Association of dietary patterns and practices on metabolic syndrome in adults with central obesity attending a mission hospital in Kenya: a cross-sectional study

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ABSTRACT
Objective Dietary patterns and practices can predispose or protect against metabolic syndrome (MetS) in humans. Despite the growing problem of MetS in adults, the underpinning dietary behaviour is poorly understood. We determined the dietary patterns and practices relevant to MetS in adults with central obesity attending a mission hospital in Kenya.

Study design Descriptive, cross-sectional.
Setting Outpatient clinic of a mission-based hospital in Nairobi.

Participants Adults (N=404) aged 18–64 years diagnosed with central obesity as per the International Diabetes Federation definition for MetS.

Primary outcomes Anthropometric measurements, clinical-biochemical markers and dietary components, quantity and frequency of food intake, as well as time-lapse between consumption of dinner and sleeping.

Results A high (87.2%) prevalence of MetS was observed for respondents who reported consumption of large amount of carbohydrates (p<0.001), proteins (p<0.001), processed/fast foods (p<0.001) and sugar (p<0.009). Frequent consumption of legumes (p<0.001), nuts (p<0.001), fruits (p<0.001) and vegetables (p=0.021) was linked to reduced MetS. Additionally, longer interval between eating dinner and going to bed was associated with reduced MetS.

Conclusion Regular consumption of fruits, vegetables, legumes and nuts, as well as observing sometime after eating dinner before sleeping, was the dietary pattern significantly associated with a lower risk of MetS. Whereas, consumption of a large quantity of carbohydrates, proteins, processed/fast foods and sugar is likely to predispose to MetS. The findings underscore the need to focus on specific dietary intake patterns including frequency, quantity, quality and variety for MetS prevention and management. The MetS-related interventions could be implemented during individual consultation, group and community health messaging sessions.

INTRODUCTION
A dietary pattern refers to the quantity, variety or combination of different foods in a diet and the frequency with which they are habitually consumed. The importance of nutritious dietary patterns and practices on metabolic syndrome (MetS) cannot be overstated. Indeed, components of MetS namely: central obesity, raised blood glucose, elevated blood pressure (BP) and dyslipidaemia are closely linked to dietary behaviour. Dietary patterns and practices have been implicated in the risk for MetS. Several important factors including genetic, unhealthy eating habits and urbanisation have been cited as risk factors for MetS; however, unhealthy dietary pattern plays a major role in the incidence of MetS. Unhealthy diet characterised by consumption of processed/fast foods has been reported to be associated with MetS and cardiovascular diseases (CVDs). Whereas, a healthy dietary pattern characterised by regular consumption of fruits and vegetables, legumes and nuts is strongly associated with a lower risk of MetS. Saturated fatty acids mainly from processed/fast foods as well as refined carbohydrates are the major dietary factors fully responsible for the occurrence of MetS. Lifestyle modification involving adjusting the type, quality and quantity of diet is attributed to reduction of the risk for
MetS. Of significance is the fact that MetS is linked to high propensity of escalation into non-communicable diseases (NCDs) notably hypertension and type 2 diabetes and the resultant morbidity and mortality. Indeed, individuals with MetS are more than seven times more likely to develop diabetes and twofold likely to develop and die from CVDs. A growing epidemic of MetS has been observed globally with sub-Saharan and developing countries bearing the biggest burden. For example, according to the International Diabetes Federation (IDF), the global prevalence of MetS is approximately 25%. MetS just like the NCDs is disproportionately heavy in sub-Saharan Africa with a resultant burden on the health system and economy. For example, the prevalence of MetS has been found to be 35.1% in Nigeria, 35.9% in Ghana, 39.0% in Cameroon and 42.1% in Egypt. In Kenya, the prevalence of MetS has been reported at 25.6%.

The growing burden of MetS in Africa is associated with nutritional transition characterised by intake of high-energy-dense foods, high quantity, lack of variety and quality of foods. Kenya is experiencing a rapid epidemiological and nutritional transition accompanied by increased consumption of unhealthy dietary pattern characterised by high intakes of refined carbohydrates, processed/fast foods, sugar-sweetened beverages, and low fruits and vegetables. Evidence by Kimani et al showed that patients with hypertension who daily consumed vegetables and fruits had lower rates of obesity, hypertension and cholesterol levels, some of the components of MetS. Elsewhere, reports from one of Nairobi’s slums showed a high prevalence of overweight and abdominal obesity related to consumption of low vegetables and fruits. The reports and other documented evidence underscore the importance of diet in relation to MetS and its related components providing a window of prevention through awareness creation using health facilities or community as avenues for the interventions.

Unhealthy dietary pattern characterised by consumption of high-calorie diet such as processed/fast foods that are high in fats and sugars promotes obesity compared with low-energy foods, for example fruits and vegetables. The high-calorie diets are causally linked to insulin resistance, type 2 diabetes, dyslipidaemia and high BP—the main components of MetS. Moreover, diet has been associated with risk for high BP and poor hypertension control. Although some studies in Kenya have demonstrated the association between nutrition and MetS, they are limited in number and methodological rigour. For well-thought evidence guided dietary/nutritional-oriented public health interventions on MetS studies are required. We sought to determine dietary patterns/practices (frequency intake of fruits, vegetables, legumes, nuts, processed and/or fast foods, proportion of protein and carbohydrate, amount of salt and sugar, as well as time interval between taking dinner and sleeping) relevant to MetS among Kenyan adults with central obesity attending a mission hospital in Nairobi.

METHODS AND MATERIALS

The study methods and materials have been well elaborated in our published work. This is part of the larger community-based lifestyle intervention study for managing MetS among adults in an ongoing project.

Study setting

The study was executed at St Mary’s Mission Hospital—a faith-based health facility located in Langata constituency Nairobi County. The hospital provides affordable services to a large low-income-earning population from the neighbouring Kibera, Mukuru-Kwa-Njenga and Kuwinda slums. Specifically, Kibera is the largest and poorest slum in Africa, with individual resident’s average monthly income of US$39 per household. The hospital has an inpatient bed capacity of 350 offering medical, surgical, maternity, paediatric, postnatal, newborn unit, operating theatre, inpatient gynaecology and physiotherapy services. Additionally, the facility has a 24-hour outpatient department that offers general outpatient care, maternal and child health, diabetic and hypertension, nutrition, dental, eye, pharmacy, laboratory and imaging services, as well as HIV/AIDS prevention treatment and care services. The hypertension–diabetic clinic operates on daily basis from Monday to Friday serving about 600 patients per month. The clinic is run by a team of professionals comprising of physicians, nurses, nutritionists, laboratory technicians, pharmacists and social workers.

