Validation and reproducibility of a semi-qualitative food frequency questionnaire for assessment of sodium intake in Iranian population

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Abstract

Background Few semi-quantitative food frequency questionnaire (SFFQ) has yet been developed to assess sodium intake s in Middle East region. This study was performed to validate SFFQ for sodium consumption assessment and evaluation of food groups′ contribution in sodium intake.

Methods This was a validation study. This study was performed on 198 healthy participants aged ≥ 6 years in Isfahan city, central part of Iran in 2014–2015. They provided two SFFQ at the beginning and after one year to evaluate the reproducibility. The validity of SFFQ for assessment of sodium intake compared with 24-hour urine sodium and twelve 24-hour dietary recalls which were completed monthly during a year as two standard methods.

Results Correlation coefficient between the contribution of food groups to sodium intake based on SFFQ and 24-hour dietary recalls varied from 0.04 for legumes ($P = 0.667$) to 0.47 for added salt ($P < 0.001$). There was a significant correlation between the estimated total sodium intake based on SFFQ and both standard methods ($P < 0.01$). Intraclass correlation coefficient (95% CI) between first and second SFFQ had a diverse range from 0.10 (0.05–0.17) for fats and oils to 0.49 (0.28–0.69) for bread. According to the Bland-Altman plots, we observed an acceptable level of agreement between the two methods for sodium intake.

Conclusions The SFFQ was a relatively valid and reliable method for estimating sodium intake and food groups contribution in its intake. A combination of two or more methods will be useful in achieving more accurate results.

Introduction

According to United Nations' summit in the 2011 (1) and World Health organization (WHO) report, a 30% decrease in salt intake by 2025 is one of the 9 goals target and the most cost-effective strategy for non-communicable diseases prevention in all countries and regions (2). National initiatives and recommendations for reducing salt consumption in Iranian population need simple and precise tools for salt intake assessment to monitor the impact of their efforts in national surveillance programs and adherence to dietary guidelines. Awareness of which foods are the major contributors of salt is the other crucial subject could assist the policy makers to target those foods for salt reduction (3).

There is no national report of salt/ sodium intake in Iran. However, there were three 24-hour urinary sodium excretion (24hUNa) studies performed in representative adult population samples in the Isfahan, a city in central part of Iran. Daily salt intake based on 24hUNa, in the years 1999, 2002, and 2007, were 8.2, 12.5, and 10.6 g/d, respectively (4, 5). The major sources of sodium were different in various populations. Processed food contributes greatly to Na intake in the USA and the UK, salt added during home cooking in China (6) and bread in France (7). However, there is no report to indicate major sources of sodium in Iran.

There are several methods for assessment of sodium intake, and each method has different strengths and limitations (8). The 24hUNa is an objective measure considered to be the standard by WHO owing to its precision (9). However, because of high cost, participant burden and difficulty in urine collection, it deemed cumbersome for repeated measurement in large-scale epidemiological studies. Dietary assessment methods are the alternative techniques. The semi-quantitative food frequency questionnaire (SFFQ) has been proposed as an accurate tool which employed extensively for various reasons including assessment of food and nutrients intake as well as food contribution in nutrients consumption (10). It is the easiest and least expensive dietary assessment method with low recall bias for evaluation of usual dietary intake in large- scale studies (11). Although several studies validated SFFQ for various purposes among Iranian population, few SFFQ has yet been developed and validated to assess Na intake in Iran and Middle East region.

The current study was performed to validate SFFQ for salt consumption assessment compared with the standard method of 24hUNa and 24-hour dietary recalls (24DRs). Moreover, we aimed to validate the SFFQ for evaluation of total consumption and major sources of sodium and food groups' contribution in sodium intake compared to monthly 24DRs during a year as a dietary standard method.

