



Original Article

Higher dietary salt and inappropriate proportion of macronutrients consumption among people with diabetes and other co morbid conditions in South India: Estimation of salt intake with a formula

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ABSTRACT

Aim: The present study analysed the regular salt and macronutrients consumption of South Indian population with diabetes, hypertension and renal dysfunction.

Methods: The cross sectional study was performed among 200 subjects, divided into four different groups consisted of control, subjects with type 2 diabetes (T2DM) without any other complications, T2DM subjects with chronic kidney disease (CKD) and T2DM subjects with hypertension (HTN). The dietary salt intake was estimated from 24-h urinary sodium excretion and the amount of macronutrients was calculated using 24-h dietary recall method.

Results: Out of 200 study subjects, only 28 (14%) were consuming salt as per the recommended levels by WHO (i.e., 5–6 g/day). Thirty-eight (19%) subjects were consuming more than 18 g of salt per day, 67 (33.5%) were consuming 12–18 g of salt per day and another 67 (33.5%) were found to be consuming salt in a range of 6–12 g/day. Calorie contribution from the carbohydrates was significantly high compared to the calories from the proteins. Fat consumption and its corresponding energy contribution were also high among HTN group subjects.

Conclusion: Observations of the study point out to the requirement of nationwide intensive and persistent efforts to enhance the public awareness on salt reduction.

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1. Introduction

The incidence of diabetes mellitus, hypertension and chronic kidney diseases are steadily increasing across the world. Diet, accompanied by lifestyle factors, is an important determinant of the health status of an individual, especially those suffering from Diabetes mellitus, hypertension, cardiovascular (CVD) and chronic kidney diseases (CKD). High dietary sodium is recognised as a silent killer responsible for millions of deaths worldwide, secondary to hypertension and its complications. Studies from diverse parts of the world designate that sodium consumption of a wide population in many countries is quite larger than their physiological need [1] as well as the recommended levels by the World Health Organization [2]. Although high salt consumption is considered as a worldwide

public health problem, its magnitude is highly variable among different communities. Strong evidence on the role of salt reduction in individuals with various health issues is still lacking. The analysis of dietary habits at the population level provides vital information on the frequency and distribution of inadequate diets or nutritional status. It is also useful in the design of population-based interventions targeting the improvement of dietary habits at the community level as well as for managing different health issues.

Salt consumption of Indians was estimated to be higher than the recommended values in various states owing to the diversity in the food habits and culture [3]. The types of food consumed by each community vary enormously and consequently the salt and micronutrient intake. Individuals are highly ignorant about the quantity of sodium they are consuming every day and also about the unfavourable effects of excessive salt consumption on health. Therefore, it is important to evaluate the amount of salt and other micronutrients consumed by different population and educate them about the surpluses as well as deficiencies of essential nutrients. Formulation of evidence-based guidelines and policies and

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conduction of national salt reduction program is of prime necessity in India in the present scenario [4]. The knowledge about the dietary intake and its variation from the recommended dietary allowances is highly helpful in formulating the personalised diet plans in local populations with different health issues. Only a few studies were reported earlier to analyse the dietary salt and macronutrient consumption of South Indian population [5–7]. All of these studies were performed in the healthy population and none of them attempted to evaluate the dietary salt and macronutrient consumption of individuals with lifestyle diseases like diabetes, hypertension as well as renal diseases. The present study was intended to assess the regular salt and macronutrients consumption as well as its important correlation with diabetes, hypertension and renal dysfunction in South Indian population. An effort is also taken to summarise the recommended dietary intake and the current knowledge related to the association between sodium consumption, blood pressure and the risk of CVD and CKD.