Study design, sampling methods and respondents

A cross-sectional study involving adults (N=404) aged 18–64 years. For inclusion into the study, we considered central obesity (waist circumference (WC) ≥94 cm for men and ≥80 cm for women) as the primary criteria for screening for the other MetS components as per the IDF guidelines. We excluded pregnant and lactating women, individuals with contraindication for exercise due to serious diseases such as CVDs, cancer, mental illness and physical disability. However, some known patients with hypertension or diabetes were included based on the components of MetS. A systematic random sampling method was used to recruit the study respondents. During the study period, the clinic served for about 600 adults with hypertension and/or diabetes per month, which translated to 1800 patients in 3-months equivalent to the duration for completion of the data collection. Thus, the sampling interval was determined by dividing the target population (1800) in a 3-month period by the number of patients with hypertension–diabetes calculated to be screened for MetS (n=125) to get the sample interval of 14. Accordingly, every 14th client with hypertension–diabetes was included in the study after consenting until the desired sample size was achieved. An additional 279 participants who included those attending outpatients and their accompanying visitors were screened using systematic random sampling as they waited at the main laboratory waiting area of the hospital. During the same period, the hospital’s main laboratory served for about
2640 adult clients (aged 18–64) per month, equivalent to 7920 in a 3-month period, the duration required to complete the data collection. Then, the total population for 3 months (7920) was divided by the initially adjusted sample size (375) to get a sample interval of 21. Then every 21st participant was included in the screening until the desired sample size was achieved (Figure 1).

**Data collection tools and procedures**

Data were collected using a researcher-assisted structured questionnaire adopted from the WHO STEPwise approach to NCD risk factor surveillance. This questionnaire had four categories, including sociodemographics, dietary intake patterns and practices, anthropometrics and biochemical markers. The data were collected by two trained research assistants with a bachelor’s degree in nursing training background. The blood glucose and biochemical markers were captured using specific questions focused on such topics integrated in the questionnaire. Time interval between taking dinner and sleeping was assessed by asking respondents at what time they usually eat their dinner. The responses were: before 20:00, between 20:00 and 21:00, between 21:00 and 22:00, between 22:00 and 23:00, and after 22:00. Then, they were asked the time they usually go to bed to sleep. The responses were: before 21:00, between 21:00 and 22:00, between 22:00 and 23:00, between 23:00 and midnight and after midnight.

**Anthropometric variables**

The anthropometric parameters included weight, height, WC and hip circumference (HC). These parameters were measured using standard measurement tools. The body weight was measured to the nearest 0.1 kg using a Soehnle mechanical weighing scale with the respondent in light clothing. The height (m) was measured using a portable stadiometer to the nearest 0.5 cm, with subjects standing upright on a flat surface without shoes, the back of the heels and the occiput on the equipment. The height and weight was then used to calculate the body mass index that is the ratio of weight (kg) over height in m². The WC was taken at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest to the nearest 0.1 cm using a procedure by WHO. The HC was taken at the greatest posterior protuberance of the buttocks to the nearest 0.1 cm using a flexible tape.
Clinical variables (BP and heart rate)

BP and heart rates were measured using OMRON automatic BP monitor (model: M3; HEM-141-E, serial no: 20170916247VG, Japan) after a rest period of 5–10 min in a sitting position. The BP was measured two times with a 5 min time interval with the mean of the two measurements being recorded. Elevated BP as a component of MetS was defined as ≥130/85 mm Hg.1 A systolic BP of 120–139 mm Hg and/or diastolic BP of 80–89 mm Hg were considered as prehypertension. Hypertension was defined as systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg.6 The heart rate was measured for 1 min as well by the BP monitor.

Biochemical variables

The blood samples for fasting blood glucose (FBG), lipids (triglycerides (TGs) and high-density lipoprotein cholesterol (HDL-C)) levels were drawn and analysed following an overnight fasting of 8–12 hours. FBG sample was obtained from the respondents’ finger using HemoCue B-Glucose photometer (photometer, 1995). A sample of 3 mL of blood was obtained from the brachial vein following standard infection prevention procedures to determine TGs and HDL-C values. Each blood sample was labelled with the participants’ number to avoid errors of recording. Raised FBG level was defined as FBG level ≥5.6 mmol/L.1 Pre-diabetes and diabetes were defined as FBG of 5.6–6.9 mmol/L and ≥7 mmol/L, respectively.30 Raised TG was defined as TGs level ≥1.7 mmol/L irrespective of gender. Whereas, low HDL-C level was defined as HDL-C <1.03 mmol/L in men and <1.29 mmol/L in women.1

Validity and reliability of the study tools

The WHO STEPwise approach to NCD risk factor surveillance questionnaire27 was used to collect the data. Additionally, the tools were reviewed for content validity by experts in the field of CVD and nutrition to ascertain relevance and completeness. The recommendations and suggestions were incorporated in the final questionnaire. To measure reliability of the questionnaire, a test re-test method was employed, whereby a repeat pre-test was carried out after 3 weeks, and Cohen’s kappa statistic was used to measure the level of agreement of the two results. The result of the repeated questions had a kappa value of 0.91 therefore, the questionnaire was considered reliable.

Patient and public involvement

There were no patients and members of the public involved in developing the research design and questions. This research was solely done by researchers without involving patients or public in any part of the research work. However, this research involved human participants. The results will be disseminated to the public during health message sharing sessions in the study area as well as seminars/conferences.

Definition of MetS

MetS was defined using the IDF criteria1 to include central obesity (WC of ≥94 cm for men and ≥80 cm for women) that was compulsory. The criteria also included other components namely: (1) raised TGs level ≥1.7 mmol/L (≥150 mg/dL) or history of specific treatment for the lipid abnormality; (2) reduced HDL-C <1.03 mmol/L (<40 mg/dL) in men and <1.29 mmol/L (<50 mg/dL) in women or history of specific treatment for the lipid abnormality; (3) elevated BP: systolic BP ≥130 mm Hg or diastolic BP ≥85 mm Hg or on treatment for previously diagnosed hypertension; (4) raised FBG level of ≥100 mg/dL (≥5.6 mmol/L) or previously diagnosed type 2 diabetes mellitus. The respondents had to display at least two of the four metabolic abnormalities in addition to the central obesity.

Data analyses

Statistical analyses were performed using the SPSS V.22. Descriptive data were analysed using proportions and summarised in frequency tables. The X² test of independence and binary logistic regression were used to determine associations between categorical variables such as frequency of specific food consumption, prevalence of MetS and its related components. A multiple logistic regression model with backward conditional was carried out to determine the dietary-related variables independently contributed to the occurrence of MetS. Backward conditional method was specified with removal at p<0.05 to determine the independent predictors of MetS as it removes the confounding variables until no further variables can be removed without a statistically insignificant loss of fit (last or reduced model). The fitness model was also performed to describe the variance and classification of MetS. A p value of less than 0.05 was considered to be significant.

