Techniques for Estimating Dietary Sodium: A Review

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Abstract

Research has demonstrated that consuming too much sodium through food is linked to high blood pressure and the complications it causes, such as cardiovascular disease and stroke. The amount of salt people consume each day varies from place to place depending on factors like geography, ethnicity, socioeconomic status, etc. In this review, the several techniques for determining daily sodium consumption, including dietary estimating methods utilizing 24-hour dietary memory, food frequency questionnaires and diet records, and biochemical techniques employing spot or 24-hour urine salt estimation are discussed. The calculation used to estimate 24-hour urine sodium from the spot urine sodium can be applied to determine how much sodium is predicted to be consumed daily. Validation studies must be carried out in order to choose the right equation. The monitoring of sodium consumption at the population level is crucial for reducing non-communicable illnesses.

Keywords: Diet, estimation, method, salt, sodium, urine

INTRODUCTION

Table salt, often known as salt, is a chemical molecule that typically contains 60% chloride and 40% sodium. Important electrolytes like sodium and chloride are necessary for the body's normal physiological operation. About 90% of the sodium we consume comes from table salt. Because sodium is the portion that is important for health and because the estimation of one yields the assessment of the other, health care professionals frequently use the terms salt and sodium interchangeably. Sodium participates in many critical processes, including nerve impulse production, cell integrity, and fluid-electrolyte balance.[1] Metabolic studies have demonstrated that a long-term consumption of 100–375 mg sodium (or 0.25–0.9 g salt) per day can maintain sodium homeostasis.[2] The amount of salt consumed by the general populace has increased over time. In 2010, the average daily intake of salt was estimated to be 10.1 g (95% confidence interval [CI]: 9.9-10.2).[3] Indian estimates of the salt intake were similar to above as 10.9 g.[4] The excessive salt consumption to high blood pressure and its side effects, including stroke and cardiovascular disease has already been established.[5,6] The kidneys may be effected in excessive salt intakes though the mechanism is yet to be disclosed.[7] Obesity, stomach cancer, osteoporosis, and chronic kidney disease are some conditions that have been linked to high salt intake.[8] The World Health Organization (WHO) advises individuals (>16 years) to lower their daily salt intake to a maximum of 2 g. WHO has similarly suggested many programms to lower the targeted sodium intake as a mechanism to tackle the non-communicable disease like stroke, kidney diseases.[9] There are numerous urine and non-urinary techniques available today to determine daily salt and potassium intake. In longitudinal studies, the sole use of dietary assessment techniques is frequently seen, while in interventional research, sodium consumption is typically estimated using a single 24-h or spot urine collection.[10] The inaccuracy of evaluation techniques, which has produced conflicting findings on the ideal sodium intake for the prevention of chronic kidney disease CKD or cardiovascular diseases CVD, is one of the main issues in research on dietary sodium intake.[11] On a personal level, erroneous sodium or potassium intake calculations may lead to inappropriate dietary recommendations and raise the risk for CKD and CVD.[12] To reduce salt consumption, it is necessary to determine the sources of dietary sodium, estimate sodium/salt intake, and periodically check the results. The only way to reduce morbidity and mortality linked to excessive salt consumption is to reduce salt intake.

RESOURCES

Our diets contain sodium for a number of purposes. Its most well-known use is probably as a taste enhancer. Moreover, it can be employed as a preservative to preserve food, improve colour, or give food a harder texture. Baking soda (sodium bicarbonate), for instance, contains sodium and is used to help bread and other baked goods rise. Despite the fact that salt is a crucial component of many dishes, it is frequently added in excess.[10] Salt added to food during preparation, processing, or at the table while eating it accounts for the majority of the sodium in our diet. Unprocessed foods low in salt include fruits, vegetables, whole grains, nuts, meat, and dairy products.[11,12] It is recognized that different nations have different dietary salt sources. Processed foods are the main dietary means of salt in modern nations. The primary source of dietary sodium was discovered to be non-vegetarian sources; dairy products in south India as well as the bakery products and fruits and vegetables in north India. The salt that was added when cooking, or "discretionary salt," was the principal source of dietary salt in Asian nations.[13] We can regulate our daily sodium consumption by identifying the main sources of salt.

TECHNIQUES FOR CALCULATING DIETARY SODIUM CONSUMPTION

Either dietary estimation or biochemical estimation can be used to determine salt consumption from food.[14] The sodium excretion of urine is used in the biochemical estimate approach because the majority of eaten sodium is eliminated in the urine. Sodium consumption can be estimated from sodium excretion.