2. Subjects, materials and methods

2.1. Research design and participants

A total of 200 subjects aged between 25 and 70 years (111 males and 89 females), who were not received or following any dietary advice previously, were recruited for this cross-sectional study. Subjects were divided into four different groups, with 50 members each, designated as control (group I), T2DM (group II), CKD (group III) and HTN (group IV). Group I consisted of healthy subjects those were not consuming or received any diuretics or relevant medications within the six months before the assessment and volunteered to provide 24 h urine samples for the study. Group II, III and IV subjects were recruited from the patients admitted in a tertiary care centre for diabetes in South India during the study period of April 2018 to March 2019. Group II consisted of individuals having type 2 diabetes with normal blood pressure and not having any other complications. Group III consisted of individuals with type 2 diabetes and chronic kidney disease (stage 2 and 3 classified based on KDOQI guidelines) [8]. Group IV consisted of individuals having type 2 diabetes as well as stage 2 hypertension (systolic blood pressure ≥ 140 mm Hg and diastolic blood pressure ≥ 90 mm Hg based on American Heart Association 2017 guideline for diagnosis of hypertension) [9] and not having any other complications. Subjects with any acute concurrent illness in the previous six months (e.g. malignancy, severe gastrointestinal disease), history of non-diabetes or obstructive kidney disease, history of cardiovascular or cerebrovascular diseases and subjects not willing to provide 24-h urine collection sample, and pregnant women were excluded from the study. Subjects on statins or using immunomodulatory medications were also excluded from the study. The study protocol was approved by the institutional ethics committee (Ref IEC/N-004/03/2019) and all methods were performed in accordance with the relevant guidelines and regulations of the institution. The written informed consent was obtained from all study participants in agreement with the principles of the declaration of Helsinki.

2.2. Clinical and biochemical parameters

Anthropometric and demographic details like age, height, weight and BMI were recorded for all the study subjects. Biochemical parameters such as fasting and postprandial blood glucose (glucose oxidase - peroxidase method), serum triglycerides (glycerol phosphate oxidase - peroxidase - amidopyrine method), serum total cholesterol (cholesterol oxidase - peroxidase amidopyrine method), high density lipoprotein (HDL) (direct method-polyethylene glycol-pre-treated enzymes), low density

lipoprotein (LDL) (direct method-polyethylene glycol-pre-treated enzymes), urea (glutamate dehydrogenase UV absorption assay) and creatinine (Jaffe's method) were analysed using Mindray BS400 fully automated biochemistry analyser. Glycated haemoglobin A1c (HbA1c) was estimated by immunoturbidimetric method (Roche Cobas C 311). Glomerular filtration rate (EGFR) was calculated based on CKD - EPI equation.

The amount of carbohydrates, protein and fat consumption was calculated using 24-h dietary recall method. Nutritive value of Indian foods published by National Institute of Nutrition (NIN) [10] was used to assess 24-h dietary recall data. Dietary salt intake was calculated based on the amount of sodium excreted in 24-h urine collection samples, as it is considered the gold standard [11]. Urinary sodium excretion was measured by direct ion-specific electrode method using Easy Lyte® PLUS Na/K/Cl Analyser, MEDICA, USA. The amount of salt intake was calculated from urinary sodium excretion by the standard method ($1 \text{ mEq of sodium} = 58.5 \text{ mg of NaCl}$) using the formula: Amount of salt = (Urinary sodium per 24hr $\times 0.023$)/0.397.

2.3. Statistical analysis

Statistical analyses were performed using IBM SPSS Version 20.0 software. Mean and standard deviation for continuous variables and percentages for categorical variables are reported accordingly. T-test and Chi-square test were performed as applicable for comparing the variables between different groups, and a P value < 0.05 was considered to be statistically significant.

3. Results

The anthropometric and biochemical parameters analysed for different study groups are given in Table 1. The control group subjects were younger compared to the other study groups. Substantial variation was found in the mean age between T2DM and CKD ($p < 0.001$) group subjects and also among T2DM and HTN ($p < 0.05$) group subjects. The BMI of all the three study groups except the control group was falling under the overweight (between 25 and 30) category defined by WHO. The BMI of CKD and HTN groups varied remarkably ($p < 0.05$ and $p < 0.01$ respectively) from the control group. A notable difference ($p < 0.05$) was also observed in the BMI among T2DM and HTN groups.