RESULTS

Demographic characteristics of the respondents

Respondents totalling 404 were recruited with mean age of 42.5±11.9 (mean±SD) years. Most (59.2%, n=239) of them were between 31 and 50 years. A high proportion of the respondents were married (76.0%, n=307), women (54.5%, n=220), Protestants (59.7%, n=241) and self-employed (52.2%, n=211). Respondents with secondary level education were 48.8% (n=197). Economically family monthly income was reported to be between US$100 and US$300 (45.5%; n=184) (table 1).

Relationship between the DASH eating plan and MetS-related components

The DASH diet was used to determine quantity or proportion of meals usually consumed by the respondents. According to the DASH diet, at each meal, vegetables and/or fruits constitute one-half of a plate, carbohydrates one-quarter of the plate and the remaining one-quarter of the plate to be filled with plant proteins like legumes,
soy products, nuts and seed proteins. Animal proteins in the diet should be limited to lean meats, low-fat dairy, eggs and fish. Most (77%; n=311) of the respondents reported consuming less than the recommended portion of a plate as vegetables and/or fruits. Further analysis revealed that those who consumed less than the recommended portion of a plate as vegetables and/or fruits were more likely to have MetS ($\chi^2=116.082$, p<0.001) and raised FBG level ($\chi^2=5.590$, p=0.018) compared with those who frequently took the recommended portion as vegetables/fruits. Most, 70.8% (n=286) of the respondents, frequently consumed a large proportion (over one-quarter of a plate) of a carbohydrate diet as part of the main meals. Respondents who frequently consumed a large proportion of carbohydrate foods were more likely to have MetS ($\chi^2=13.122$, p<0.001), elevated BP ($\chi^2=33.342$, p<0.001) and raised FBG level ($\chi^2=6.393$, p=0.011) compared with those who ate the recommended amounts (≤25% portion of a plate). With regards to protein consumption, slightly above a quarter (29%; n=117) of the respondents frequently consumed large proportion (over one-quarter of a plate) of protein diet as part of the main meals. Respondents who frequently consumed large proportion of foods rich in proteins were more likely to have MetS ($\chi^2=13.055$, p<0.001) and elevated BP ($\chi^2=33.342$, p<0.001) compared with those who ate the recommended amounts (less than or 25% portion of a plate) (table 2).

### Frequency of fruit and vegetable intake in relation to MetS and related components

Of the respondents, some, 17.8% (n=72) and 41.1% (n=166), daily consumed fruits and vegetables, respectively. Further analysis showed a significant association between daily consumption of fruits and vegetables and MetS with some of its components. Respondents who did not consume fruits daily were more likely to have MetS ($\chi^2=14.276$, p<0.001), elevated BP ($\chi^2=13.505$, p<0.001) and raised FBG level ($\chi^2=9.301$, p=0.002) compared with those who frequently consumed fruits. Similarly, respondents who did not daily consume vegetables were more likely to have MetS ($\chi^2=5.313$, p=0.021) and elevated BP ($\chi^2=24.677$, p<0.001) compared with those who ate daily (table 3).

### Association between legume and nut consumption and MetS-related components

According to the DASH eating plan, the recommended frequency of legume and nut consumption is four to five times per week. Less than a quarter (20.5%; n=83) of the respondents included legumes/pulses in their meals as recommended (four to five times in a week). Similarly, a small proportion (15.1%; n=61) of the respondents consumed nuts 4–5 days in a week as part of their meals. Further analysis with binary logistic regression showed a significant association between frequency of legume and nut consumption and MetS. Respondents who consumed legumes less than the recommended frequency were more likely to have MetS (OR=125.8; p<0.001), elevated BP (COR=2.3; p=0.001), low HDL-C (crude OR/COR=3.0; p<0.001), raised TGs (OR=4.1; p<0.001) and raised FBG level (adjusted OR=2.2; p=0.037) compared with those who ate them as recommended. Respondents who sometimes (two to three times/week) consumed nuts were more likely to have MetS (OR=105.6; p<0.001), elevated BP (COR=5.4; p<0.001), reduced HDL-C (OR=3.0; p<0.001), raised TGs (OR=6.2; p<0.001) and raised FBG level (OR=3.2; p=0.011) compared with those who

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**Table 1** Demographic characteristics of the respondents

| Characteristics          | Number | %    |
|--------------------------|--------|------|
| Age (years)              |        |      |
| ≤30                      | 68     | 16.8 |
| 31–40                    | 124    | 30.7 |
| 41–50                    | 115    | 28.5 |
| >50                      | 97     | 24   |
| Gender                   |        |      |
| Male                     | 184    | 45.5 |
| Female                   | 220    | 54.5 |
| Marital status           |        |      |
| Married                  | 307    | 76   |
| Single                   | 69     | 17.1 |
| Divorced                 | 6      | 1.5  |
| Separated                | 11     | 2.7  |
| Widowed                  | 10     | 2.5  |
| Cohabitng                | 1      | 0.2  |
| Religion                 |        |      |
| Protestant               | 241    | 59.7 |
| Catholic                 | 131    | 32.4 |
| Muslim                   | 32     | 7.9  |
| Level of education       |        |      |
| No formal education      | 7      | 1.7  |
| Primary                  | 75     | 18.6 |
| Secondary                | 197    | 48.8 |
| College/university       | 125    | 30.9 |
| Occupation               |        |      |
| Government employee      | 15     | 3.7  |
| Non-government employee  | 111    | 27.5 |
| Self-employed            | 211    | 52.2 |
| Unemployed               | 67     | 16.6 |
| Family monthly income (US$) |    |       |
| Less than 100            | 67     | 16.6 |
| 101–300                  | 184    | 45.5 |
| 301–500                  | 66     | 16.3 |
| Over 500                 | 49     | 12.1 |
| No response              | 38     | 9.4  |
| Total                    | 404    | 100  |
Table 2  Relationship between the DASH eating plan and metabolic syndrome (MetS)-related components

