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Urinary Sodium Excretion and Frequently Consumed High Sodium Foods by Civil Servants in South West Nigeria

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Abstract

One of the major dietary risk factors for mortality worldwide is a high consumption of sodium.

Current guidelines for the diagnosis and management of hypertension indicate that a reduction in sodium Na^+ intake levels and an increase in potassium K^+ are paramount to the blood pressure control. Salt Intake of Apparently Healthy Civil Servants in Abeokuta Southwest Nigeria was assessed using Lithium tagged salt method. A 24 hr dietary recall method was used to assess individual household salt intake while food frequency questionnaires were used to determine the frequency of consumption of foods high in sodium and potassium contents of foods.

Using the Lithium tagged method the total intake of salt was 6.29 ± 28 g/day and 6.86 ± 5 in men and women respectively. The mean of the total potassium intake in men was 2.40 ± 10 g/day and 2.3 ± 22 g/day in women. The mean intake of 24 hours' dietary recall in men was 7.87 ± 25 g/day and 7.89 ± 21 g/day in women. Most (73%) of the subjects had perception that they consumed too little salt, out of which 45% were women. Thirteen percent perceived that they consumed too much salt, out of which 7% of them were women. Only fourteen percent perceived that they consumed moderate salt, among which 8% were women. The salt intake of the subjects is high and must be reduced to meet the guidelines of World Health Organization guideline.

Keywords: Sodium; Lithium; Potassium; Civil servants; Potassium; Women; Perception

Introduction

Non-Communicable Diseases (NCDs) are becoming more prevalent and cause of most deaths globally as the world's health is shifting gradually [1]. Cardiovascular Diseases (CVDs) are among the most prevalent; ischemic heart disease and stroke make up the majority of cases. CVDs accounted for the majority of deaths roughly 26 percent of all deaths [2]. According to the Global Burden of Disease Study (GBD) 2019 iteration, the most important risk factors for all deaths worldwide are high systolic blood pressure, tobacco use and dietary risks. In terms of CVDs, diet-related risk is even the second most important risk factor after high blood pressure. About 14.5% of all deaths worldwide in 2019 were due to dietary risks and it ranked third among attributable Level 2 risks of global deaths. In 1990, dietary risks were the fifth most important risk factor [3].

One of the major dietary risk factors for mortality worldwide is a high consumption of sodium, which contributed to 3.2 million deaths globally in 2017 [4]. Apart from the widely recognized connection between elevated Blood Pressure (BP) and a heightened risk of cardiovascular disorders, additional health consequences such persistent renal disease and enhanced physical performance have also been documented. Salt is a basic ingredient of almost every meal worldwide. High salt intake is a major contributor to elevated blood pressure and a major risk factor for Cardiovascular Diseases (CVDs), representing the leading attributable risk factor for death worldwide. High levels of dietary sodium (consumed as common salt, sodium chloride) are associated with raised Blood Pressure (BP) and adverse cardiovascular health [5].

One of the main causes of premature death in the twenty-first century is high salt intake. Two of the main NCDs that are frequently linked to salt consumption are cardiovascular disease and stroke. In low and middle-income countries, where 85% of all premature deaths from these diseases occur, NCDs are linked to 12 million premature deaths annually and estimated economic losses of US$ 500 billion.

Animal experiments, epidemiological studies and clinical trials provide compelling evidence for a detrimental effect of sodium intake on BP among both hypertensive and normotensive individuals [6]. In addition to its effects on BP, excess dietary sodium consumption has been associated directly with Coronary Heart Disease (CHD), stroke and non-cardiovascular diseases [7].

Dietary sodium (consumed as common salt, sodium chloride) comes not only from naturally occurring sodium in foods but also during storage, cooking and processing of food. People may also add salt to foods in various forms of salt containing condiments at the table for taste, high sodium intake is a major contributor to elevated blood pressure and the major source of sodium is salt [8]. Salt is widely acceptable and used in everyday meal preparation of commonly consumed staples such as rice, yam, beans and a variety of vegetable soups and stews (meat, fish, poultry etc.). Vegetables are usually prepared with a mixture of ingredients (pepper, onion, tomato) and seasoned with bouillon cubes and salt [9].

Salt present in manufactured food may not all be ingested if the item is cooked in water, variable amounts of these cooked foods are taken by individuals so that the assessment of different routes for salt entry is complex, several attempts have been made to assess the dietary intake of salt in individuals in different countries. These estimates are usually based on individual responses to questionnaire, national food consumption statistics or figures for household salt purchase [10]. In some developing countries, calculations of potential consumption of iodized salt are based on food balance sheet data, which is the total consumption of salt divided by the population.

