety of medical conditions such as kidney disease. Tobacco products **that contain** nicotine also **increase** blood pressure. Heavier alcohol consumption exceeding 2 drinks per day increased the risk of developing hypertension in both women and men (Howard *et al.,* 2008). Studies have shown that diabetes and hypertension are diseases that affect people of different ages and sexes worldwide (WHO, 2017).

Experimental models of hypertension have been associated with reduced serum and tissue levels of magnesium. In spontaneously hypertensive rats (SHRs), increase of blood pressure arises from the age of young adults, around 12 to 16 weeks of life, being attributed to a genetic component similar to human essential hypertension (J´unior *et al*., 2001). Magnesium deficiency (hypomagnesemia) has been shown to be associated with diabetes. When it comes to Mg and CKD, many questions remain unanswered. Even though there are reports of renal function deterioration being recognized as a regular prerequisite for hypermagnesemia development (because of the high adaptability of Mg renal excretion), serum levels should be maintained within the normal values in stages 1–3 of CKD, secondary to the increase in fractional excretion of magnesium. As renal function declines beyond this threshold, the increased fraction excretion can no longer compensate, and hypermagnesemia is frequently noted in patients with a creatinine clearance <10 mL/min/1.73 m^2 (Cunningham *et al.,* 2012). Magnesium deficiency results from insufficient intake of the recommended daily allowance for magnesium. Furthermore, Magnesium deficiency results in impaired insulin secretion action while magnesium replacement restores its functions.

Hypertension is also known as high blood pressure. It is a medical condition involving the heart, in which the systematic arterial blood pressure is elevated (Carrtero and Oparil, 2000).

In view of the importance of these two ions in relation to glucose metabolism and heart function, it has become necessary to evaluate the concentrations of Magnesium and Potassium ion levels in Diabetic and Hypertensive patients undergoing medical treatment at the Federal Medical Centre Keffi, Nasarawa State, Nigeria.

II. MATERIALS AND METHODS

Sample collection

Ahead of sample collection, ethical clearance was obtained from the ethics committee of the hospital while individuals provided written consent to participate in the study. A total of 120 samples were collected from diabetic and hypertensive patients of the Medical **Out-Patient** Department of Federal Medical Centre, Keffi. Sixty (60) samples were collected from diabetic and hypertensive patients respectively. The samples were equally distributed among the gender. The Study population included individuals of different age brackets (≥18) and gender (male and female) diagnosed with diabetes and hypertension.

Magnesium forms a complex with Cal-migrate in alkaline medium to produce a red complex that is measured spectrophotometrically at a wavelength of 530 nm. The colour produced is proportional to the magnesium concentration within the expected range of 1.3 – 2.5mmol/l.

The amount of potassium was determined by using sodium tetraphenylboron in a specifically prepared mixture to produce a colloidal suspension. The turbidity is proportional to the potassium concentration within the expected range of 3.40 – 5.30mmol/l. (Rastegar, 1990)

Magnesium and Potassium test kits produced by Teco diagnostics (USA) were used. The procedure for both tests is the same. The samples were spun using a centrifuge in order to obtain the serum content of the whole blood. Working reagent was prepared by adding 10ml of colour reagents to 1ml of buffer reagent in a disposable plastic container. Three test tubes labeled reagent bank, standard and sample were set up. 1000µL of the working reagent was added to each of the test tubes. 10µL of magnesium standard, serum and water were added to the test tubes labeled standard, sample and blank respectively. The tubes were properly mixed by shaking and the solutions were incubated for five (5) minutes at room temperature. The absorbance of the reagent blank was taken followed by that of the standard and lastly the sample.

The concentrations of the ions were then calculated thus;

Abs of unknown ÷ Abs of standard × concentration of standard

Where: Abs= absorbance, Concentration of standard= 2 mM

III. RESULTS AND DISCUSSION

Results

Magnesium concentrations in Male Diabetic patients

The results of the Magnesium ion concentrations in male patients across different age range is presented in table 1. The result indicate that Low magnesium ion concentration was observed in male patients across all the age range compared to the reference value of 1.3 - 2.5mmol/l. There were however fairly high magnesium ion concentrations in the age range of 19-24 (1.20± 0.00), 49-54 (1.10±0.21), and 55-60 (1.02±0.15) respectively. The lowest magnesium ion concentration was recorded in the age range 79-84 (0.53±0.00) years.