| MetS and its components | Proportion of a plate filled with vegetables and/or fruits | Total | χ² | Df | P value |
|-------------------------|----------------------------------------------------------|-------|----|----|---------|
|                         | Less than half of a plate                                 |       |    |    |         |
|                         | Half and above of a plate                                 |       |    |    |         |
|                         | Total                                                    |       |    |    |         |
| MetS                    | N (%)                                                    | N (%) | N (%) | 32.004 | 1 | <0.001 |
| Yes                     | 287 (81.5)                                               | 65 (18.5) | 352 (100) |
| No                      | 24 (46.2)                                                | 28 (53.8) | 52 (100) |
| Total                   | 311 (77.0)                                               | 93 (23.0) | 404 (100) |
| Blood pressure (BP)     |                                                         |       |    |    |         |
| Elevated BP             | 248 (93.2)                                               | 18 (6.8) | 266 (100) |
| Normal BP               | 63 (45.7)                                                | 75 (54.3) | 138 (100) |
| High-density lipoprotein cholesterol (HDL-C) | | | | |
| Reduced HDL-C           | 231 (75.7)                                               | 74 (24.3) | 305 (100) |
| Normal HDL-C            | 80 (80.8)                                                | 19 (19.2) | 99 (100) |
| Triglycerides (TGs)     |                                                         |       |    |    |         |
| Raised TGs              | 207 (79)                                                 | 55 (21) | 262 (100) |
| Normal TGs              | 104 (73.2)                                               | 38 (26.8) | 142 (100) |
| Fasting blood glucose (FBG) |                                                         |       |    |    |         |
| Raised FBG level        | 76 (86.4)                                                | 12 (13.6) | 88 (100) |
| Normal FBG level        | 235 (74.4)                                               | 81 (25.6) | 316 (100) |
| Proportion of a plate filled with carbohydrates | | | | |
| ≤one-quarter of a plate | N (%)                                                    | N (%) | N (%) | 33.866 | 1 | <0.001 |
|                         | Yes                                                      | 85 (24.1) | 267 (75.9) | 352 (100) |
|                         | No                                                       | 33 (63.5) | 19 (36.5) | 52 (100) |
|                         | Total                                                   | 118 (29.2) | 286 (70.8) | 404 (100) |
| BP                      |                                                         |       |    |    |         |
| Elevated BP             | 39 (14.7)                                                | 227 (85.3) | 266 (100) |
| Normal BP               | 79 (57.2)                                                | 59 (42.8) | 138 (100) |
| HDL-C                   |                                                         |       |    |    |         |
| Reduced HDL-C           | 90 (29.5)                                                | 215 (70.5) | 305 (100) |
| Normal HDL-C            | 28 (28.3)                                                | 71 (71.7) | 99 (100) |
| TGs                     |                                                         |       |    |    |         |
| Raised TGs              | 69 (26.3)                                                | 193 (73.7) | 262 (100) |
| Normal TGs              | 49 (34.5)                                                | 93 (65.5) | 142 (100) |
| FBG                     |                                                         |       |    |    |         |
| Raised FBG level        | 21 (23.9)                                                | 67 (76.1) | 88 (100) |
| Normal FBG level        | 97 (30.7)                                                | 219 (69.3) | 316 (100) |
| Total                   | 118 (29.2)                                               | 286 (70.8) | 404 (100) |
| Proportion of a plate filled with protein | | | | |
| ≤one-quarter of a plate | N (%)                                                    | N (%) | N (%) | 13.122 | 1 | <0.001 |
|                         | Yes                                                      | 239 (67.9) | 113 (32.1) | 352 (100) |
|                         | No                                                       | 33 (63.5) | 19 (36.5) | 52 (100) |
|                         | Total                                                   | 118 (29.2) | 286 (70.8) | 404 (100) |

Continued
included nuts as recommended (four to five times/week) (table 4).

**Consumption of processed and/or fast foods relative to MetS and related components**

Slightly over one-third (36.4%; n=147) of the respondents always consumed processed and/or fast foods, of which, 96.6% presenting with MetS. Further analysis showed a significant association between frequency of eating processed/fast foods and MetS. Respondents who always consumed processed/fast foods were more likely (χ²=66.34; p<0.001) compared with those who rarely ate those types of food. Moreover, respondents who sometimes ate processed/fast foods were more likely to have elevated BP (OR=6.3; p<0.001), low HDL-C (OR=2.5; p=0.002), raised TGs (OR=2.6; p<0.001) and raised FBG level (OR=5.8; p<0.001) compared with those who rarely ate these foods (table 5).

**Consumption of sugar and salt in relation to MetS-related components**

Most (62.6%; n=253) of the respondents consumed more than the recommended amount of sugar in a day. With regards to salt intake, the majority, 57.9% (n=234) of the respondents added salt to their meal right before they ate or as they were eating it. Further analysis revealed respondents who consumed more than the recommended amount of sugar were more likely (χ²=21.718, p<0.001) to have elevated BP compared with those who did not add salt after the food has been cooked. However, respondents who did not add salt after the food has been cooked were more likely to have both raised TGs (χ²=9.697, p=0.002) and FBG (χ²=10.028, p=0.002) levels compared with those who added salt while they were eating their meals (table 6).

**Time interval after consumption of dinner and sleeping in relation to MetS-related components**

Less than a quarter (19.6%; n=79) of the respondents observed more than a 2-hour interval between taking dinner and sleeping. Analysis with binary logistic regression revealed a significant association between the time interval of taking dinner and sleeping with MetS. Respondents who observed more than a 2-hour interval between eating dinner and sleeping were 20% (p<0.001), 40% (p=0.001), 50% (p=0.027) and 50% (p=0.011) less likely to have MetS, elevated BP, reduced HDL-C and raised TGs, respectively, compared with those who observed less than a 1-hour time interval between eating dinner and sleeping (table 7).

**Multivariable analysis for dietary risk factors of MetS**

Binary logistic regression analysis was performed to model MetS (presence or absence) as a dependent variable and the independent variables that revealed significant association at p<0.05 during the bivariate analysis.
Accordingly, the logistic model included the following factors: proportion of a plate filled with vegetables and/or fruits; frequency of processed/fast food, fruit, vegetable, legume and nut intake; sugar consumption status; and time interval between taking dinner and sleep. Backward conditional method was specified with removal at $p<0.05$ to determine the independent predictors of MetS as it removes the confounding variables until no further variables can be removed without a statistically insignificant loss of fit (last or reduced model). After considering all, frequency of processed/fast food, legume and nut intake was independently associated with MetS. The fitness model according to Hosmer and Lemeshow Test was 0.248, which indicates the model fits. Respondents who often consumed processed/fast foods were three times (95% CI: 1.48–7.29, $p=0.003$) more likely to develop MetS compared with those who rarely consumed legumes. Respondents who rarely and

| MetS and its components | Frequency of fruit intake | Frequency of vegetable intake |
|------------------------|--------------------------|-------------------------------|
|                        | Daily N (%)              | Not daily N (%)               | Total N (%) | $\chi^2$ | Df | P value |
| MetS                   |                          |                              |              |         |    |         |
| Yes                    | 53 (15.1)                | 299 (84.9)                   | 352 (100)    | 14.276  | 1  | <0.001  |
| No                     | 19 (36.5)                | 33 (63.5)                    | 52 (100)     |          |    |         |
| Total                  | 72 (17.8)                | 332 (82.2)                   | 404 (100)    |          |    |         |
| Blood pressure (BP)    |                          |                              |              | 13.505  | 1  | <0.001  |
| Elevated BP            | 34 (12.8)                | 232 (87.2)                   | 266 (100)    |          |    |         |
| Normal BP              | 38 (27.5)                | 100 (72.5)                   | 138 (100)    |          |    |         |
| High-density lipoprotein (HDL) |              |                              |              | 1.029   | 1  | 0.31    |
| Reduced HDL            | 51 (16.7)                | 254 (83.3)                   | 305 (100)    |          |    |         |
| Normal HDL             | 21 (21.2)                | 78 (78.8)                    | 99 (100)     |          |    |         |
| Triglycerides (TGs)    |                          |                              |              | 2.403   | 1  | 0.121   |
| Raised TGs             | 41 (15.6)                | 221 (84.4)                   | 262 (100)    |          |    |         |
| Normal TGs             | 31 (21.8)                | 111 (78.2)                   | 142 (100)    |          |    |         |
| Fasting blood glucose (FBG) |                      |                              |              | 9.301   | 1  | 0.002   |
| Raised FBG level       | 6 (6.8)                  | 82 (93.2)                    | 88 (100)     |          |    |         |
| Normal FBG level       | 66 (20.9)                | 250 (79.1)                   | 316 (100)    |          |    |         |