All the study groups except the control group had significantly higher fasting and postprandial blood glucose levels indicating poor glycemic control. The mean HbA1c value for the control group was comparatively lower than the other study groups. Even though the HbA1c values of T2DM, CKD and HTN groups were drastically elevated, there was no significant difference noted among the groups. Urea and creatinine levels were elevated and the glomerular filtration rate was drastically reduced ($p < 0.001$) in the CKD group compared to the control group. A considerable difference was also observed in the urea ($p < 0.001$) and GFR ($p < 0.001$) values among CKD and HTN groups and also between CKD and T2DM groups. But there was no significant variation observed in the urea, creatinine and GFR values among T2DM and HTN group. Total cholesterol, triglycerides, LDL, VLDL and non HDL values for all the groups were found to be within the normal range. However, HDL values of CKD group were slightly lower than the recommended healthy range. Moreover, there was also a prominent difference ($p < 0.001$) in the triglyceride values of CKD and HTN group individuals compared to the control group.

Table 2 illustrates 24hr urinary sodium excretion, the sodium-creatinine ratio as well as calculated dietary salt intake of various study groups. Urinary sodium excretion for the control group was $217.4 \pm 100 \text{ mmol/24h}$ and the estimated dietary salt intake was

Table 1
Demographic, anthropometric and biochemical parameters of the study groups.

Parameters/Groups	Control	T2DM	CKD	HTN
Age (years)	37.48 ± 9.72	49.94 ± 8.84***	61.02 ± 9.63***##	54.34 ± 8.62***##
Body mass index (Kg/m ²)	24.94 ± 3.69	25.58 ± 3.85	27.10 ± 5.02*	28.30 ± 6.19**
Systolic BP (mm Hg)	113 ± 10	116 ± 9	126 ± 17***##	150 ± 17***##
Diastolic BP (mm Hg)	72 ± 7	74 ± 6	75 ± 8*	88 ± 7***##
Fasting Plasma Glucose(mg/dL)	92.46 ± 9.98	176.41 ± 95.20***	169.40 ± 79.04***	165.02 ± 60.58***
Post Prandial Glucose(mg/dL)	111.20 ± 17.52	261.49 ± 84.02***	254.63 ± 102.46***	234.28 ± 75.95***
HbA1c (%)	5.42 ± 0.38	8.94 ± 2.62	9.84 ± 2.28	8.24 ± 1.69
Urea(mg/dL)	18.11 ± 4.97	22.00 ± 6.21	49.58 ± 29.71***##	21.02 ± 4.88##
Creatinine(mg/dL)	0.89 ± 0.12	0.94 ± 0.12	1.81 ± 1.11	0.95 ± 0.15
eGFR (ml/min/1.73m ²)	91.65 ± 10.39	86.24 ± 12.68	46.68 ± 19.37***##	80.52 ± 16.43***##
Total Cholesterol (mg/dL)	168.26 ± 13.44	165.02 ± 40.45	145.84 ± 49.24*	153.13 ± 37.37
Triglycerides (mg/dL)	105.26 ± 24.32	126.15 ± 57.30*	135.86 ± 55.78***	133.53 ± 66.78***
HDL (mg/dL)	45.00 ± 06.92	41.46 ± 12.96	37.65 ± 16.03	42.81 ± 12.32
LDL (mg/dL)	95.11 ± 11.69	93.12 ± 21.91	86.02 ± 31.81	88.13 ± 24.74
VLDL (mg/dL)	28.16 ± 11.95	25.76 ± 11.56	25.91 ± 13.98	22.53 ± 09.98
Non HDL (mg/dL)	123.26 ± 12.16	117.75 ± 31.09	111.74 ± 43.08	103.94 ± 28.77

Values are Mean ± SD, * (p < 0.05), ** (p < 0.01), *** (p < 0.001) versus control group; # (p < 0.05), ## (p < 0.01), ### (p < 0.001) versus T2DM group and † (p < 0.05), ‡ (p < 0.01), §§ (p < 0.001) versus CKD group.

Table 2
Urinary sodium excretion and dietary salt intake of various study groups.

Groups	U Na Excretion (mmol/day)	Na/Crt Ratio	Salt Intake (g/day)
Control	217.44 ± 100.40	214.98 ± 70.63	12.60 ± 5.82
T2DM	250.76 ± 114.12	280.58 ± 160.05**	14.52 ± 6.62
CKD	204.6 ± 121.33	271.12 ± 161.50*	11.85 ± 7.03
HTN	230.78 ± 81.12	242.13 ± 96.62	13.37 ± 4.70

Values are Mean ± SD, * (p < 0.05), ** (p < 0.01), *** (p < 0.001) versus control group; # (p < 0.05), ## (p < 0.01), ### (p < 0.001) versus T2DM group and † (p < 0.05), ‡ (p < 0.01), §§ (p < 0.001) versus CKD group.