All these methods are suspected of being inaccurate because they do not account for salt losses during cooking or on the table, or for the use of salt for other purposes [11].

Civil servants in Abeokuta contribute a significant portion to the economic sector of the state, ten thousand six hundred and seventy-four civil servants are currently working within the state government in Abeokuta [12].

There are few studies on salt intake in Nigeria with limitations as the salt consumption reported for some households in the study may not be a true representation of the daily salt intake of the respondents [13]. To the best of our knowledge, no study has been carried out in Nigeria using a lithium tracker. The aim of the study is to assess the salt intake of the civil servants in Abeokuta Ogun state Nigeria using lithium tracked salt.

Materials and Methods

Subjects

Subjects were recruited by advertising at the state ministry secretariat in Okemosan Abeokuta with full explanations of the purpose of the study. Five hundred ready and willing participants were randomly selected out of the total population. Subjects were not included in the study under the following conditions:

- Were pregnant or breastfeeding.
- Had chronic renal failure.
- We're not civil servants.
- If they were less than 20 years or older than 60 years.
- We're not ready to comply with the procedures of the study.

Method of data collection

Ethical clearance: Prior to the commencement of the field work, permission was sought and obtained from the Department of Nutrition and Dietetics and the Ethical Committee of Civil Service Commission and Ogun State Ministry of Health. Individual consent was obtained.

Data collection: A structured pretested questionnaire was used to obtain information on food frequency of consumption from Five Hundred respondents.

24-hour dietary recall: Using interview method, subjects were asked to recall what meals and drinks they had taken for the previous 24-hour. This information included details of the amount of food consumed, which was estimated in household measures, estimated amounts, and other portion sizes of snacks consumed. The 24 hours' dietary recall was carried out 3 times on two weekdays and one weekend day.

Lithium tagged salt preparation: This was done in the Pharmaceutical Department in Moshood Abiola Polytechnic using the modified method described by Sanchez-Castillo et al.

Preparation of lithium tagged salt: A premix (92 g Li_2Co_3 kg^{-1} salt) was molten in a muffle oven at 900°c for 2 hours and milled after cooling Fractions <125 μm were removed (approximately 10-15%). The coarse part was milled again to obtain a finer salt, too many fine particles were formed, and a homogenous distribution of lithium would have been obtained. Therefore, the lithium tagged salt was coarser than ordinary table salt. The premix was then mixed with the normal salt (NaCl).

Lithium marker protocol: The protocol used was adapted from that described by Sanchez-Castilo, et al.

A personal meeting was arranged with the respondents. At the personal meeting a salt cellar with lithium tagged salt was given to each participant. They were asked to replace their normal salt with the lithium tagged salt for 5 consecutive days. Prior to the 5 days' period, a 24-hour urine sample was collected. Likewise, on each of the 3 days of a 5 days' period when the urinary sodium would have reached the plateau [14]. Urine was collected in separate containers each day. Open ended diary of food intake for the three days was given to the subjects to record all meals consumed, portion sizes, weight and/or equivalent prices for the previous three days including the snacks and drinks consumed were recorded.

Method of urine collection: The protocol used for urine collection was adapted from that described by Anderson, et al. The subjects were asked to record the time of the start and finish of the urine collection in a questionnaire. Urine collection was done in 2.5 l plastic bottles, containing 10 ml of hydrochloric acid (1 mol 1-1) as preservative. The bottles were delivered in black plastic bags to avoid light contamination and disturbance of analysis for para-amino benzoic acid measurements [15]. The 24 hours' urine collections were stored in 2 liters' test tubes at -18°C form subsequent analysis

Analysis of urine: The protocol used for urine analysis was adapted from that described by Andersen, et al., to collect the urine samples. Urinary lithium and lithium content of the lithium tagged salt was measured by flame photometer (ICP-MS), using an ELAN6100 DRC ICP-MS instrument (MDS Sciex, Concord, Ontario, Canada). Prior to ICP-MS analysis 10 g of salt was dissolved in v/v 1% nitric acid equivalent to dilution by a factor of 10000. The thawed urine samples, in which a precipitate was visible, were homogenised prior to dilution by a factor of 10 in 2% v/v nitric acid. Lithium was measured in the diluted sample with lithium as internal standard, and was quantified by external calibration. The ICPS-MS was operated at 1100 Wrf power using a dwell time of 200 ms per isotope. The Lithium content of the lithium-tagged salt was measured in duplicate samples taken from 10 randomly picked salt containers. Urinary sodium was measured by adding a drop of urine and a drop of reference liquid on each end of a *vitro* sodium slide, which is a multilayered disc containing two ions-selective electrodes. Both liquids were filtered through the layers of disc, and created a stable fluent connection between the two electrodes.

