

**Original article:**

**Correlation Between Spot Urine Sodium, 24 Hour Urinary Sodium and Food Frequency Questionnaire in Estimation of Salt Intake in Healthy Individuals**

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**Abstract**

**Background:** Salt intake is a known contributor to increased blood pressure. However, it is rarely monitored in clinical practice. 24-hr urinary sodium (24-HrNa) is the gold standard method to estimate salt intake but this method is rather burdensome. **Objective:** The objective of this study is to correlate between spot urine sodium (SUNa), 24-HrNa and Na intake estimation by food frequency questionnaire (FFQ) (FFQNa). **Methods :** 430 healthy participants aged between 20-40 years old were recruited. Second morning voided urine samples were obtained from all participants to estimate SUNa. 24-HrNa samples were obtained from 77 out of 430 participants. All participants were required to answer a validated FFQ. Urine samples were analysed for Na using indirect ion-selective electrode (ISE) method. Daily sodium intake was calculated from the FFQ. **Results:** The mean daily sodium intake from 24-hrNa (n=77) was 155 mmol/day, SUNa (n=430) was 158 mmol/L and FFQNa (n=430) was 271 mmol/day. There was a moderate correlation between SUNa and 24-hrNa ( $\rho = 0.62$ ,  $P < 0.000$ ). No correlation was seen between both 24-hrNa and SUNa with FFQNa ( $\rho = 0.035$ ,  $P = 0.768$  and  $\rho = 0.026$ ,  $P = 0.597$  respectively). **Conclusion:** Spot urine Na is a simple cost-effective method to estimate daily Na intake and has the potential to replace 24-hour urinary Na.

**Keywords:** Spot urine sodium, 24-hour urinary sodium, salt intake, Second Morning Urine (SMU), FFQ Na, hypertension.

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**Introduction**

The main risk factor for Ischaemic Heart Disease (IHD) and stroke is hypertension<sup>1</sup>. It is also the number one risk factor contributing to mortality globally. Studies have shown that hypertension is related to an increased intake of dietary sodium throughout adult life<sup>2</sup>. In 2010, it was estimated that the mean level of sodium consumption worldwide was 3950 mg per day equivalent to 9.9 g of salt, ranging from 2180 to 5510 mg (5.5 to 12.9 g salt)<sup>3</sup>. Population monitoring on dietary sodium intake is essential. This is necessary to determine whether a particular population is consuming more than the recommended level of daily sodium intake. However, among the challenges in measuring dietary sodium intake is the precise quantification of the intake itself<sup>4</sup>. An exact measure of individual intake of sodium

is not needed, instead, a valid estimate of the range of sodium intake is necessary to estimate the population sodium intake<sup>5</sup>. Methods used in measuring sodium intake would be of two types; the dietary and urinary assessment<sup>6</sup>. The objective of this study was to estimate the daily sodium intake in a sample of young healthy individuals using three methods, 24-hour urinary sodium excretion (24-HrNa), Spot Urine Sodium Excretion (SUNa) and Food Frequency Questionnaire to estimate sodium intake (FFQNa). The study also aims to investigate the correlation between SUNa and FFQNa against the 24-HrNa which is the gold standard for estimating daily sodium intake.

**Materials and Method**

This study was done at three different colleges; Kolej Pembantu Kesihatan Seremban (KPKS), the Technical University of Malaysia Melaka or

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University Teknikal Melaka Malaysia (UTeM) and Cyberjaya College University of Medical Sciences (CUCMS). Convenient sampling was used as the sampling method. Samples were recruited through voluntary participation. The research was registered prior to data collection under the National Medical Research Register (NMRR) and approved by the local ethics committee. The inclusion criteria were 18 to 40 years of age, both males and females, Malaysia citizen, not having kidney or eating disorder and not being pregnant for the females. Written informed consents were obtained from all of the participants prior to the study. The information on height, weight, calculation of BMI, education and socioeconomic background, blood pressure measurement and information on past medical history were obtained. 24-HrNa urine were collected after their second-morning void to the following day's second-morning void. The volume of urine was recorded. SUNa was collected from the second-morning void on the second day (howmuch). The SUNa and 24-Hr Na samples were collected, labelled using subjects' identification and dispatched according to the same accredited laboratory. Sodium and creatinine analysis were done. A validated FFQNa intake with 74 food items related to dietary sodium intake was used<sup>7</sup>. The FFQNa was designed to estimate 1-2 months recall of food intake on sodium<sup>7,8</sup>. This was a self-administered assessment that would reflect the subjects' food consumption on sodium for 1 to 2 months period. The data were put in excel files, then analysed using Nutritionist Pro™, a dietary analysis software to assist with quantification and identification on dietary sources on sodium. This was done under the consultation of a qualified dietitian.