Table 3 Frequency of fruit and vegetable intake in relation to metabolic syndrome (MetS) and related components

| MetS and its components | Frequency of fruit intake | Frequency of vegetable intake |
|------------------------|--------------------------|-------------------------------|
|                        | Daily N (%)              | Not daily N (%)               | Total N (%) | $\chi^2$ | Df | P value |
|                        |                          |                              |              |         |    |         |
| MetS                   |                          |                              |              |         |    |         |
| Yes                    | 137 (38.9)               | 215 (61.1)                   | 352 (87.1)   | 5.313   | 1  | 0.021   |
| No                     | 29 (55.8)                | 23 (44.2)                    | 52 (12.9)    |          |    |         |
| Total                  | 166 (41.1)               | 238 (58.9)                   | 404 (100)    |          |    |         |
| BP                     |                          |                              |              |         |    |         |
| Elevated BP            | 86 (32.3)                | 180 (67.7)                   | 266 (65.8)   | 24.677  | 1  | <0.001  |
| Normal BP              | 80 (58)                  | 58 (42)                      | 138 (34.2)   |          |    |         |
| HDL                    |                          |                              |              | 0.748   | 1  | 0.387   |
| Reduced HDL            | 129 (42.3)               | 176 (57.7)                   | 305 (75.5)   |          |    |         |
| Normal HDL             | 37 (37.4)                | 62 (62.6)                    | 99 (24.5)    |          |    |         |
| TGs                    |                          |                              |              | 0.019   | 1  | 0.89    |
| Raised TGs             | 107 (40.8)               | 155 (59.2)                   | 262 (64.9)   |          |    |         |
| Normal TGs             | 59 (41.5)                | 83 (58.5)                    | 142 (35.1)   |          |    |         |
| FBG                    |                          |                              |              | 0.204   | 1  | 0.652   |
| Raised FBG level       | 38 (43.2)                | 50 (56.8)                    | 88 (100)     |          |    |         |
| Normal FBG level       | 128 (40.5)               | 188 (59.5)                   | 316 (100)    |          |    |         |
| Total                  | 166 (41.1)               | 238 (58.9)                   | 404 (100)    |          |    |         |
### Table 4  Association between legume and nut consumption and metabolic syndrome-related components

| Frequency of legume intake | Metabolic syndrome | Total | COR (95% CI) | P value |
|----------------------------|--------------------|-------|--------------|---------|
|                            | Yes                | No    |              |         |
| Always                     | 40 (48.2)          | 43 (51.8) | 83 (100)     | 1       |
| Sometimes                  | 78 (91.8)          | 7 (8.2)   | 85 (100)     | 125.8 (29.3–539.9) | <0.001 |
| Rarely                     | 234 (99.2)         | 2 (0.8)    | 236 (100)    | 10.5 (2.1–51.6)   | 0.004  |
| Total                      | 352 (87.1)         | 52 (12.9)  | 404 (100)    |          |

| Frequency of legume intake | Blood pressure (BP) | Elevated BP | Normal BP |       |
|----------------------------|---------------------|-------------|-----------|------|
| Often                      | 43 (51.8)           | 40 (48.2)   | 83 (100)  | 1    |
| Sometimes                  | 54 (63.5)           | 31 (36.5)   | 85 (100)  | 2.3 (1.4–3.9) | 0.001 |
| Rarely                     | 169 (71.6)          | 67 (28.4)   | 236 (100) | 1.4 (0.9–2.4) | 0.167 |
| Total                      | 266 (65.8)          | 138 (34.2)  | 404 (100) |      |

| Frequency of legume intake | High-density lipoprotein (HDL) | Low HDL | Normal HDL |       |
|----------------------------|---------------------------------|---------|------------|------|
| Often                      | 48 (57.8)                       | 35 (42.2) | 83 (100)   | 1    |
| Sometimes                  | 67 (78.8)                       | 18 (21.2) | 85 (100)   | 3.0 (1.8–5.2) | <0.001 |
| Rarely                     | 190 (80.5)                      | 46 (19.5) | 236 (100)  | 1.1 (0.6–2.0) | 0.739 |
| Total                      | 305 (75.5)                      | 99 (24.5) | 404 (100)  |      |

| Frequency of legume intake | Triglycerides (TGs) | Raised TGs | Normal TGs |       |
|----------------------------|---------------------|------------|------------|------|
| Often                      | 33 (39.8)           | 50 (60.2)  | 83 (100)   | 1    |
| Sometimes                  | 57 (67.1)           | 28 (32.9)  | 85 (100)   | 4.1 (2.4–6.9) | <0.000 |
| Rarely                     | 172 (72.9)          | 64 (27.1)  | 236 (100)  | 1.3 (0.8–2.3) | 0.309 |
| Total                      | 262 (64.9)          | 142 (35.1) | 404 (100)  |      |

| Frequency of legume intake | Fasting blood glucose (FBG) | Raised FBG level | Normal FBG level |       |
|----------------------------|-----------------------------|------------------|------------------|------|
| Often                      | 10 (12)                     | 73 (88)          | 83 (100)         | 1    |
| Sometimes                  | 24 (28.2)                   | 61 (71.8)        | 85 (100)         | 2.2 (1.0–4.5) | 0.037 |
| Rarely                     | 54 (22.9)                   | 182 (77.1)       | 236 (100)        | 0.8 (0.4–1.3) | 0.325 |
| Total                      | 88 (21.8)                   | 316 (78.2)       | 404 (100)        |      |

| Frequency of nut intake    | Metabolic syndrome | Total | COR (95% CI) | P value |
|----------------------------|--------------------|-------|--------------|---------|
|                            | Yes                | No    |              |         |
| Often                      | 19 (31.1)          | 42 (68.9) | 61 (100)     | 1       |
| Sometimes                  | 94 (94.9)          | 5 (5.1)     | 99 (100)     | 105.6 (37.4–298.4) | <0.001 |
| Rarely                     | 239 (98)           | 5 (2)      | 244 (100)    | 2.5 (0.7–9.0) | 0.147 |
| Total                      | 352 (87.1)         | 52 (12.9)   | 404 (100)    |       |