Each electrode produced an electrical potential, which depended on the sodium concentration and the difference between their potential was proportional to the sodium concentration in the sample. As high concentrations of potassium in the sample interfered with the results, potassium was measured and if necessary a correction was made. The linear response over the range 5.0-250 mmol and samples with higher

concentrations were diluted. Accuracy of intra-assay CV:1.5%, Inter-assay CV:4.3% were used.

The urinary sodium or lithium excretion was calculated as each concentration (mmol) multiplied by the total urine volume. From mean urinary sodium excretion, the total salt intake was estimated by multiplication with the factor 2.5. This was done for participants who had complete urine collections.

Household salt intake was assessed from the mean urinary lithium excretion after subtraction of base line excretion and divided by the concentration of lithium-tagged salt.

Statistical analysis: Five hundred completed questionnaires were used for analysis. Data collected were analysed using Statistical package for social science version 15.1.

Values were reported in mean and standard deviation; percentages. Multiple regression analysis was employed to determine the relationships of various factors to the nutritional status of the subjects. Analysis of Variance (ANOVA) was used to evaluate the significant differences in food and nutrient intake and nutritional status. Pearson coefficient correlation was used to establish the relationships between variables.

Results and Discussion

Biochemical serum indices of the subjects

In this present study, we assessed the salt intake of Nigerians using a lithium tagged salt. The selected biochemical serum indices of the subjects are presented in Table 1. Sodium and potassium content are important intracellular and extra cellular cations in the human body, the Na/K ratio is important in determining the health status of individuals. To conduct nerve impulses, contract and relax muscles, and maintain the ideal balance of water and minerals, the human body needs a tiny quantity of sodium. Human beings require 500 mg of sodium every day for these essential processes [16]. Subjects had normal levels of serum sodium, potassium and creatinine. Creatine level shows the state of the kidney whether the kidney is functioning properly or is degenerating. The creatinine level indicated that the kidneys of the subjects were functioning well. The study estimated the sodium intake as being equivalent to the urinary excretion of sodium, but sodium is also lost through the skin in sweat and in faeces [17]. The mean serum Na of the male subjects was 140.07 ± 5 mmol while mean value for females was 139.4 ± 1 mmol. The mean serum K^+ of the male subjects was 4.24 ± 1 mmol while mean serum K^+ for females was 4.2 ± 2 mmol. This result obtained is suggestive that the subjects who are apparently healthy have no hyponatraemia. The most prevalent electrolyte imbalance is hyponatraemia, which is frequently discovered by chance during standard blood testing. A serum sodium content that is less than normal (<135 mmol/L) is referred to as hyponatraemia. Although hyponatraemia is most frequently caused by an excess of water diluting the body's serum sodium levels (as in the case of congestive heart failure), it can also occur when the body's water levels are normal or reduced [18].

Parameter	Male	Female	Normal range
Serum Na (mmol)	140.07 ± 5[a]	139.4 ± 1[a]	135-145
Serum K^+ (mmol)	4.24 ± 1[a]	4.2 ± 2[a]	3.5-5.3
Serum Creatinine (mmol)	0.6 ± 10	0.7 ± 12	0.5-1.5
Note: Means with different letters are significantly different			

Table 1: Selected biochemical serum indices of the subjects.

Urinary excretion of NA and potassium by the subjects

Mean of three days urinary excretion of Na and Potassium by the subjects are presented in Table 2. The urinary excretion of sodium and potassium for each of the three days was estimated and the mean daily loss for sodium in males was 120 ± 28 mmol while that of female was 139 ± 42 mmol. The mean urinary loss of potassium for males was 42 ± 19 mmol while for females was 37 ± 22 mmol. The mean urinary loss of sodium and potassium for each of the three days between male and women were different (P<0.05). This result obtained is in support with the study of Sanchez-Castilo, et al., who observed similar result in a related study though in a different location. The strength of this study is the use of lithium tagged salt and the result obtained suggests that this method may be the best in assessing the urinary excretion of healthy people. Our findings from this study agree with the report of Augustine, et al., that observed similar results in Nigeria though using the different methods in different locations. People who dwell in urban centers of the state consumed more salt than people in the rural area and the high level of the sodium excretion observed in our study may be attributed to their geographical location [19].