Methods

Design and sampling:

This cross-sectional study was performed on healthy participants aged≥ 6 years in 2014-2015 by the Cardiovascular Research Institute and previously described in detail (12). Briefly, participants were recruited from Isfahan city, in central part of Iran. A total of 345 participants including 167 children and adolescents aged 6-18 years and 198 adults aged ≥ 19 years were eligible and scheduled for an initial visit. They provided at least one complete SFFQ, only adults had one 24-h urine collection sample. A complete urine sample was identified by a total 24-h urinary volume 500 mL and no menstruation during the collection period. Then we excluded the adolescents and adult participants who had less than nine 24DRs in a year and adult subjects who did not collected 24-h urine sample. Totally 147 subjects refused to complete study including dietary assessment interview or 24-h urine and/ or spot urine samples collection. Subjects were recruited from healthy individuals referred to the Isfahan Cardiovascular Research Institute (ICRI) clinics for routine check-up. Inclusion criteria was age ≥ 6 years, while exclusion criteria included history of diabetes insipidus, special dietary regimen or fasting at the day and time of sampling, history of using diuretics, history of renal insufficiency, menstruation, oral contraceptives use or pregnancy in women, and excessive sweating during the day of urine collection. The study was approved by the Isfahan Cardiovascular Research Institute (a WHO collaborative center) ethics committee. Written informed consents were obtained from adult participants and the parents of children and adolescents.

Data collection:

Trained health professionals carried out detailed interviews at study baseline to obtain required information about participants' socioeconomic, demographic characteristics and smoking status. Physical activity was assessed by means of International Physical Activity Questionnaire (13).

Anthropometric measurements: At the baseline visit, the trained health professionals measured standing height without shoes and recorded it to the nearest 0.5 cm. Body weight was measured with the subjects wearing light clothes, without shoes and recorded it to the nearest 0.5 kg (14).

Blood pressure measurement: Blood pressure (BP) was measured, manually by a trained operator using a mercury sphygmomanometer according to a standard protocol (15), twice each from right and left arms in sitting position after 5 minutes of rest. The first Korotkoff sound was recorded as the systolic BP and the disappearance of the sounds (V phase) was considered as the diastolic BP. The values of BP used in analysis were the recorded mean level of measured BP in higher arm (15).

Validity and reproducibility of the SFFQ:

The SFFQ was completed twice, at the beginning of the study and after one year to evaluate the reproducibility. The initial FFQ was accompanied by the first 24DR which was administered by trained dietitian. The validity of SFFQ as a subjective method for assessment of sodium intake compared with the gold standard 24hUNa was carried out at baseline and after one year at the end of the study. We utilized twelve 24DRs which were completed monthly during a year as another gold standard for estimation of SFFQ validation for the assessment of total consumption and food groups′ contribution in sodium intake. Details were presented in previous publication (12). The first 24DR was completed by trained nutritionist in their baseline visit to ICRI and the trained nutritionist completed the others monthly through call interview.

Initially face and content validity of the questionnaire were confirmed by an expert panel consisting of 10 nutrition experts and calculating content validity ratio (CVR) and content validity index (CVI) (12). The final SFFQ contained 165 food items were categorized into 11 groups including: 1) dairy products; 2) fruits; 3) vegetables; 4) meat, poultry, fish and egg; 5) grains and legumes; 6) mixed dishes, prepared foods, restaurant foods and fast foods; 8) nuts and seeds; 8) oils and fats; 9) sauces and desserts; 10) drinks; 11) others. Respondents were asked how many times they consume the foods, scoring the frequency in ten option categories ('seldom/never', '1 per month', '2–3 per month', '1 per week', '2–3 per week', '4–6 per week', '1 per day', '2–3 per day', '4–5 per day' and '6 or more per day'). All reported numbers were converted to daily frequency and multiplied by the portion size indicated. Seldom and never were calculated as "zero".

Dietary intake analyses: The 24DRS and SFFQ were coded by giving a gram weight to every portion reported. Using Iranian Food Consumption Program (IFCP) designed by ICRI (16), the nutrient and food group intakes were calculated. It has a research quality nutrient database analyzing nutrients and calories for a variety of food items using the Iranian Food Composition Table (17), which was translated to Persian and modified based on USDA National Nutrient Database. Trained nutritionists assisted in

fulfillment and rechecking as well as data entry of the assembled dietary questionnaire. The reliability of the questionnaire was obtained through a test and re-test process and completing the SFFQ twice at the beginning and after one year of the study.