Dietary estimation

24-hour diet recall

This technique aims to record every meal and beverage consumed over the course of a 24-hour period. There may be significant heterogeneity in the distribution of a same daily intake. By interviewing a subsample on a different day, it is possible to determine an estimate of salt intake. This will allow you to determine the normal intake.[10]

Eating habits

The "*Food frequency questionnaire*-FFQ" has a short list of foods and drinks, together with replies that reveal how frequently every item was ingested within a predetermined time frame. Instead of just one day's worth of consumption, FFQ can record typical intakes. In general, the FFQ does not inquire about the amount of salt used during cooking or eating.[10,12]

Diet history

It is a thorough listing of the kinds and quantities of foods, drinks, and other foods ingested throughout a predetermined time frame. It is more dependable but necessitates a high level of motivation and knowledge. Training on proper record intakes can be necessary.

Limitations

When field surveys employ dietary estimation techniques, they are believed to be more realistic. One of the restrictions is the inability to properly quantify the quantity of sodium chloride supplied while cooking and at the table. The amount of salt that is added during cooking and retained by the dish, the amount of sodium in processed foods, and the level of sodium in nearby water supplies are further constraints.[10,12,15]

Dietary evaluation also makes it possible to link sodium intake to dietary practices or intake of other nutrients (like potassium) linked to outcomes connected to disease. This information may then be used to inform public health activities. Dietary salt from food sources will be miscalculated as a result, as dietary assessment techniques frequently considerably underestimate total food consumption (and thus total calorie intake).

The numerous techniques used to measure nutrient intakes—dietary recall, weighted diet records, food diaries, and FFQ—require a lot of work from individuals and researchers alike. Although there is some debate regarding the usefulness of dietary assessment techniques, it is crucial to use them to identify sources of sodium intake in order to inform public health initiatives for dietary sodium reduction. It is crucial to identify foods linked to high intake across demographics and cultural groups in order to inform public health initiatives focused on dietary changes, consumer education, and the reformulation of processed foods.[15] [25]

Biochemical estimation

24 h urine collection

A 24-hour urine sodium estimate is given here. This approach is frequently used to evaluate and compare different approaches.[14] The best procedure is multiple nonconsecutive 24-hour urine salt measurements.

Overnight collection of urine

Low-burden substitute to 24-hour collection because it requires fewer voiding and the subject is free to go about their regular business. Due to the obvious diurnal variation in sodium excretion, it can be skewed.[10,16]

Collecting urine on-site

This approach is a practical and inexpensive replacement for 24-hour urine collection. When a calibration study for the use of spot urine has been conducted in the particular population of interest, this can be employed.[17]

Limitations

Even though it is thought of as a superior and more objective method, biochemical estimate has its limits. The calculation of sodium consumption using urine sodium excretion, for instance, can change depending on variables that can affect sodium absorption, metabolism, and excretion. In homeostasis, the kidneys manage the majority of the sodium ingested each day, and 90%–95% of it is eliminated in the urine within 24 hours. A 24 hour time is required to capture the significant diurnal fluctuation in salt, chloride, and water excretion. In healthy people, electrolyte excretion peaks around or about midday and troughs at the end of the night while they sleep. Since the 24-hour urine excretion approach only accounts for electrolyte loss through the kidney, it tends to overestimate actual intake. The amount of sodium lost by perspiration and feces is negligible in temperate climes, but it can be significant in other circumstances.[10,18]

The 24-hour urine collection is not subject to reporting biases, unlike the majority of dietary techniques. Although the sodium/creatinine ratio and the para-aminobenzoic acid marker have been used, 24-h urine sodium estimation has some drawbacks of its own. Rates of attrition may be high due to participant burden, and the estimates rely on the volume of samples collected. Although the sodium/creatinine ratio and the para aminobenzoic acid marker are utilized, there is no definitive way to ensure that all samples have been collected. To prevent both overcollection and undercollection, as well as to allow for the correction of slight deviations from a 24-hour collection time, the collection must be precisely timed.[10,18]

LITERATURE SUPPORT FOR ESTIMATION

The historic "*INTERSALT (International Study of Salt and Blood Pressure)*" study, which measured dietary sodium consumption, used 24-hour urine collection to assess population sodium intake.[19] By far the most comprehensive collection of standardized data on 24-hour sodium excretion patterns worldwide, INTERSALT collected data on over ten thousand middle aged adults from 52 population sample clusters in 32 countries. The median sodium levels throughout the centers ranged from 4.6 to 5.6 g/24 h and were substantially correlated with people's blood pressure. According to multiple regression, a difference in salt consumption of 100 mmol/day in the general population was associated with 2.2 mmHg lower systolic pressure. Men and women, aged 40 to 59, from 17 population samples in four countries participated in the "*INTERMAP (International Study of Macro- and Micro-Nutrients and Blood Pressure)"*, which included measures of dietary salt intake and urine sodium excretion.[20] The average amount of sodium excreted by the 4680 subjects was 4165 mg. Based on the participants' sodium excretion, the subjects were split into quartiles. After controlling for age, sex, and sample alone, those in the highest quartile of sodium excretion consistently had greater systolic and diastolic blood pressure than those in the lowest quartile.