12.6 ± 5 g/day. The urinary sodium excretion and dietary salt intake of T2DM group subjects were found to be 250.8 ± 114 mmol/24h and 14.5 ± 6 g per day respectively. HTN group subjects were estimated to consume 13.4 ± 4 g salt per day and their urinary sodium excretion was 230.8 ± 81 mmol/24h. Urinary sodium excretion of CKD group subjects was 204.6 ± 121.33 mmol/24h and they were found to consume 11.9 ± 7 g of salt per day. There was only a minor variation observed in the urinary sodium excretion (p > 0.05) and salt intake (p > 0.05) levels among the study groups. However, there was a substantial difference observed in the amounts of salt consumed by all the study groups when compared with the recommended salt intake levels (5–6 g/day) by WHO. All the study subjects including those having hypertension and CKD were found to be consuming nearly double the amount of salt than that recommended for the healthy individuals. T2DM group individuals were found to be consuming a comparatively higher amount of salt per day than the other study groups.

Table 3 represents the number and percentage distribution of various study group subjects falling under different salt consumption range. Out of 200 study subjects, only 28 (14%) were consuming the salt in the recommended levels (i.e., below 6 g/

day). Sixty-seven (33.5%) were found to consume salt in a range of 6–12 g/day and another 67 subjects (33.5%) were consuming 12–18 g of salt per day. Thirty eight subjects (19%) which consists of 10 subjects from control group (26.32%), 16 subjects (42.11%) from T2DM group and 6 subjects each (15.79%) from both CKD and HTN group were consuming above 18 g of salt per day which is more than thrice the amount of recommended salt intake for healthy individuals.

While considering the percentage distributions of subjects falling under different salt consumption range within the group, out of 50 subjects in the hypertension group, only 10% were consuming less than 6 g of salt/day. The remaining 34%, 44% and 12% of subjects were consuming 6–12 g, 12–18 g and more than 18 g of the salt/day respectively. In the CKD group as well, only 22% were consuming less than 6 g of salt/day. The rest 30%, 36% and 12% were consuming 6–12 g, 12–18 g and more than 18 g of the salt/day respectively. Similarly, 12%, 44%, 24% and 20% of subjects from control and 12%, 26%, 30% and 32% of subjects from T2DM groups were taking less than 6 g, 6–12 g, 12–18 g and more than 18 g of salt respectively per day.

Table 4 describes the dietary macronutrients consumption of various study groups calculated from their 24hr dietary recall. Total carbohydrate and protein consumption of Control, T2DM and CKD groups showed a similar range. However, subjects with hypertension were found to be consuming a comparatively higher amount of carbohydrate and protein compared to the control group. Fat consumption of HTN group individuals was found to be remarkably higher than control (p < 0.01) and CKD group (p < 0.001). T2DM group serves the second position after the HTN group, in terms of fat consumption, compared to the other groups. Recommended protein intake calculated for different study groups, considering the average optimal body weight, is also provided in Table 4. All the study subjects were found to be consuming approximately 10 g of

Table 3
Distribution of study subjects falling under different salt consumption range.

Category	Total Number (%)	Control Number (%)	T2DM Number (%)	CKD Number (%)	HTN Number (%)
Up to 6 gm	28 (14)	6 (21.43)	6 (21.42)	11 (39.29)	5 (17.86)
6–12 g	67 (33.5)§§§	22 (32.84)	13 (19.40)	15 (22.39)	17 (25.37)
12–18g	67 (33.5)§§§	12 (17.91)	15 (22.39)	18 (26.87)	22 (32.84)*
Above 18g	38 (19)@@@&&	10 (26.32)	16 (42.11)	6 (15.79)##	6 (15.79)##

* (p < 0.05), ** (p < 0.01), *** (p < 0.001) versus control group; # (p < 0.05), ## (p < 0.01), ### (p < 0.001) versus T2DM group and † (p < 0.05), ‡ (p < 0.01), §§ (p < 0.001) versus CKD group; § (p < 0.05), §§ (p < 0.01), §§§ (p < 0.001) versus up to 6 gm category; @ (p < 0.05), @@ (p < 0.01), @@@ (p < 0.001) versus 6–12 gm category and & (p < 0.05), && (p < 0.01), &&& (p < 0.001) versus 12–18 gm category.