Statistical analysis:

We calculated the means and SDs for estimated sodium intake from SFFQ as examined method, 24DR and measured 24hUNa as standard methods. To assess agreement between SFFQ and standard methods, paired t-test with logarithmic transformations were conducted to examine the difference in estimated sodium intake based on SFFQ and standard methods including 24hUNa and 24DRs. Spearman's test and intraclass correlation (ICC) were used to evaluate the correlation between sodium intake assessed by SFFQ and standard methods. The Bland-Altman analysis of agreement method was used to estimate the mean bias and 95% limits of agreement between SFFQ and standard methods. For this method, the difference of estimated sodium from (SFFQ – 24DRs or 24hUNa for each participant is plotted against the mean of the two methods. Cross classification between SFFQ and both standard methods were evaluated by calculating frequency of participants in the same adjacent and opposite categories of SFFQ and each standard method. The frequency of All statistical analyses were performed with SPSS for Windows 19.0 (SPSS Inc., Chicago, IL, USA). P values less than 0.05 were considered statistically significant.

Results

After exclusion of subjects with incomplete dietary recalls and urine samples, a total of 113 adults (60 women, 53 men) and 106 children and adolescents were included in the final analysis. Table 1 illustrates the subjects' socio-demographic characteristics in the validation phase. The mean age of adults was 39.93 ± 10.77 while in children and adolescent was 12.35 ± 3.21 years. Generally, 46.9% of adults were composed of male participants and 50% of children and adolescence were boys.

Table 1
Basic characteristics of participants based on gender in adults, children and adolescents

	Adults	**Children and Adolescence**
	n = 113	**n = 112**
Age (year)	39/93 ± 10.77	12.35 ± 3.21
Sex (Male) n (%)	53 (46.9)	56 (50)
Marital status n (%)		
Single	18 (15.9)	99 (93.4)
Married	91 (80.5)	1 (6.6)
Spouse (dead/ divorced)	4 (3.6)	-
Education n (%)		
Illiterate and elementary school	15 (13.2)	-
Guidance school	22(19.4)	-
High school and diploma	39 (34.5)	-
University	37 (32.7)	-
Education (Father) n (%)		
Illiterate and elementary school	-	20 (18.8)
Guidance school	-	30 (28.3)
High school and diploma	-	47 (44.3)
University	-	9 (8)
Education (Mather) n (%)		
Illiterate and elementary school	-	17 (16)
Guidance school	-	35 (33)
High school and diploma	-	39 (36.8)
University	-	15 (14.2)
Weight (kg)	71.82 ± 15.18	44.77 ± 17.31
Height (cm)	165.37 ± 10.17	148.43 ± 16.78

*BMI: Body mass index

**WC: Waist circumference

	Adults n = 113	Children and Adolescence n = 112
BMI * (kg/m^2)	26.43 ± 4.32	19.58 ± 4.56
WC ** (cm)	91.36 ± 11.60	70.44 ± 12.37
Physical activity (METS min/week)	547.12 ± 216.56	653.42 ± 249.53
Systolic Blood pressure (mmHg)	115.88 ± 11.00	103.02 ± 12.05
Dystonic Blood pressure (mmHg)	72.31 ± 8.99	59.54 ± 7.17
24 – hour urinary Sodium (mg/d)	4130.8 ± 1741.56	-
24 – hour urinary Potassium (mg/d)	3801.72 ± 861.51	-
24 – hour urinary Creatinine (mg/d)	1287.85 ± 577.22	-
24 – hour urinary Volume (ml/d)	1174.82 ± 671.54	-
*BMI: Body mass index		
**WC: Waist circumference		

As presented in (**Supplementary Table 1)**, in both phases, the mean intakes of sodium and salt in adults and also children and adolescents were significantly higher compared to those from 24DRs (all p values < 0.01). Also, in the first phase, there was no significant difference between the mean of sodium and salt derived from SFFQ when compared to the standard method of 24-h urine samples however, it was significantly higher in the second SFFQ (all p values < 0.001). Table 2 shows the Spearman correlation coefficient between the contribution of food groups to sodium intake based on data from first and second SFFQ, with 24DRs in adult population. This correlation varied from non-significant for legumes (0.04) in the first phase (P = 0.667) to significant correlation for added salt (0.47) in the second phase (P < 0.001). It was ranges, from non-significant correlation for legumes (0.09, P = 0.42) in the first phase up to significant correlation for bread in the second phase (0.45, P < 0.001) among children and adolescents. There was a significant correlation between the estimated sodium intake based on first and second SFFQ with 24DRs and 24hUNa in adults (P < 0.01).