### Statistical Analysis

Using SPSS Statistics 22.0 software, the descriptive data of the variables attained were tabulated using the appropriate tests. The data were tested for its normality. For monitoring the completeness of the 24-hour urinary sodium collection, urinary creatinine was used as a standard. Exclusion of incomplete urine collection would be calculated using Equation 1. The volume for 24-hour urine collection for creatinine should be more than 120 mmol/kg body weight per day in male and more than 124 mmol/kg in females. 24-HrNa, SUNa and FFQNa were calculated for their mean, standard deviation and range. For calculation and standardization, all measurements of dietary sodium were in mmol per day (mmol/day) or

mmol/ Litre (mmol/L), mEq/L is equal to mmol/L or mEq/day is equal mmol/day. To calculate and for reference, 1 mmol Na = 23 mg Na, 1g NaCl (salt) = for 17.1mmol Na = 393 mg Na. Dietary salt content can be estimated by multiplying sodium content by 2.5<sup>9,10</sup>. For example, 150 mmol/day is equal to (150\*23mg Na) = 3450 mg/day and for NaCl is equal to (3450mg/day\*2.5) = 8625mg/day. Pearson or Spearman Correlation tests were conducted to find the correlation between 24-HrNa and SU Na as well as the correlation between 24-HrNa and daily Na intake as determined by FFQNa. This was further tested with linear regression graphs to show the linear relationship between the variables. Null hypotheses of no difference were rejected if the respective *p* value was <0.05.

### Equation 1: Creatinine Concentration

$$\frac{\text{Concentration of Cr (mmol/L)} \times \text{vol of urine (l)}}{\text{(body weight in kg} \times 1000)}$$

### Results

469 subjects took part in the study but only data from four hundred thirty subjects (430) were analysed, after thirty-nine (39) were rejected due to incomplete data. Subjects were recruited from three locations, namely Cyberjaya College of Medical Sciences/ CUCMS, (N = 120), University Teknologi Melaka/ UTeM, (N = 55) and KolejPembantu Kesihatan Seremban (KPKS), (N = 255). Out of the 430 subjects, 89 subjects had agreed to do the 24-hour urine sample collection (Figure 1). From the data collected, there were 268 males (64%), and 150 females (36%), with 87% were Malay, most were single (98%). They were students either taking either diploma (60%) or degree (40%). The average age for the subjects was 22 years old, ranging between 19 – 40 years old, with BMI 22.73 kg/m<sup>3</sup>. The systolic and diastolic measurements showed a mean of 116 mmHg and 74 mmHg, respectively. All subjects were assumed to be healthy and under no medical treatment based on the questionnaire on socioeconomic and health background given (Table 1). Further screening on completion of 24-hour urine samples was done based on of urinary creatinine excretion. Twelve (12) samples were removed from the 89 samples collected due to incomplete creatinine excretion. The results showed that the mean SUNa (n=430) was 158 mmol/L while mean 24-HrNa (n=77) was 155 mmol/day. Mean daily sodium intake calculated from FFQNa (n=430) was 271 mmol/day (6241 mg/day). This, when converted to salt intake for SUNa, 24-HrNa and FFQNa, would

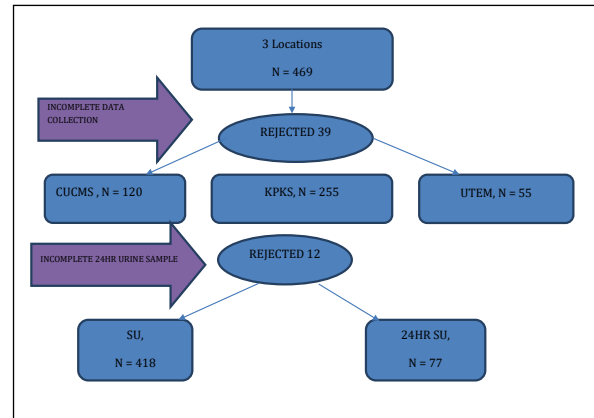
be 9 g/L, 8.9 g/day and 15 g/day, respectively (Table 2). For calculation, 1 mmol Na = 23 mg Na, dietary salt content can be estimated by multiplying sodium content by 2.5<sup>9,10</sup>. Spearman test was done to test the correlation between 24-HrNa, SUNa and FFQNa. SUNa and 24-hour urine sodium showed that it was significantly correlated ( $p < 0.000$ ) with a moderately positive relationship, the correlation coefficient was 0.62. This was further showed in the scatter plot graph (Figure 2), with linear regression equation  $y = 0.57x + 85.4$ ,  $R = 0.33$ . However, there was no significant correlation ( $p > 0.05$ ) obtained between both 24-hour urine sodium and SUNa with FFQ,  $\rho = 0.035$ ,  $p = 0.768$ , (Table 3, Figure 2).