Table 4

Dietary macronutrients intake of various study group and recommended protein levels calculated from optimal body weight.

Groups	Body weight (Kg)	Optimal body weight (Kg)	Total Carbohydrate (g/day)	Total Fat (g/day)	Total Protein (g/day)	Recommended protein (g/day)
Control	62.28 ± 12.32	61.01 ± 6.21	154.43 ± 25.39	27.99 ± 7.32	39.54 ± 12.36	48.8 ± 04.96
T2DM	67.67 ± 10.98	64.85 ± 6.97	149.68 ± 48.51	31.54 ± 8.30*	39.50 ± 10.57	51.88 ± 5.58
CKD	69.85 ± 13.05	64.22 ± 7.46	152.00 ± 38.36	24.44 ± 8.91***	39.05 ± 12.78	51.38 ± 5.97
HTN	73.42 ± 16.17	63.90 ± 6.53	163.91 ± 28.36	33.15 ± 8.34***	42.93 ± 09.28	51.12 ± 5.22

Values are Mean ± SD, * (p < 0.05), ** (p < 0.01), *** (p < 0.001) versus control group; # (p < 0.05), ## (p < 0.01), ### (p < 0.001) versus T2DM group and ¥ (p < 0.05), ¥¥ (p < 0.01), ¥¥¥ (p < 0.001) versus CKD group.

protein less than the recommended levels per day. Even though an average of 51.38 ± 5.97 g of protein intake is calculated for the CKD group based on the optimal body weight, they ought to regulate the protein intake because of their impaired renal filtration.

Measurements of total calorie and calorie distribution from the three macronutrients of various study groups are given in Table 5. Total calorie intake of Control, T2DM, CKD and HTN groups were estimated to be 1008 ± 274, 1081 ± 239, 1023 ± 233 and 1165 ± 175 K calories per day respectively which is considerably less than the recommended levels for moderately active individuals having optimal body mass index. But the overweight status of T2DM, CKD and HTN group individuals elucidates the requirement of reduced energy intake. The calorie contribution from the total carbohydrates was found to be considerably high than the recommended levels. Correspondingly, calories from the proteins were found to be very much low than the optimum levels. Calorie proportion from the fat was noticeably high in the case of HTN group compared to control (p < 0.001) and CKD groups (p < 0.001).

4. Discussion

The current study was an attempt to assess the dietary pattern and salt consumption of normal subjects as well as subjects having type 2 diabetes, hypertension and chronic kidney diseases. Salt or sodium chloride is highly essential for the maintenance of a healthy life as it takes part in a number of life-sustaining processes. Hyponatremia (abnormally low sodium concentrations in blood, <136 mmol/L) is a common and fatal condition among older adults. Sodium and chloride ions together play a vital role in the electrolyte and fluid balance of the body. Sodium has a critical role in maintaining the membrane potential and it also aids in the absorption and re-absorption of nutrients. Chloride, in the form of hydrochloric acid (HCl), is a major constituent of gastric juice that helps the digestion and absorption of food [12].

Even though sodium is an essential nutrient; consistent incorporation of too much sodium in the form of sodium chloride in the diet raises the circulatory sodium levels leading to the disturbance in the delicate fluid balance. Several studies have established the effect of sodium intake on fluid overload and hypertension [13,14]. Excess fluid retention, in turn, increases the blood pressure and this extra strain eventually can damage the kidneys. The chronic high blood pressure caused by too much sodium also adds to the risk of atherosclerosis and cardiovascular diseases including stroke. High sodium in the diet was reported to contribute sensorineural

hearing loss and induce bone loss by enhancing the urinary calcium excretion [15,16]. Excessive sodium intake is also associated with the development of stomach cancer, obesity, kidney stones and increased severity of asthma symptoms [17,18]. Even if sodium exists as numerous forms, sodium chloride or the table salt is recognised for its hypertensive effects than other salts like sodium bicarbonate, sodium citrate or sodium phosphate [19].