Table 2
Spearman correlation coefficient between sodium and salt intake estimated by food frequency questionnaires and 24-hour dietary recalls based age group

Food groups (gr/ day)	Adults		Children and adolescents	
	Time 1	Tome 2	Time 1	Time 2
	ρ (P)*	ρ (P)	ρ (P)	ρ (P)
Dairy (except cheese)	0.19 (0.126)	0.26 (0.0101)	0.24 (0.030)	0.29 (0.006)
Cheese	0.41 (< 0.001)	0.45 (< 0.001)	0.32 (0.003)	0.42 (< 0.001)
Fruits	0.27 (0.004)	0.31 (0.002)	0.11 (0.172)	0.20 (0.051)
Salty vegetables	0.25 (0.044)	0.33 (0.002)	0.27 (0.009)	0.32 (0.003)
Other vegetables	0.07 (0.594)	0.28 (0.004)	0.31 (0.004)	0.36 (0.002)
Bread	0.21 (0.029)	0.45 (< 0.001)	0.27 (0.004)	0.45 (< 0.001)
Other cereals	0.24 (0.025)	0.29 (0.008)	0.22 (0.034)	0.25 (0.026)
Meat	0.24 (0.051)	0.37 (< 0.001)	0.23 (0.035)	0.35 (0.003)
Legumes	0.04 (0.667)	0.14 (0.192)	0.09 (0.452)	0.11 (0.326)
Canned foods	0.21 (0.019)	0.31 (0.002)	0.39 (< 0.001)	0.43 (< 0.001)
Fast food	0.30 (0.004)	0.42 (< 0.001)	0.28 (0.014)	0.44 (< 0.001)
Nuts and seeds	0.27 (0.007)	0.35 (0.001)	0.28 (0.006)	0.32 (0.003)
Sweets and soft drinks	0.35 (< 0.001)	0.37 (< 0.001)	0.39 (< 0.001)	0.42 (< 0.001)
Junk foods	0.26 (0.005)	0.35 (0.002)	0.41 (< 0.001)	0.43 (< 0.001)
Oils and fats	0.13 (< 0.197)	0.29 (0.009)	0.25 (0.011)	0.24 (0.031)
Souses	0.24 (0.010)	0.36 (0.001)	0.24 (0.030)	0.35 (0.004)
Added salt	0.46 (< 0.001)	0.47 (< 0.001)	0.35 (0.001)	0.40 (< 0.001)
Total sodium**	0.41 (< 0.001)	0.65 (< 0.001)	0.37 (0.001)	0.61 (< 0.001)
Total sodium***	0.27 (0.004)	0.35 (0.002)	-	-

*ρ (P): Spearman correlation coefficient (P. value); **Based on 24-hour dietary recalls (mg/ day); ***Based on 24-hour dietary recalls (mg/ day)

ICC (95% CI) between first and second SFFQ for assessment of sodium intake had a diverse range from 0.11 (-0.15 -0.37) for legumes up to 0.49 (0.28–0.69) for bread in adults. These values ranged among children and adolescents from 0.10 (0.05–0.17) for fats and oils to 0.47 (0.17–0.66) for breads (Table 3).

Supplementary Table 2 depicts the Kappa agreement and the frequency of participants in the same, adjacent and opposite quartiles of sodium estimates, based on SFFQ compared with a 24DRs and 24hUNa. The proportion of adult participants in the same quartiles varied from 28.3% for 24hUNa in the first phase to 63.7% for 24DRs in the second phase, while in the same and adjacent quarters ranged from 72.6% for 24hUNa in the first phase to 78.7% for 24DRs in the second phase. In the opposite quartile, the percentage of participation ranged for 3.5% 24DRs of the second phase up to 8.8% for the 24hUNa in the first phase.