ESTIMATING 24-HOUR SODIUM EXCRETION FROM SPOT URINE SODIUM

Spot urine sodium has been touted as a more cost-effective substitute for 24-hour urine sodium. There aren't many published equations or formulas that can translate spot urine sodium concentration into estimates of 24-hour excretion. By Tanaka et al. and Kawasaki et al. in Japanese populations, two have been derived.[21,22] The Pan American Health Organization (PAHO), the WHO regional office, has offered one equation (the PAHO formula), while another equation was created by analyzing the data from the INTERSALT study in populations from North America and Europe.[17,23] For the Danish people, the Toft equation was created.[24] Age, weight, height, sex, spot urine sodium, spot urine potassium, and spot urine creatinine are some of the variables employed in these equations. The population under study determines which formula is used. These equations only provide an estimate of sodium consumption at the population level; they do not provide sodium intake for an individual.

Studies comparing the mean dietary salt intake determined by spot urine sodium and 24-hour urine sodium revealed that the estimation of daily salt consumption determined by spot urine sodium depends on the equation utilized. The Kawasaki equation was found to overestimate daily consumption, while some studies indicated that the INTERSALT equation provided estimates that were comparable to sodium levels reported in the 24 hour urine.[10,12,25,26] To determine the right equation for any given location of the world, additional calibration or validation investigations are needed. **Box 1**

Box 1: Summary of commonly used equations established on spot urine (adapted from Ginos et al.[12])

Method	Age	Sex	Height	Weight	BMI	Spot Na^+	Spot K^+	Spot Cr	Spot Ur	24-h uV	Region	Men	Women	Age	BMI	eGFR
INTERSALT [33]	grey	grey			grey	grey	■	grey			North America and Europe	2841	2852	20–59	25.8	N/A
CKDSALT [34]	grey	grey			grey	grey			grey	grey	China	2939	2296	54	24.2	56.7
Kawasaki [37]	grey	grey	grey	grey		grey		grey			Japan	78	81	34	22.1 *	N/A
Tanaka [32]	grey		grey	grey		grey		grey			Japan	295	296	40	22.4	N/A
Toft [38]	grey	grey	grey	grey		grey		grey			Denmark	102	371	51	25.5	N/A
Mage [36]	grey	grey	grey	grey	grey	grey		grey			United States	483	246	N/A	N/A	N/A

Grey marked variables are included in the method equation: age, sex, height, weight, body mass index (BMI), spot urine sodium concentration (spot Na^+), spot urine potassium concentration (spot K^+), spot urine creatinine concentration (spot Cr), spot urine urea concentration (spot Ur) and 24-h urine volume (24-h uV); ■ indicates that the use of spot K^+ for estimation of sodium intake is optional. Summary of original study population characteristics per method: age (years), BMI (kg/m^2) and eGFR ($ml/min/1,73\ m^2$) are displayed as mean, median or range; * calculated mean BMI using provided mean height and weight.

FUTURE PERSPECTIVES

Equation Established on Repeated Spot Urine

The finding that seven consecutive 24-hour urine samples substantially increase the precision of individual salt consumption estimates raises the possibility that the number of measurements may be more significant compared to accuracy.[27] In this regard, the recurrent collection of spot urine, which has a fair degree of accuracy and little patient burden, may be an alternative. An investigation investigating the potential utility of repeated spot urine collection for measuring sodium intake at the individual and community levels revealed that estimation accuracy increased with the number of samples used.[28] The correlation coefficients for the one-spot urine sample, two-spot and three- spot urine samples were 0.20, 0.31, and 0.42, respectively. Another study that examined the usefulness of repeated spot urine samples to estimate the normal population's sodium intake revealed no improvement when three samples were used.[29] Both investigations sought to calculate the sodium excretion over 24 hours as determined by three 24-hour urine samples. This reference approach has important restrictions, as was already mentioned. Nevertheless relationship between salt and potassium estimates derived from repeated measurements of spot urine samples and actual dietary intake is currently unknown.

CONCLUSION

Accurate valuation of dietary sodium intake is crucial for preventing health problems associated with excessive sodium intake. Several methods are available for estimating dietary sodium intake, ranging from self-reported dietary records to laboratory-based methods. Each method has its advantages and limitations, and the choice of the method depends on the study design, population characteristics, and available resources. Combining multiple methods can provide a more accurate estimate of dietary sodium intake. Future research should focus on developing and validating new biomarkers and improving the accuracy and precision of existing methods for dietary sodium estimation.

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