| Frequency of nut intake    | BP                 | Elevated BP | Normal BP |       |
|----------------------------|--------------------|-------------|-----------|------|
| Often                      | 22 (36.1)          | 39 (63.9)   | 61 (100)  | 1    |
| Sometimes                  | 60 (60.6)          | 39 (39.4)   | 99 (100)  | 5.4 (3.0–9.9) | <0.001 |
| Rarely                     | 184 (75.4)         | 60 (24.6)   | 244 (100) | 2.0 (1.2–3.3) | 0.007 |
| Total                      | 266 (65.8)         | 138 (34.2)  | 404 (100)  |      |

| Frequency of nut intake    | HDL                | Reduced HDL | Normal HDL |       |
|----------------------------|--------------------|-------------|------------|------|
| Often                      | 35 (57.4)          | 26 (42.6)   | 61 (100)   | 1    |
| Sometimes                  | 74 (74.7)          | 25 (25.3)   | 99 (100)   | 3.0 (1.7–5.5) | <0.001 |
| Rarely                     | 196 (80.3)         | 48 (19.7)   | 244 (100)  | 1.4 (0.8–2.4) | 0.254 |
| Total                      | 305 (75.5)         | 99 (24.5)   | 404 (100)  |      |
Table 4  Continued

| Frequency of legume intake | Metabolic syndrome | Yes | No | Total | COR (95% CI) | P value |
|---------------------------|-------------------|-----|----|-------|--------------|---------|
| Frequency of nut intake   | TGs               |     |    |       |              |         |
| Often                     | Raised TGs        | 17  | 44 | 61    | 61 (100)     | 1       |
|                           | Normal TGs        |     |    |       |              | <0.001  |
| Sometimes                 | Raised TGs        | 73  | 26 | 99    | 6.2 (3.3–11.5)|         |
|                           | Normal TGs        |     |    |       |              |         |
| Rarely                    | Raised TGs        | 172 | 72 | 244   | 0.9 (0.5–1.4)| 0.547   |
|                           | Normal TGs        |     |    |       |              |         |
| Total                     |                   | 262 | 142| 404   |              |         |

COR, crude OR.

Table 5  Relationship between consumption of processed/fast foods and metabolic syndrome-related components

| Frequency of eating processed/fast foods | Metabolic syndrome | Yes | No | Total | χ2 | Df | P value |
|-----------------------------------------|-------------------|-----|----|-------|----|----|---------|
| Rarely                                  | Metabolic syndrome | 90  | 38 | 128   | 66.34 | 2 | <0.001 |
| Sometimes                               |                   | 120 | 9  | 129   |     |    |         |
| Always                                  |                   | 142 | 5  | 147   |     |    |         |
| Total                                   |                   | 352 | 52 | 404   |     |    |         |

COR, crude OR.
sometimes consumed legumes were six (95% CI: 3.27–12.52, p<0.001) and four (95% CI: 1.24–10.83, p=0.022) times, respectively, more likely to develop MetS compared with those who always consumed legumes. With regards to nut intake, respondents who rarely consumed nuts were seven (95% CI: 3.68–13.62, p<0.001) and four (95% CI: 1.36–9.54, p=0.011) times, respectively, more likely to develop MetS compared with those who always consumed nuts (table 8).

**DISCUSSION**

Our findings underscore the relationship between dietary patterns/practices and MetS in adults with central obesity. In sum, we report that MetS is linked with frequent consumption of: large proportion of carbohydrates, proteins, processed/fast foods, large amounts of sugars, less than 50% portion of a plate filled as vegetables and/or fruits, and adding salt to food. However, adequate and/or frequent consumption of: fruits, vegetables, legumes and nuts were linked with protection against MetS. Additionally, those who observed more than a 2-hour interval between eating dinner and sleeping were less likely to have MetS. Although these findings show the importance of diet practices/patterns in the development and sustainability of MetS—a well-documented narrative, such link has also been locally reported with

### Table 6  Consumption of sugar and salt in relation to metabolic syndrome (MetS)-related components

| MetS and its components | Sugar consumption status | Total | $\chi^2$ | Df | P value |
|-------------------------|--------------------------|-------|---------|----|---------|
|                         | $\leq 5$ tsp per day | $>5$ tsp per day |       |     |         |
| MetS                    | N (%) | N (%) | N (%) | 6.917 | 1 | 0.009   |
| Yes                     | 123 (34.9) | 229 (65.1) | 352 (100) |     |     |         |
| No                      | 28 (53.8) | 24 (46.2) | 52 (100) |     |     |         |
| Total                   | 151 (37.4) | 253 (62.6) | 404 (100) |     |     |         |
| Blood pressure (BP)     |              |       |         |     |     |         |
| Elevated BP             | 100 (37.6) | 166 (62.4) | 266 (100) | 0.016 | 1 | 0.9     |
| Normal BP               | 51 (37) | 87 (63) | 138 (100) |     |     |         |
| High-density lipoprotein (HDL) | 109 (35.7) | 196 (64.3) | 305 (100) | 1.428 | 1 | 0.232   |
| Reduced HDL             | 42 (42.4) | 57 (57.6) | 99 (100) |     |     |         |
| Normal HDL              |              |       |         |     |     |         |
| Triglycerides (TGs)     |              |       |         |     |     |         |
| Raised TGs              | 101 (38.5) | 161 (61.5) | 262 (100) | 0.438 | 1 | 0.508   |
| Normal TGs              | 50 (35.2) | 92 (64.8) | 142 (100) |     |     |         |
| Fasting blood glucose (FBG) | 53 (60.2) | 35 (39.8) | 88 (100) | 25.099 | 1 | <0.001  |
| Raised FBG level        | 98 (31) | 218 (69) | 316 (100) |     |     |         |
| Normal FBG level        |              |       |         |     |     |         |
| Total                   | 151 (37.4) | 253 (62.6) | 404 (100) |     |     |         |

| Adds salt to meals at the table | Total |                |
|----------------------------------|-------|----------------|
| MetS                             | N (%) | N (%) | N (%) | 0.113 | 1 | 0.736 |
| Yes                              | 205 (58.2) | 147 (41.8) | 352 (100) |     |     |         |
| No                               | 29 (55.8) | 23 (44.2) | 52 (100) |     |     |         |
| Total                            | 234 (57.9) | 170 (42.1) | 404 (100) |     |     |         |
| BP                               |       |       |       | 21.718 | 1 | <0.001 |
| Elevated BP                      | 176 (66.2) | 90 (33.8) | 266 (100) |     |     |         |
| Normal BP                        | 58 (42) | 80 (58) | 138 (100) |     |     |         |
| HDL                              |       |       |       | 0.006 | 1 | 0.936 |
| Reduced HDL                      | 177 (58) | 128 (42) | 305 (100) |     |     |         |
| Normal HDL                       | 57 (57.6) | 42 (42.4) | 99 (100) |     |     |         |
| TGs                              |       |       |       | 9.697 | 1 | 0.002 |
| Raised TGs                       | 137 (52.3) | 125 (47.7) | 262 (100) |     |     |         |
| Normal TGs                       | 97 (68.3) | 45 (31.7) | 142 (100) |     |     |         |
| FBG                              |       |       |       | 10.026 | 1 | 0.002 |
| Raised FBG level                 | 38 (43.2) | 50 (56.8) | 88 (100) |     |     |         |
| Normal FBG level                 | 196 (62) | 120 (38) | 316 (100) |     |     |         |
| Total                            | 234 (57.9) | 170 (42.1) | 404 (100) |     |     |         |
intake of refined carbohydrate, processed/fast foods, sugar-sweetened beverages, low fruits and vegetables as the main associated risks.