**Table 1.** Socioeconomic and Health Background

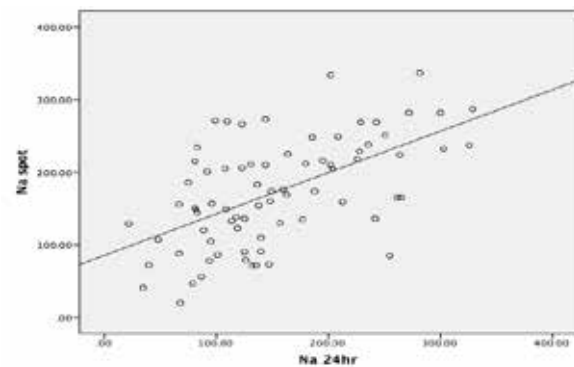
	Means	SD	Range
N	418		
Gender	Male – 268 (64%)		
	Female – 150 (36%)		
Education	Degree 169 (40%)		
	Diploma – 249 (60%)		
Status	Married – 6 (2%)		
	Single – 411 (98%)		
Ethnicity	Malay – 363 (87%)		
	Chinese – 23 (6%)		
	Indian – 15 (3%)		
	Others – 17 (4%)		
Age	22	3.3	19 – 40
Weight (kg)	61.98	14.23	30 – 134.60
Height (cm)	164.76	8.22	136 – 192
BMI (kg/m <sup>2</sup> )	23	4.40	16 - 49
Systolic (mmHg)	116	12.55	74 - 152
Diastolic (mmHg)	74	9.44	4.2.3 - 100

**Table 2.** Mean Sodium Intake or Output

	Mean	Std. Deviation	Mg/dl	Salt (mg)
SUNa (mmol/l)	158	71.0	3640	9099
24-HrNa (mmol/day)	155	73.6	3574	8935
FFQNa (mmol/day)	269	278	6187	15468



**Figure 1:** Data Collection



**Figure 2:** Scatter plot of SUNa (mmol/L) vs 24-HrNa (mmol/day)

\* R = regression

\*\* $\rho$  = correlation score

**Table 3.** Spearman Correlation for SUNa, FFQNa and 24-HrNa

Tests variables	$\rho$	P	N
SUNa vs 24HrNa*	0.62	0.000*	76
FFQNa vs 24HrNa	0.035	0.768	75
SUNa vs FFQNa	0.026	0.597	408

**Discussion**

The optimal sodium intake recommended by WHO/FAO is below 85 mmol/ day (2000 mg/day)<sup>10</sup>. The gold standard for sodium intake is the 24-HrNa urine excretion since 95 % of sodium ingested would be excreted out from the body within 24 hours<sup>11</sup>. The results from 24-HrNa urine excretion for this study was 155 mmol/day (3565 mg/day). This is consistent with previous studies in Malaysia (Table 4), ranging from 91.1 to 142 mmol/day (2095 to 3266 mg/day), which are higher than the recommended sodium intake. The results from this study, revealed the highest sodium intake compared to earlier studies. The closest previous research that was done among young adults was in 2011, showing results of 115 mmol/day (2645 mg/day) of sodium intake. However, it

was done using 24-hour dietary food recall; this has been known to have either the subjects under-report or over-report their sodium intake<sup>12</sup>. Thus, this study had showed that even in young adults their dietary sodium intake was beyond what was recommended based on 24-HrNa urine. This was expected, because, in another similar study, the results showed that healthy young adults tend to frequently eat at fast food restaurants, chain fast foods stores and thus had higher processed foods consumptions<sup>13,14</sup>. In a survey done in New Zealand, it was found that young adults 19 to 25 years old, had a mean sodium excretion of 3040 mg/day in males and 2552 mg/day in females. Their consumption of processed foods, mostly hamburgers, bacon, margarine, soup, pasta sauce, tomato sauces, muffins, and other processed foods was higher than other age groups<sup>15</sup>. Increased 24-HrNa excretion was reported in South East Asian (SEA) countries such as Brunei 117 mmol/day (2697 mg/day), Singapore 125-148 mmol/day (2800-3400 mg/day), Thailand 133-211 mmol/day (3050-4850 mg/day) and Philippines 54-91 mmol/day (1250-2900 g/day)<sup>16-18</sup>. However, this was not the case for Indonesia, as the results showed a lower sodium intake, ranging from 7-99 mmol/day (160 to 2280 mg/day)<sup>19,20</sup>. The reason