Table 3
Reproducibility of food frequency questionnaire for assessment of sodium dietary intake

Food groups (gr/ day)	Adults		Children and Adolescence	
	ICC (95% CI) *	P-value	ICC (95% CI)	P-value
Dairy (except cheese)	0.36 (0.18–0.52)	< 0.001	0.43(0.23–0.59)	< 0.001
Cheese	0.45 (0.28–0.59)	< 0.001	0.28 (0.06–0.47)	0.007
Fruits	0.30 (0.12–0.48)	0.001	0.18 (0.04–0.38)	0.053
Salty vegetables	0.34 (0.16–0.52)	< 0.001	0.37 (0.16–0.55)	< 0.001
Other vegetables	0.31 (0.12–0.49)	0.001	0.39 (0.19–0.56)	< 0.001
Bread	0.49 (0.28–0.69)	< 0.001	0.47 (0.17–0.66)	< 0.001
Other cereals	0.31 (0.13–0.50)	< 0.001	0.36 (0.16–0.54)	< 0.001
Meat	0.46 (0.25–0.68)	< 0.001	0.45 (0.24–0.65)	< 0.001
Legumes	0.11 (-0.15–0.37)	0.179	0.17 (-0.04–0.38)	0.061
Canned Foods	0.33 (0.15–0.52)	< 0.001	0.21 (0.07–0.35)	0.008
Fast Food	0.35 (0.18–0.55)	< 0.001	0.24 (0.05–0.45)	0.005
Nuts and seeds	0.21 (0.01–0.40)	0.032	0.20 (0.03–0.42)	0.035
Sweets and soft drinks	0.32 (0.13–0.49)	< 0.001	0.48 (0.29–0.63)	< 0.001
Junk foods	0.36 (0.17–0.54)	< 0.001	0.40 (0.21–0.57)	< 0.001
Oils and fats	0.19 (0.10–0.18)	0.166	0.10 (-0.05–0.27)	0.058
Souses	0.20 (0.005–0.37)	0.031	0.18 (0.03–0.36)	0.037
Added salt	0.48 (0.28–0.71)	< 0.001	0.34 (0.22–0.58)	< 0.001
Total sodium**	0.43 (0.24–0.63)	< 0.001	0.35 (0.17–0.43)	0.001

*ICC (95%): Intraclass correlation coefficient (95% confidence interval); **Based on 24-hour dietary recalls (mg/ day)

According to the Bland-Altam plots, the mean bias of sodium intake based on SFFQ compared to 24DRs was 453.7 mg /day in adults. Also, the mean bias of sodium intake according to the second SFFQ was 443.8 mg /day in adults when compared to the 24DRs. In adults, the mean bias of sodium estimation based on SFFQ compared to 24hUNa was 239 mg /day and 525.1 mg/day in the first and second phases, respectively (Fig. 1). In children and adolescents, the mean bias of estimated sodium intake was 532.4 mg/day based on first SFFQ and 517.1 mg /day based on second SFFQ compared to the 24DRs (Fig. 2).

Discussion

The results of this study showed that the SFFQ had a reasonable validity in determining the sodium or salt intake in adults, children and adolescents in comparison with the standard method of 24DRs. The validity of SFFQ was relatively good in adults as compared to the 24hUNa. In this study, SFFQ overestimated the sodium intake compared to the other two standard methods. The overestimation of nutrients by SFFQ compared to other dietary assessments has been previously reported by several studies (18, 19, 20). Reproducibility of the SFFQ for assessment of sodium intake was acceptable. Although the validity of SFFQ was good but according to the Bland-Altman plots, the current bias between SFFQ and standard methods was about 500 mg sodium which was equivalent to 1.2 gr of salt. Since the mean of salt intake per day was higher than 10 gr (21), we speculate one gram of salt intake bias is not high.