Consumption of large amounts of carbohydrates and proteins, as well as small proportion of vegetables and/or fruits, was linked to higher prevalence of MetS, elevated BP and raised FBG level. The aforementioned does not meet the DASH diet criteria.9 31 However, excess consumption of carbohydrates3 and specifically animal-based protein foods32 increases the risks for MetS. Importantly, consumption of unhealthy diet characterised by a high-calorie content is known risk factor for obesity, a principal element for various metabolic-clinical abnormalities such as dyslipidaemia, high BP, insulin resistance features of MetS.21 The cardiometabolic protective effects of fruits and vegetables can be attributed to their richness in vitamins, minerals, phytochemicals, fibres, potassium, magnesium and antioxidants. Fruits and vegetables are rich in phytochemicals and flavonoids which have been reported to support cardioprotective properties.33 Both fruits and vegetables are also rich in soluble dietary fibres that may decrease the intestinal absorption for cholesterol and bile salts, thus controlling their levels.34 Consumption of high-fibre diets such as fruits and vegetables slows absorption of foods in the gut, resulting in a regulated release of insulin from the pancreas, thus maintaining normal glucose level. Furthermore, vegetables and fruits are rich in potassium, an important cofactor for BP regulation. Mechanistically, when serum potassium level is low, sodium and water retention increases resulting in high BP.35 36

We show that the prevalence of MetS and related components was inversely associated with legume consumption. The findings are consistent with reported beneficial effect of legumes on MetS,7 8 TGs and BP.37 The cardiometabolic protective effect of dietary legumes is attributed to the high content of viscous soluble fibres which contributes to slow absorption of carbohydrates, cholesterol and bile salts in the intestine resulting in improved blood sugar control and blood lipid levels.34 Similarly, regular consumption of nuts is associated with lower risk of MetS.

| Time interval between taking dinner and sleep | Metabolic syndrome | Total | COR (95% CI) | P value |
|----------------------------------------------|-------------------|-------|--------------|---------|
|                                              | Yes               | No    |              |         |
| Less than 1 hour                             | 97 (90.7)         | 10 (9.3) | 107 (100) | 1       |
| 1–2 hours                                    | 201 (92.2)        | 17 (7.8)  | 218 (100) | 0.2 (0.1–0.5) | <0.001 |
| More than 2 hours                            | 54 (68.4)         | 25 (31.6) | 79 (100)  | 0.2 (0.1–0.4) | <0.001 |
| Total                                        | 352 (87.1)        | 52 (12.9)  | 404 (100) |         |
|                                              | Blood pressure (BP) |       |              |         |
|                                              | Elevated BP       | Normal BP |              |         |
| Less than 1 hour                             | 69 (64.5)         | 38 (35.5)  | 107 (100) | 1       |
| 1–2 hours                                    | 157 (72)          | 61 (28)   | 218 (100) | 0.6 (0.3–1.0) | 0.059 |
| More than 2 hours                            | 40 (50.6)         | 39 (49.4)  | 79 (100)  | 0.4 (0.2–0.7) | 0.001 |
| Total                                        | 266 (65.8)        | 138 (34.2) | 404 (100) |         |
|                                              | High-density lipoprotein (HDL) |       |              |         |
|                                              | Reduced HDL       | Normal HDL |              |         |
| Less than 1 hour                             | 92 (86)           | 15 (14)   | 107 (100) | 1       |
| 1–2 hours                                    | 164 (75.2)        | 54 (24.8)  | 218 (100) | 0.3 (0.1–0.5) | <0.001 |
| More than 2 hours                            | 49 (62)           | 30 (38)   | 79 (100)  | 0.5 (0.3–0.9) | 0.027 |
| Total                                        | 305 (75.5)        | 99 (24.5)  | 404 (100) |         |
|                                              | Triglycerides (TGs) |           |              |         |
|                                              | Raised TGs        | Normal TGs |              |         |
| Less than 1 hour                             | 62 (57.9)         | 45 (42.1)  | 107 (100) | 1       |
| 1–2 hours                                    | 156 (71.6)        | 62 (28.4)  | 218 (100) | 0.9 (0.5–1.6) | 0.76 |
| More than 2 hours                            | 44 (55.7)         | 35 (44.3)  | 79 (100)  | 0.5 (0.3–0.9) | 0.011 |
| Total                                        | 262 (64.9)        | 142 (35.1) | 404 (100) |         |
|                                              | Fasting blood glucose (FBG) |         |              |         |
|                                              | Raised FBG level  | Normal FBG level |              |         |
| Less than 1 hour                             | 21 (19.6)         | 86 (80.4)  | 107 (100) | 1       |
| 1–2 hours                                    | 50 (22.9)         | 168 (77.1) | 218 (100) | 1.1 (0.5–2.3) | 0.752 |
| More than 2 hours                            | 17 (21.5)         | 62 (78.5)  | 79 (100)  | 0.9 (0.5–1.7) | 0.796 |
| Total                                        | 88 (21.8)         | 316 (78.2) | 404 (100) |         |

COR, crude OR.
### Table 8  Multivariable analysis for dietary risk factors of metabolic syndrome