for this was because the samples were taken among the elderly and the method used could not be properly executed due to a reduced required dietary intake among this group<sup>20</sup>. In a later study done in Indonesia, a smaller sample but among younger age participants, showed higher sodium intake<sup>19,21</sup>. The mean for dietary sodium intake from FFQNa (271 mmol/day) was higher than the gold standard, 24-hour urine sodium by 75%. The value for SD higher than the mean, which means the range of the results were high. The result was also much higher than the previous studies done using the same method, questionnaire (24-hour food dietary recall). This could be explained by the administration of the questionnaire itself. Although during data collection participants were guided on how to answer the questions, they would still under or over-report their dietary intakes, as the questionnaire included 1-4 weeks food recall<sup>5,12,18</sup>. Thus, for FFQ survey, it should be guided so that a thorough question-answering could be achieved for more accurate results. However, this was not easily done as there would need to be many assistants for this particular task. Also, the circumstances such as under-reporting or over-reporting might play a role in the final data collection<sup>4</sup>.

**Table 4.** Sodium Intake/ Output Research in Malaysia

Year	Location	Method	N	Results (Mg/ day)	(mmol/ day)	Age group	Research
2008	5 States	Food Recall Dietary	6886	2576	112	18-59	<sup>12</sup>
2011	Klang Valley: College Students	24-Hour Dietary Recall Method	584	2645	115	18-24	<sup>34</sup>
2014	Klang Valley: Health Staff	24-Hour Urine	445	3266	142	20-56	<sup>35</sup>
2015	Klang Valley: low-income communities	24-Hour Urine	180	2095	91.1	48-60	<sup>36</sup>
2019	National survey	24-hour urine	1027	2772.97	121	20-59	<sup>37</sup>

SUNa is significantly correlated with 24-HrNa. This result is consistent with previous work whereby SUNa was considered to be an alternative to 24hr Na after using a few methods to calculate estimated 24-HrNa<sup>9,11,22-27</sup>. In other studies, comparing the ratio of sodium/creatinine (Na/Cr) to 24-hour sodium excretion showed that there were varied correlations, from weak to moderate correlation (Table 5). H. Koo et al. (2015), reported that the reason for a weak correlation was due to substantial intra-individual biological variation of urinary electrolytes compared to albumin and time of urine collection i.e. either late morning or early afternoon<sup>28</sup>. Another reason to this was the time of collection of SU<sup>29</sup>. There are a few

methods of collecting SU, which is, casual urine (CU), second morning urine (SMU), AM urine, PM urine, overnight urine (OV), 8 hours urine and 12 hours urine. For all these methods, the range of correlation was highly variable, from as weak as 0.17 to 0.94, depending on the time of collection and average of multiple SU collection<sup>11</sup>. As for the FFQNa and 24-HrNa, there was no correlation. This was expected due to significant variability in the results achieved. This was also due to a large difference of value of means between the actual value of 24-HrNa and FFQNa. Systematic review reported that there were some studies that showed positive correlation between FFQNa and 24-HrNa, however most had weak relationship,  $r < 0.5$ <sup>30</sup>.

Nevertheless, FFQNa can be a reliable method in order to predict and identify and quantify sodium-rich food<sup>31</sup>.

**Table 5.** SU Na/Cr vs. 24-hour Urinary Sodium Excretion Studies

Correlation, r	N	Research
0.34	103	<sup>38</sup>
0.452	143	<sup>39</sup>
0.430	240	<sup>40</sup>
0.651 N1 am		
0.617 N2 pm	42	<sup>41</sup>
0.713 N3 am (next day)		
0.34	204	<sup>28</sup>

### Limitations

The limitation was that the completeness of the 24-hour urine collection was not verified by an objective marker. Although assessment of 24-HrCr excretion was used to determine whether the urine collection was complete, it was reported that this method had a low sensitivity for detecting all incomplete collection<sup>4</sup>. Samples were rejected if the urine volume was low. In some research, participants were asked to report any missed collections. In previous studies, para-aminobenzoic acid (PABA) was used to determine the completeness of the urine collection because PABA was excreted 95% through urine<sup>32</sup>. However, it was not popular due to the need to ingest the

PABA marker in the form of tablet multiple times during the time of urine collection. Thus, potential bias may occur in 24-hour urine collection by low response rate and undetected under collection<sup>33</sup>.

### Conclusion

Sodium intake is high among healthy young Malaysian adults. Single SUNa to estimate 24-HrNa urine excretion can be used as part of the nutritional assessment and to minimize the need for multiple visits to health care facilities. This method can also be used in population survey as it is very convenient, affordable and practical.

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**Ethical approval issue:** This study was reviewed and approved by the ethics committee of the National Medical Research Register (NMRR) of Malaysia. (KKM/NIHSEC/08/0804/P11-263)

**Individual authors contribution:** Conception – J.M.K.; Writer – J.M.K.; Data collection – J.M.K.; Analysis or interpretation – J.M.K., N.N., A.R.A.R.; Supervision – A.R.A.R., N.N.

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