Table 1. Magnesium concentrations in Male Diabetic patients

Age range	Frequency of age range	Magnesium concentration (mmol/l)
19-24	4	1.20± 0.00
37-42	3	0.90±0.35
43-48	5	0.77±0.05
49-54	2	1.10±0.21
55-60	1	1.02±0.15
61-66	2	0.70±0.21
67-72	2	0.60±0.08
73-78	3	0.55±0.09
79-84	8	0.53±0.00
Reference range	**30**	**1.3 – 2.5mmol/l**

Magnesium concentrations in Female diabetic patients

Table 2: presents the results of the magnesium ion concentration of the female patients. The magnesium ion concentration of the female patients was lowest in the age range 73-78 in comparism to the reference range. However, the values of the magnesium ion concentration were remarkably high in younger age ranges 31-36 (1.20±0.00), 37-42 (1.20±0.70) and 43-48 (1.20±0.34) than the older age ranges.

Table 2. Magnesium concentrations in Female diabetic patients

Age range	frequency of age range	Magnesium concentration (mmol/l)
31-36	2	1.20±0.00
37-42	4	1.20±0.70
43-48	4	1.20±0.34
49-54	6	0.93±0.17
55-60	3	0.88±0.46
61-66	4	0.66±0.18
67-72	2	0.50±0.62
73-78	5	0.40±0.00
Reference range	**30**	**1.3 – 2.5mmol/l**

Potassium concentrations of Male Hypertensive patients

Table 3 resents the results of potassium ion concentration in male hypertensive patients. The results showed that the patients across all age ranges had high potassium ion concentrations, though within the normal range when compared to the reference standard range (3.40-5.30 mmol/l). The result in older age ranges; 68-73 (4.23±0.57) and 74-79 (4.40±0.00) was appreciably higher .

Table 3. Potassium concentrations of Male Hypertensive patients

Age Range	frequency of age range	Potassium concentration (mmol/l)
38-43	5	3.25±1.55
44-49	3	3.52±0.23
50-55	6	3.50±1.18
56-61	4	3.50±1.18
62-67	2	3.85±0.72
68-73	3	4.23±0.57
74-79 **Reference range**	7 **30**	4.40±0.00 **3.40-5.30mmol/l**

Potassium concentrations of Female hypertensive patients

The potassium ion concentration in female hypertensive patients is represented in table 4; the result was also observed to be remarkably high across all age ranges when compared to the reference standard range and more obvious in the age ranges of 56-61 (4.23±0.56), 62-67 (4.25±0.79), 74-79 (4.26±0.00).

Table 4. Potassium concentrations of Female hypertensive patients

Age Range	frequency of age range	Potassium concentration (mmol/l)
38-43	2	3.73±0.90
44-49	4	4.10±0.50
50-55	3	4.10±0.99
56-61	4	4.23±0.56
62-67	3	4.25±0.79
68-73	4	3.40-0.96
74-79 **Reference range**	10 **30**	4.26±0.00 **3.40-5.30mmol/l**

IV. DISCUSSION

In this study, the magnesium and potassium ion concentrations were analyzed in diabetic and hypertensive patients respectively. These patients were accessing medical care at the Federal Medical Centre, Keffi, Nasarawa State, Nigeria. The Mg^{2+} concentration in both male and female diabetic patients as observed in the result, generally showed a low Mg^{2+} level compared to the expected standard range (1.3-2.5mmol/l) in normal subjects. It also revealed that the lowest age range (19-24) in male and 31-36 in female subjects had a relatively high Mg^{2+} ion concentration compared to the highest age range of 79-84 whose Mg^{2+} concentrations were 0.53±0.00 and 0.40±0.00 respectively. This may imply that Mg^{2+} deficiency is associated more with older diabetic subjects than the younger ones. This finding is similar to the report given by the National Health and Nutrition Examination Surveys (2006) which states that Mg^{2+} deficiency is more associated with older people. This is because Mg^{2+} absorption decreases with an increase in renal excretion. A rise in urinary magnesium excretion rates in diabetics with increasing insulin dosage has also been reported, which suggests the effect of insulin on renal magnesium handling (McNair, 2003).