| Variable                                                                 | AOR   | 95% CI         | P value |
|--------------------------------------------------------------------------|-------|----------------|---------|
| **Full/first model**                                                     |       |                |         |
| Proportion of plate filled with vegetables and/or fruits                 |       |                |         |
| Less than half of a plate                                               | 2.15  | 0.63           | 7.29    | 0.221  |
| Half and above of a plate                                               | Ref   |                |         |        |
| Frequency of processed/fast food intake                                 |       |                |         |
| Always                                                                   | 3.192 | 1.246          | 6.903   | 0.004  |
| Sometimes                                                                | 2.132 | 0.775          | 5.648   | 0.109  |
| Rarely                                                                   | Ref   |                |         |        |
| Frequency of fruit intake                                               |       |                |         |
| Not daily                                                                | 2.015 | 0.526          | 7.16    | 0.306  |
| Daily                                                                    | Ref   |                |         |        |
| Frequency of vegetable intake                                           |       |                |         |
| Not daily                                                                | 1.048 | 0.293          | 3.744   | 0.942  |
| Daily                                                                    | Ref   |                |         |        |
| Frequency of legume intake                                              |       |                |         |
| Rarely                                                                   | 6.19  | 2.624          | 11.725  | <0.001 |
| Sometimes                                                                | 3.702 | 1.096          | 10.248  | 0.039  |
| Often                                                                    | Ref   |                |         |        |
| Frequency of nut intake                                                 |       |                |         |
| Rarely                                                                   | 6.667 | 3.78           | 12.811  | <0.001 |
| Sometimes                                                                | 4.718 | 1.934          | 9.18    | 0.012  |
| Always                                                                   | Ref   |                |         |        |
| Sugar consumption status                                                |       |                |         |
| >5 tsp per day                                                          | 1.505 | 0.426          | 5.315   | 0.525  |
| ≤5 tsp per day                                                          | Ref   |                |         |        |
| Time interval between taking dinner and sleep                            |       |                |         |
| Less than 1 hour                                                        | 4.21  | 0.819          | 21.644  | 0.085  |
| 1–2 hours                                                               | 3.824 | 0.908          | 16.11   | 0.061  |
| More than 2 hours                                                       | Ref   |                |         |        |
| **Reduced/last model**                                                  |       |                |         |
| Frequency of processed/fast food intake                                 |       |                |         |
| Always                                                                   | 3.286 | 1.482          | 7.289   | 0.003  |
| Sometimes                                                                | 3.358 | 0.864          | 13.053  | 0.08   |
| Rarely                                                                   | Ref   |                |         |        |
| Frequency of legume intake                                              |       |                |         |
| Rarely                                                                   | 6.395 | 3.267          | 12.519  | <0.001 |
| Sometimes                                                                | 4.28  | 1.235          | 10.832  | 0.022  |
| Often                                                                    | Ref   |                |         |        |
| Frequency of nut intake                                                 |       |                |         |
| Rarely                                                                   | 7.081 | 3.68           | 13.622  | <0.001 |
| Sometimes                                                                | 4.03  | 1.359          | 9.538   | 0.011  |
| Often                                                                    | Ref   |                |         |        |

AOR, adjusted OR.
and related components. The beneficial effect of regular consumption of nuts on MetS, central obesity, type 2 diabetes, BP and TGs is well established. Nuts may exert protective effect on MetS through several mechanisms. First, they are rich in both macronutrients and micronutrients including unsaturated fatty acids, fibre, non-sodium minerals, tocopherols and bioactive phytochemicals such as polyphenols and phytosterols. These biomolecules have cardioprotective effect via improving inflammation, oxidative stress and endothelial function. The mechanisms can improve insulin secretion and sensitivity and thus reduce the risk of type 2 diabetes, dyslipidaemia, central obesity and hypertension. Furthermore, dietary fibres from nuts have cholesterol and blood glucose reducing effects. Nuts have magnesium that can reduce peripheral inflammation improving insulin resistance as well as stimulating production of vasodilators specifically nitric oxide and prostacyclin, hence controlling both blood glucose and BP.

As regards to frequent consumption of processed/fast foods, they were directly linked to MetS (elevated BP, low HDL-C, raised TGs and FBG levels). These findings are consistent with reports showing frequently consumption of processed/fast foods increases chances of having MetS. Processed/fast foods are high in refined carbohydrates, cholesterol, salt, processed sugars—MetS-friendly food but poor in whole grains, fruits and vegetables. Additionally, excessive sugar consumption (more than five teaspoons in a day) is a risk factor for MetS. Intake of below 25 g (five teaspoons) per person is recommended by the WHO to prevent NCDs notably hypertension and diabetes. Added sugars and/or sugar-sweetened beverages are linked with central obesity, insulin resistance, type 2 diabetes, high BP and MetS. Surprisingly, we found consumption of less sugar per day to be associated with raised FBG levels. This finding could have been attributed to the known patients with diabetes recruited into the study who were more likely to have been taking less or no sugar as per the recommendation compared with non-diabetics.

Adding salt to foods after the food has been cooked was shown to be associated with elevated BP. The relationship between salt consumption and high BP is well documented. Dietary guideline by WHO recommends daily salt intake of less than 5 g (one teaspoon) per person to help prevent high BP, reduce risk of heart disease and stroke in adults. Of particular interest in our study finding is that low-salt consumption was significantly associated with both raised TGs and FBG levels. Indeed, reducing or restriction salt intake has a beneficial effect on lowering BP. However, an unwanted side effect that we also show is consuming less salt has increased risk of elevated levels of blood cholesterol. The mechanisms associated with low salt intake and hyperlipidaemia can be explained by the fact that limited sodium intake reduces body water content and in an attempt to revert the low plasma volume, epinephrine, renin and angiotensin increase. These hormones inhibit insulin action, causing insulin resistance and consequently high insulin level in the blood inhibits lipid metabolism and increases blood cholesterol. With regards to the raised FBG level in relation to low salt intake, there is so far no explanation to this association. However, it could be due to mechanisms associated with the aforementioned hormones.

A finding of interest is the short time interval between taking dinner and going to bed and likelihood of MetS. This is related to the fact that quantity of food consumed is directly associated with shunting of blood into the mesenteric system resulting into early sleepiness. This finding is consistent with reports that eating too close to bedtime is a risk factor for obesity, dyslipidaemia, MetS and hyperglycaemia, diabetes and cardiovascular morbidity. Indeed, eating an early dinner allows the body time to burn off those unwanted calories before going to sleep and thus reduces the risks of CVDs. Whether, the likelihood of sleepiness relative to the quantity and quality of food was not a subject of our investigation. However, reports show carbohydrate-rich food is associated with sleepiness due to their possibility of increasing plasma concentration of tryptophan—a precursor for serotonin and sleep-inducing agent.

**Strengths and limitations of this study**

This was the first study conducted among the informal settlements (slums) in Kenya that determined the association between dietary intake patterns and MetS. The relatively large sample size increases the possibility of replication and generalisation of the findings. The use of widely recognised and validated dietary questionnaires is another strength of the study. The findings reinforce the importance of dietary consideration in public health interventions addressing MetS and related cardiovascular problems. The study was limited by its cross-sectional design. The self-reported dietary patterns and practices may suffer from information bias. The current study was conducted in Nairobi, the capital city of Kenya, where consumption of processed and/or fast foods as well as sweetened beverages is common, thus, generalisability to the rural areas in the country may not be possible.

In conclusion, regular consumption of fruits, vegetables, legumes and nuts, as well as observing sometime after eating dinner before sleeping, was the dietary pattern significantly associated with reduced risk of MetS. However, consumption of a large quantity of carbohydrates, proteins, processed/fast foods and sugar is likely to predispose to MetS. The findings underscore the need to focus on specific dietary intake patterns including frequency, quantity, quality and variety for MetS prevention and management. The MetS-related interventions could be implemented during individual consultation, group and community health messaging sessions.

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