Various studies indicated a wide range of validity ranging from 0.04 to 0.91 for dietary assessment methods compared to 24hUNa (22, 23, 24). According to a pooled analysis of Freedman et al of five validation studies, the mean validity of SFFQ for estimation sodium intake was 0.16 and the underestimation of the SFFQ compared to 24hUNa was 5.6% (25). The current study found a similar cross-classification agreement and higher validity and of SFFQ for sodium assessment than Xu et al' s study among Chinese women (24), while relatively less reproducibility. This is probably because of the short interval of two-week between the two SFFQs in Xu et al' s study (24). Sasaki et al. (22) showed a less validity of SFFQ for assessment of sodium intake compared to 24hUNa than the current study (26). Consistent to our findings, Reinivuo et al. (27) reported that the classification of individuals in the same and adjacent quartiles was relatively comparable in both methods. Similarly, several studies conveyed overestimation of sodium intake by dietary assessment compared to the 24hUNa (3, 27, 28). It could be reasonable since about 90% of total sodium intake might be excreted from urine (29, 30). On the contrary, the underestimation of SFFQ observed in the Finnish study (27) might have been due to collecting urine samples on Sundays, however most recall days were weekdays. It was reflecting a more consumption of high content of sodium foods during the weekends. In the current study, we estimated discretionary salt which was added at table and cooking through questioning about the weight of salt packages, the number of households, and the period of time that each salt package is used (31, 32). In the line with previous studies, adding these questions to SFFQ improved the validity and reproducibility of the questionnaire (31, 32). Our SFFQ was also valid in estimating the contribution of major food sources in sodium intake including added salt, bread, cheese meet, fast food, canned food, nuts and seeds, sweet

and soft drinks and junk food, sauce and salty vegetables due to reasonable correlation coefficients between the SFFQ and the standard method of 24DRs in both age groups.

A study among Belgian school-aged children reported that the validity of SFFQ for assessment of food intake compared to a 24DRs varied from 0.10 for potato to 0.65 for skimmed milk (33). Similar to our study, they indicated an overestimation of foods such as cereals, beverages, and dairy products (33). Fumagalli et al. similarly reported that the validity of a SFFQ assessing against 24DRs in children (5–10 yrs) ranged between 0.5–0.7 for most nutrients, however it was low and prone to overestimation of sodium (34).

Possible causes of the inconsistency can be attributed to the daily changes in 24-h urine samples, individuals' recalling errors during dietary assessments, and lack of completeness and accuracy of food composition tables (22). Recently Titze et al. suggested that salt can be stored gradually and in a great extent in the inner layer of skin. Therefore, the homeostasis of intercellular sodium cannot be confined to the kidneys, and thus, the sodium estimates by 24-h urine collection might not be accurate (35). Further potential explanations for these dissimilarities can be due to the excretion of sodium via sweat, which varies greatly depending on the type of weather and physical activity (28). Also, underestimations in 24-urine collection can simply occur through errors in urine collection methods or the loss of urine volumes. These errors were avoided in the current and previous studies (36) by calculating 24-h creatinine/weight ratio, and questioning about the individuals' complete urine collection. On the other hand, there are several errors related to the SFFQ such as, lack of completeness and accuracy of food composition tables, errors in individuals' reports, different sodium content in food items, and daily alterations in diet (22). Precise measurement of sodium intake is rather challenging, due to diverse distribution of sodium in foods, widespread use of sodium compounds in processed foods as well as drinking water, and high consumption of salt at the table (32).

We used the latest food composition table with primary sources being the closest to Iranian food and cuisine. The table was enhanced by adding the sodium content of sodium-containing foods, measured in previous studies (37). Over- and underestimations in sodium intake has been similarly reported by various studies, however since the most national community-based studies examined the trend of salt intake and also have categorized the people based on nutrients such as sodium, the error in the amounts of intake, when it does not correlate with the high and low levels of intake, is negligible.

Strengths and limitations:
The first strength was encompassing two standard methods including 24DRs and 24hUNa. The second strength was the wide range of age group of study population 6 years and over. This study has also accounted for the seasonal variation, hence collecting twelve 24DRS, as a dietary standard method, during one year. The limitations of this study included recall bias of in SFFQ and 24DRs, overestimation of SFFQ and using single 24-h urine collection. Finally, a larger study population could have been a valuable asset to increase the capability and accuracy the findings.

Conclusion:

The present study suggested that SFFQ was a relatively valid and reliable method for estimating total sodium intake and food groups contribution in its intake in both adults and children and adolescents. However, this method overestimated the sodium intake. Since each method has its own strengths and weaknesses in assessments of food consumption, a combination of two or more methods will be useful in achieving more accurate results. Hence, the use of a valid SFFQ along with the valid urine collection method can be effective in accurate estimation of sodium intake.