Gerry and Stephen, (2017) posits that magnesium absorption is reduced with aging by as much as 30% which could be associated with inadequate magnesium intake. This could be seen in our findings. Magnesium works as an insulin sensitizer by autophosphorylation of insulin receptors, it regulates tyrosine kinase activity on these receptors and blocks the entry of calcium into adipocytes through the L-type calcium channel (Guerrero-Romero and Rodriguez-Moran 2011). On the other hand, previous studies have shown that insulin facilitates shift of magnesium from the extracellular to the intracellular space and reduces the tubular reabsorption of magnesium, which can lead to hypomagnesemia in people with poorly controlled diabetes and hyperinsulinemia (Abdullah et al., 2018).

Blood glucose levels and potassium share a complex relationship. Certain complications of diabetes, including diabetic ketoacidosis and hyperglycemia, are involved in both high blood glucose levels and abnormal potassium levels. Some medications can also cause both elevated blood glucose levels and potassium imbalances (Shannon, 2022). Therefore, people with blood sugar disorders such as diabetes could benefit from adding potassium-rich food to their diets, so long as the choice foods are low on the glycemic index.

The result obtained for K^+ concentration in our study is within the normal range, there is no difference in the potassium concentration of the various age ranges. However, there are conflicting results as to the status of K^+ concentration in hypertensive patients. Luft *et al* (1991) in their work on "salt sensitivity and resistance of blood pressure: age and race as factors in physiological response", reported low K^+ concentration in hypertensive individuals. Another study done by Langford and Watson (1990) in "Electrolytes, environment and blood pressure" also reported low K^+ concentration in hypertensive patients. In this study, normal level of K^+ concentration was observed in hypertensive patients. This is similar to the findings in the study done by Pikilidou *et al*, (2007). This normal level could be as a result of the appropriate intake of the recommended daily allowance for dietary potassium. Certain medications such as potassium sparing diuretics and angiotensin converting enzymes inhibitors could also help to retain the normal K^+ levels in hypertensive individuals.

Potassium is the most abundant intracellular ion, and its role in the regulation of BP is well established (Houston et al., 2008). Dietary supplementation with potassium can lower BP in normal and hypertensive patients (Gerry, and Stephen 2017). Potassium channels, along with Na^+-K^+-ATPase (also known as Na^+- K^+ pump), are central in determining the resting membrane potential and cell volume (Cornelius et al., 2016; Salomonsson et al., 2017). Because the concentration of potassium is much higher in intracellular than extracellular medium, activation, and consecutive opening of potassium channels, results in hyperpolarization of the plasma membrane,

thereby changing an electrogenic driving force for Na^+ reabsorption in the distal nephron (Wang et al., 2017). It is evident that High potassium intake is associated with lower Blood pressure (BP) (Tobian, 1986, Houston et al., 2008). Although data from individual trials have typically been inconsistent, several meta-analyses have each documented a significant inverse relationship between potassium intake and BP in hypertensive patients and equivocal effects in non-hypertensive individuals (Wen et al., 2014). In one meta-analysis, a net increase in urinary potassium excretion of 2 gm per day (50 mmol/day) was associated with average systolic and diastolic BP reductions of 4.4 and 2.5 mm Hg in hypertensive individuals, and 1.8 and 1.0 in non-hypertensive persons. Increased potassium has beneficial effects on BP in the setting of a low potassium intake (e.g., 1.3 to 1.4 gm/day, or 35 to 40 mmol/day), or a much higher intake (e.g., 3.3 gm/day, or 84 mmol/day) (Xuexian et al., 2016, Mamenko et al., 2017). Importantly, increased potassium intake reduces BP to a greater extent in African Americans compared with whites, and therefore may be a valuable tool to reduce health disparities related to the prevalence of elevated BP and its complications (Welling, 2016).

V. CONCLUSION

This study showed that diabetics were deficient in magnesium ion which promotes insulin sensitivity, while potassium level in hypertensive individuals were found to be normal. Though, further studies using larger sample size is advocated to substantiate these findings, magnesium potassium aspartate should from time to time be included in the supplements or fortified foods to increase the amount of magnesium and potassium intake of patients. Importantly, Health care providers should consider monitoring serum magnesium levels periodically in patients especially the elderly to provide medical assistance where necessary.

Limitation of the study

The sample population used was not large enough for generalization. A larger sample population size is therefore advocated to provide clearer basis on the impact of the Mg^{2+} and K^+ concentration in the population.

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Conflict of Interest.

No conflict of interest whether financial or otherwise expressed amongst the researchers.

Author Contribution

Each author contributed in varied significant parts towards the success of this research work.

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