Days	Men		Women	
	Na mmol	K mmol	Na mmol	K mmol
1	115 ± 6[a]	42 ± 12[b]	139 ± 5[b]	37 ± 12[a]
2	129 ± 14[a]	43 ± 35[b]	141 ± 85[b]	38 ± 27[a]
3	117 ± 8[a]	42 ± 12[b]	137 ± 38[b]	38 ± 27[a]

Daily mean	120 ± 28[a]	42 ± 19[b]	139 ± 42[b]	37 ± 22[a]
Note: Means with different letters are significantly different				

Table 2: Mean of urinary excretion of Na and potassium.

Estimated urinary excretion of salt, potassium and salt perception of the subjects

The estimated urinary excretion of salt, potassium and salt perception of the subjects are presented in Table 3. The mean of the total salt intake in men was 6.29 ± 28 g/day and 6.86 ± 5 in women was higher than 5 grams guidelines of World Health Organization per day. The mean of the total potassium intake in men was 2.40 ± 10 g/day and 2.3 ± 22 g/day in women. The mean intake of 24-hour dietary recall in men was 7.87 ± 25 and 7.89 ± 21 in women. Most (73%) of the subjects had perception that they consumed too little salt, out of which 45% were women. Thirteen percent perceived that they consumed too much salt, out of which 7% of them were women. Only fourteen percent perceived that they consumed moderate salt, among which 8% were women. According to Sanchez-Castillo et al., 93% of the sodium intake is excreted in the urine. The study revealed that women had higher consumption of salt than men ($p<0.05$) in the study population. This finding confirms the report of other researchers that observed the same in a related study [20]. This could be due the culture and practices in Nigeria where women are the custodian of culinary and have more access to food than men. The strength of the present study is that an, objective technique capable of measuring individual house hold salt intake was used. Intake of salt at individual household has not been assessed in Nigeria using the method of lithium tagged salt. The result obtained using this method was lower than what Sanusi, et al. obtained in their studies using 24 hours' dietary excretion method. The result obtained using this method when compared with the result obtained in developed countries where the same method had been used was lower than what other researchers obtained in their studies. This could be explained by the fact that the study populations were not high consumer of salty foods as reflected by the dietary intake compared with the western diets. Previous studies have shown that in populations that do not consume western diets, salt intakes may be lower, the findings in this study seem to support this assumption. Daily urinary sodium excretion for individuals in this study varied widely among males and females. This might be due to variation in dietary intake of table salt from day to day with diet. This is consistent with the known non-predictable variability of sodium excretion, considered as a confounder in behavioral studies. The estimated daily salt intake between women and men was significantly higher in women than men ($p<0.05$). This observation is in variance with what other researchers reported in Nigeria though in different study location.

Parameter	Men	Women	P Value
Salt intake from urinary excretion (g/day)	6.29 ± 28[a]	6.86 ± 5[b]	0.05
24 hour dietary recall (g/day)	7.87 ± 25[a]	7.89 ± 21[a]	0.945
Total potassium intake (g/day)	2.40 ± 10[a]	2.3 ± 22[a]	0.786
Salt intake perception%			
Too Little	28	45	
Too much	6	7	
Moderate	6	8	
Added salt			
Yes	6	8	
No	34	52	
Note: Means with different letters are significantly different			

Table 3: Estimated urinary excretion of salt, potassium and salt perception of the subjects.

Frequency of consumption of foods high in salt by the subjects

Frequency of consumption of foods high in salt by the Subjects results (Table 4) showed foods high in salt frequently consumed by the subjects were; bouillon cubes (94%), bread (82%), Monosodium Glutamate (MSG) (62%), salted groundnuts (78%). Other foods consumed occasionally were salted fish (50%), hamburgers (67%), Suya (66%), canned meat (69%), canned fish (59%), dodo ikire (90%), sausages (69%), cornflakes (65%), shell fish (74%), cheese (65%), avocado pear (67%), sardines (65%). Most of the participants thought they added more salt to their food and didn't use much salt overall. The participants' assumption is risky and could have serious health repercussions because they might not have a clear picture of the amounts of salt in the food from just tasting it. The results of this study showed that the subjects' salt intake exceeded the World Health Organization recommendation of consuming less than 5 grams of salt daily. Our findings are in accordance with stories from awareness week that punch news in Nigeria published under the headline "It's