Abbreviations

WHO
World Health Organization
24hUNa
24-hour urinary sodium excretion
SFFQ
Semi-quantitative food frequency questionnaire
24DRs
24-hour dietary recalls
ICRI
Isfahan Cardiovascular Research Institute
BP
Blood pressure
CVR
Content validity ratio
CVI
Content validity index
IFCP
Iranian Food Consumption Program
ICC
Intraclass correlation

Declarations

Ethics approval and consent to participate:

The study was approved by the Isfahan Cardiovascular Research Institute (a WHO collaborative center) ethics committee. Written informed consents were obtained from adult participants and the parents of children and adolescents.

Consent for publication:

All authors consent to the publication of the manuscript in Nutrition Journal.

Availability of data and materials:

The authors confirm that the data supporting the findings of this study are available.

Competing interests:

We declare that we have no conflict of interest.

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Authors' contributions:

NM, AKH & NS designed the study; NM &AKH collected the data; AF analyzed the data; NM, AE & ZA interpreted the data; NM & NG wrote the first draft; All authors read and confirmed the manuscript.

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Figures

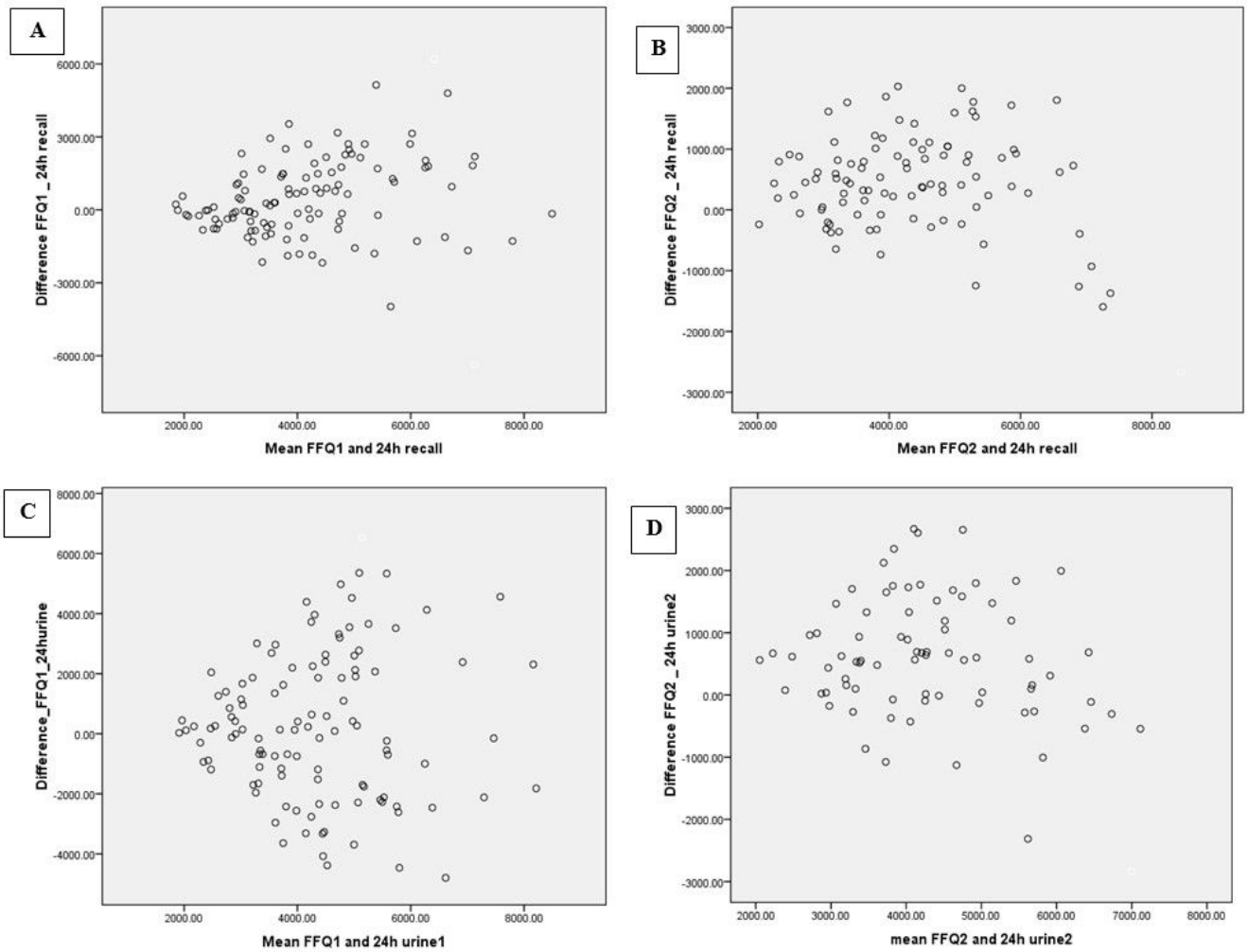

Figure 1

Bland-Altman plots of the mean bias (difference in agreement) between sodium intake assessed by food frequency questionnaire and 24-hour recall (A), Time 1 (B) Time 2 or measured 24-hour urinary sodium excretion (C), Time 1 (D) Time 2 in adult participants. The mean bias for each individual is the assessed sodium intake by food frequency questionnaire minus assessed by 24-hour recall (A and B) or minus measured 24-hour urinary excretion (C and D and is plotted against the mean of sodium intake assessed

by food frequency questionnaire and 24-hour recall (A and B) or assessed by food frequency questionnaire and measured 24-hour urinary sodium excretion (C and D).

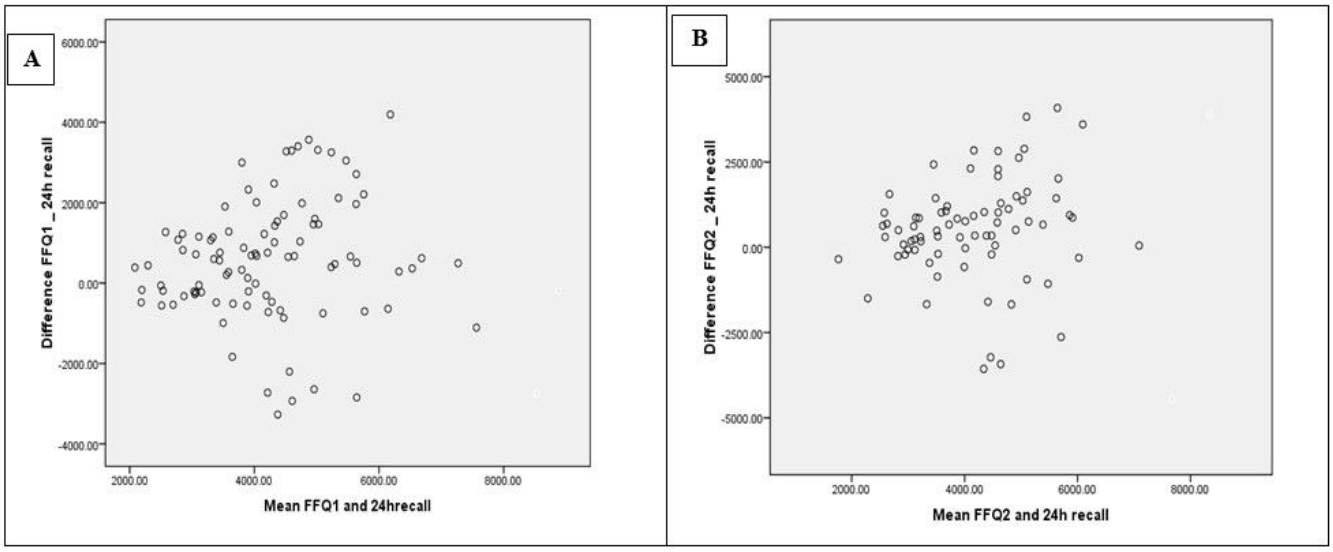

Figure 2

Bland-Altman plots of the mean bias (difference in agreement) between sodium intake assessed by food frequency questionnaire and 24-hour recall (A), Time 1 (B) Time 2 in children and adolescent participants. The mean bias for each individual is the assessed sodium intake by food frequency questionnaire minus assessed by 24-hour recall and is plotted against the mean of sodium intake assessed by food frequency questionnaire and 24-hour recall.

Supplementary Files

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