As per the WHO guidelines for a healthy diet, recommended intake of dietary salt for a healthy individual is 5–6 g/day, i.e., ≤2300 mg of sodium per day. Persons with hypertension, diabetes, or chronic kidney disease are further recommended to reduce their daily sodium intake to 1500 mg, which accounts for only 3–4 g of salt. Evidence suggests that 10–20 mmol/day, i.e., 230–460 mg/day of sodium is sufficient enough to meet the physiological needs in healthy adults [1,20,21]. In the present study, control group subjects were found to be consuming more than double the recommended levels of dietary salt. T2DM group subjects were found to be consuming even more salt than the control group. Subjects with hypertension were also perceived to be consuming a higher amount of salt than the control group and are more than double the amount of recommended levels for healthy adults. Even though the salt consumption of CKD group individuals was estimated to be slightly lower than the control group in the current study, it was considerably high than the recommended levels. The impaired renal function could be attributed towards the observed lower urinary sodium excretion levels of CKD group individuals, compared to other group individuals with a healthy kidney. The results of the present study point out to the fact that even after strenuous efforts from the side of WHO and other global organisations, the awareness about the consequences of consumption of large quantities of salt is not reached to the populations living in developing countries like India, especially those living in rural and urban slums.

A study from South India has revealed that an average, 1.5–2 g increase in the salt intake among non-hypertensive subjects was associated with an increase in both systolic and diastolic blood pressure by ~1 mm Hg [5]. Similarly, reducing the dietary salt intake by 3 g per day is reported to reduce the risk of coronary heart disease, stroke and myocardial infarction [22]. Experiments conducted in sodium restriction also demonstrated a considerable decline in proteinuria and albuminuria [13,23,24]. Plasma sodium lessens endothelial nitric oxide synthase activity and sodium reduction was found to improve flow-mediated vasodilatation in healthy non-hypertensive volunteers [25]. These observations

Table 5

Calorie intake of various study groups and its percentage distribution from macronutrients.

Groups	Total calorie (Kcal)	Calorie from CHO (Kcal) (%)	Calorie from Protein (Kcal) (%)	Calorie from Fat (Kcal) (%)
Control	1008.16 ± 274.48	617.70 ± 101.57 (61.27)	158.18 ± 49.44 (15.69)	251.90 ± 65.86 (24.99)
T2DM	1081.59 ± 239.81	598.72 ± 194.02 (55.35)	157.98 ± 42.28 (14.61)	283.83 ± 74.72* (26.24)
CKD	1023.96 ± 233.64	608.00 ± 153.45 (59.38)	156.21 ± 51.10 (15.26)	219.92 ± 80.17*** (21.48)
HTN	1165.83 ± 175.9***¥	655.66 ± 113.46 (56.24)	171.70 ± 37.14 (14.73)	298.34 ± 75.09***¥¥¥ (25.59)

Values are Mean ± SD, * (p < 0.05), ** (p < 0.01), *** (p < 0.001) versus control group; # (p < 0.05), ## (p < 0.01), ### (p < 0.001) versus T2DM group and ¥ (p < 0.05), ¥¥ (p < 0.01), ¥¥¥ (p < 0.001) versus CKD group.

emphasise towards the importance and benefits of salt regulation as well as lifestyle modification in individuals with both normal as well as abnormal blood pressure. Subjects with CKD commonly have higher blood pressure levels and are predominantly sensitive to high salt intake than people with normal kidney function. This may be explained by the impaired glomerular filtration of CKD subjects that reduced their ability to excrete the extra salt load through urine [26]. Salt reduction interventions can have a greater impact on these individuals and may provide a simple, inexpensive and potential way of improving CVD and CKD progression risk.