time to shine the spotlight on salt." According to the minister, at least 10% of deaths in Nigeria from cardiovascular disease are caused by excessive sodium consumption. Nigerian adults are expected to eat between 5.8 and 25 grams of salt per day and receive between 2.3 and 10 grams of sodium from their foods on average. The World Health Organization (WHO) recommends 5.0 grams of salt and 2.0 grams of sodium per day, although this level is significantly higher. This is just excessive and can lead to serious health issues. Potassium has been shown to have strong lowering effects on blood pressure in adults with pre-hypertension and hypertension when a high-potassium diet, such as the Dietary Approaches to Stop Hypertension (DASH) diet, is added to a high-sodium diet. There is mounting evidence that a diet rich in potassium may improve vascular health in addition to lowering blood pressure, even though dietary potassium has been demonstrated in randomized controlled trials to lower blood pressure. Hypertension is linked to elevated sodium and lowered potassium levels and intake equal of potassium to salt in molar units is necessary to prevent hypertension. Consuming less sodium and more potassium promotes low blood pressure. Conversely, a diet heavy in salt causes greater calciuria, which increases the risk of osteoporosis; on the other hand, a diet high in potassium reduces the effects of calciuria. The study subjects consumed insufficient amounts of potassium. The best sources of potassium are fruits and vegetables; yet, based on the individuals' dietary records, a significant amount of their diet appears to consist of vegetables. Overall food intake revealed that the respondents occasionally ate foods high in salt; for instance, bread, salted groundnuts, bouillon cubes, and monosodium glutamate were regularly consumed by the subjects. m This study supports the recent protests of journalists published in Nigerian newspapers, stating that typical Nigerian meals often contain high salt content due to the availability of dried fish, bouillon cubes, and other salty condiments. The growing intake of processed foods, which are often high in sodium, exacerbates the problem. Many Nigerians are unaware of the amount of salt they consume daily because salt can be found in a wide variety of meals. Nigerians dine more out of their homes these days. Vendors add pepper and salt to make these meals appetizing and spicy. The public's health is at stake because of this. According to the National Institutes for Health, an American organization, 28.9% of Nigerians are estimated to have hypertension. The percentages for males and women are 29.5 percent and 25.0%, respectively.

Type of food	<1 X/wk (%)	1-2 X/wk (%)	>3 X/wk (%)	Occasionally (%)	Never (%)
Salted fish	6	6	8	50	30
Bacon	NA	NA	NA	28	72
Hamburger	NA	NA	NA	67	33
Suya	NA	8	12	66	14
Locust bean	16	9	19	48	8
Canned meat	5	4	NA	69	22
Canned fish	NA	5	9	59	27
Bouillon cubes	26	5	63	6	NA
Bread	13	35	34	18	NA
MSG	6	2	54	11	29
Salted					
Groundnuts	4	7	67	22	NA
Dodokire	NA	4	NA	90	6
Sausages	9	9	13	69	NA
Cornflakes	8	9	4	65	14
Shellfish	17	4	5	74	NA
Cheese	NA	NA	NA	65	35
Avocado pear	2	3	NA	67	26
Sardines	NA	7	28	65	NA

Table 4: Frequency of consumption of foods high in salt by the subjects.

Sodium is an extracellular cation that regulates muscle and nerve contraction, acid-base balance, and plasma volume. Essential hypertension has been linked to high dietary salt intake. High sodium content in bouillon cubes was reported by Elemo and Makinde, accounting for 26.80–29.00% of the recommended daily allowance for this element. The subjects' dietary sodium intake increased greater when they consumed bread, salted groundnuts, bouillon cubes, and monosodium glutamate (P<F 0.05). Additionally, it was noted that the individuals frequently ingested baked goods, candy, carbonated drinks, and biscuits. This might be the consequence of the individuals' easy

access to these meals at work, which makes them convenient, and it might have a big impact on how much salt they eat.

Conclusion

This study revealed that the salt intake of the civil servants is high. The serum level and lithium tagged measurement were within the normal range. The study showed that the salt intake can be best measured using lithium tagged salt method. The increase in cardiovascular problems currently experienced in Nigeria should not be attributed solely to salt intake. Further studies should be carried out to determine the cause.

Credit Authorship Contribution Statement

Nupo S.S: Draft, writing, and review.

Oguntona CRB: Review, Correction and editing.

Oguntona Babatundec: Review, Correction, editing and supervision

Akinloye O.A: Biochemical aspect, supervision and correction.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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