Recent data point towards a considerable high intake of sodium in most of the countries around the world [27–30]. According to the Centres for Disease Control and Prevention (CDC) survey, nine in ten Americans consume more than the recommended limits for sodium, major source being diet. Reports also declare that more than 90% of children and 89% of adults in the US, irrespective of age, race, gender or having high blood pressure, consume more sodium than the recommended levels [31]. An international study on electrolyte excretion and blood pressure reported the median intake of sodium in 32 countries as 9.9 g/day, which range from 0.1 g/day in Brazil to 15 g/day in China [32]. Various Studies by international research groups have demonstrated that Asians, especially Chinese have the highest sodium intakes in the world [33,34]. Studies on various parts of India have also revealed that dietary sodium consumption is higher than recommendations, especially in South Indian Population [4–6] which possibly will elucidate the escalating incidence of hypertension in southern parts of India [35,36].

Dietary sodium intake depends on several sources which comprise as natural content in the regular food and as added salt while cooking. Cultural background and dietary habits determine the extent of sodium consumption of various populations [37]. In Asian countries, high proportions of sodium in the diet come from salt added in cooking and from sauces [1]. Regular intake of ethnic foods like chutneys, papads and pickles contribute prominently to the increased sodium consumption of Indians [38]. Avoiding processed meats, canned goods and fast food, as well as high-sodium bread, broths and cottage cheese would be an appropriate option for dietary salt reduction. Preference should be given to alternate choices like minimally processed foods such as whole grain vegetables, fruits, nuts and lean proteins that are naturally lower in sodium content [39].

Macronutrients, which include carbohydrates, proteins and fats, are the energy providing nutrients required in large quantity for the maintenance of body functions and also to carry out day today activities. An appropriate proportion of energy-giving foods in the diet is highly recommended for preventing the incidence as well as the progression of lifestyle diseases. According to Acceptable Macronutrient Distribution Range or AMDR, carbohydrates should supply 45–65% of our total daily energy needs and 10–35% of total calorie should be from protein [40]. It is also recommended that 20–35% of our daily energy requirement should be supplied through the consumption of fats and oils. Total calorie recommendation for moderately active healthy males is ≤ 2500 K Calories and for females, it is ≤ 2000 K Calories. Protein and carbohydrates both provide 4 K Calories per gram (17 kJ/g), while fat supplies 9 K Calories per gram (37 kJ/g). Recommended daily allowance of carbohydrates for both adult male and female subjects was intended as 130 g per day. Similarly, 0.8 g/kg body weight of protein intake is precisely to be appropriate for a healthy adult that accounts for around 56 g and 46 g for males and females respectively. In the current study, total energy consumption for all the four groups was observed to be approximately 1000–1100 K Calories. However, all the four group individuals were found to consume nearly 150 g of carbohydrates which contribute approximately 600 K Calories per

day. On the contrary, all the four group individuals were found to consume only 40 g of protein per day which provides close to 160 K Calories. Even though total calorie consumption of individuals from T2DM, CKD and HTN groups were found to be appropriate considering their overweight BMI status, calorie contribution from the carbohydrates was significantly high compared to the energy from the proteins. For subjects with T2DM without having any kidney diseases, protein is the preferable source of energy than carbohydrates. However, the subjects having CKD should restrict their protein intake to the minimum.

Though the amount of macronutrients that we consume is important, its type and quality deserve equal attention. Indian diets receive nearly 60% of their protein from cereals with comparatively less digestibility and quality [7]. Extra care should be taken to include proteins of high nutritional value that provide all the nine essential amino acids in adequate amounts. One of the limitations of the current study is that it measured only the protein-energy ratio (P/E ratio) that indicates information about protein concentration or density which is only one aspect of diet's quality. Future studies are needed to evaluate the biological value or quality of the macronutrients in the diet.

In conclusion, observations of the present study indicated the consumption of an alarmingly high amount of dietary salt and an inappropriate proportion of macronutrients in the South Indian population with diabetes and other co morbid conditions. Even though elevated sodium intake has been associated with a number of life-threatening conditions, most of the Indians are not aware of the high amount of sodium they eat every day. Nationwide intensive and persistent efforts are necessary to enhance public awareness on the harmful effects of excessive salt intake, the quantity of sodium present in various food, recommended salt allowances in different health conditions as well as the appropriate food choices for the regulation of excess salt intake. Individuals should also educate about the necessity of a balanced diet that contains all the macro and micronutrients in proper proportion.

Conflicts of interest

Authors declare no conflict of interest.

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