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Sugar intake and metabolic syndrome among older adults in Peninsular Malaysia

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ABSTRACT

Introduction: Sugar is widely consumed and excessive intake has been associated with increased risk of weight gain, diabetes mellitus and cardiovascular diseases, leading to metabolic syndrome (MetSyn). However, the association between sugar intake and MetSyn has seldom been studied among multi-ethnic Malaysian older adults. **Methods:** A total of 1,057 respondents aged ≥60 years were recruited through multistage random sampling from selected states. Anthropometric parameters, blood pressure, blood test for sugar and lipid profile were determined. Dietary intake was derived using a 7-day dietary history questionnaire (DHQ) and a semi-quantitative food frequency questionnaire (FFQ) for added sugar intake. **Results:** Prevalence of MetSyn was 39.9%, 30.9% and 42.2% using the harmonised definition, International Diabetes Federation (IDF) and National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATPIII) definitions respectively. Mean total sugar intake was 40.5±32.0 g (8 tsp) and added sugar intake was 33.0±31.0 g (6 tsp). Excessive added sugar consumption at 100th percentile increased risks of high total cholesterol by two-fold (p<0.001) and triglyceride by 1.8 fold (p<0.001). Total sugar intake at 50th percentile increased risk of high blood pressure by 0.68 fold (p<0.05) and total sugar intake at 50th, 75th and 100th percentile increased total cholesterol risk by 1.7 fold (p<0.01), 1.5 fold (p<0.05) and 2.3 fold (p<0.001) respectively. **Conclusion:** Excessive sugar consumption among older adults showed no association with MetSyn but revealed significant associations with blood pressure and lipid profiles. Effects of long term excessive consumption of sugar on health outcomes in older persons should be investigated.

Keywords: Metabolic syndrome, older adults, elderly, sugar intake, sugar consumption

INTRODUCTION

Metabolic syndrome (MetSyn) is defined as an existence of several risk factors, including abdominal obesity, dyslipidemia, high blood pressure, high blood sugar and insulin resistance (Gami *et al.,* 2007). While several criteria and definitions have been used to

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identify MetSyn, it is generally agreed that a combination of three or more of the following components must be present: large waist circumference, elevated triglycerides, low HDL-cholesterol, raised blood pressure, and elevated fasting blood glucose (Alberti *et al.,* 2009). MetSyn is categorised as a low grade chronic inflammation due to multiple complex interactions between genetic and environment factors (Kaur, 2014).

The prevalence of MetSyn among Malaysian adults was 37.1% (Mohamud *et al.,* 2011), with figures was notably high among the older adults (43.4%) (Johari & Shahar, 2014).

MetSyn was associated with inappropriate dietary pattern such as high fat and high carbohydrate induced metabolic syndrome and cardiovascular re-modeling in rats (Panchal *et al.,* 2011). In particular, Johari & Shahar (2014) showed that MetSyn was associated with higher intake of carbohydrates. Excess intake of carbohydrate would further increase blood sugar, blood pressure and metabolic effects. However, there was no description of which type of carbohydrates will actually affect the metabolic system. Sugar has been associated with increase the risk of weight gain, insulin resistance and dyslipidemia (Yang *et al.,* 2014). The latest recommendation from WHO (2015) and also Malaysian RNI (NCCFN, 2017) both suggested that consumption of additional sugar should be reduce, i.e. it should be limited to no more than 10% from total energy intake.

Daily total sugar intake of the adult population was 7 tsp which is equivalent to 37 g per day (Norimah *et al.*, 2008). A study among older adults in a rural area of Malaysia found that the sources of sugar intake were mainly from sweetened beverages (especially tea and coffee) and also traditional *kuih* (Shahar, Earland & Rahman, 2000). However, the amount of sugar intake and the effect towards health among older adults were not yet identified. Hence, the objective of this study was to identify the sugar intake and its association with the risk of MetSyn among older adults in Peninsular Malaysia.

MATERIALS AND METHODS

Study design and sampling

This was a cross-sectional study involving 1,336 individuals recruited from four states i.e. Johor, Perak, Kelantan and Selangor through a multistage random sampling between March to September 2016. This study was part of a large scale population-based study among older adults in Malaysia (LRGS TUA) (Shahar *et al.,* 2016). Inclusion criteria included individuals aged 60 years and above, able to communicate well either in Malay or English language with no known mental and terminal illness. A total of 1,057 candidates had completed the data that being included in the analysis. The formula used for sample size calculation for a cross-sectional study to relate between two parameters, namely P_1=0.3 (prevalence of MetSyn and high carbohydrate intake) and P_2=0.41 (prevalence of MetSyn and lower carbohydrate intake) (Mirmiran *et al.,* 2008).

Data collection

Respondents were interviewed at respective community centres to obtain socio-demographic data, health status and sugar intake using 7-day dietary history questionnaire (DHQ) (Shahar, Earland & Abdul Rahman, 2000) and supplemented with semi-quantitative food frequency questionnaire (FFQ) of added sugar intake (Nik Shanita *et al.,* 2012) which was used as a checklist of total sugar consumption. Anthropometric measurements including height, weight, waist and hip circumference were taken. Clinical measurements including blood pressure test and biochemical measurement such as blood sugar and lipid profiles were also performed by trained interviewers.

Body weight was measured using a digital weighing scale (Tanita, HD-319 Digital Lithium Scale, Japan) to the nearest 0.1 kg. Height was measured using stadiometer (SECA, Seca 220 Portable, German) to the nearest 0.1 cm. Body mass index (BMI) was calculated using the formula [weight in kg/ (height in m)^2] and cut-off point of normal BMI as suggested by Nutrition Screening Initiative (NSI) for older adults of 22-27 kg/m^2 was used prior from WHO criteria however it should be taken note that there were no specific BMI criteria for diagnosis of obesity in the elderly until now (Vasconcelos *et al.,* 2010). Waist and hip circumferences were measured using Lufkin tape with ±0.1 cm. Waist-hip ratio was calculated using the formula (waist circumference in cm/hip circumference in cm).

Blood pressure was measured using automatic blood pressure instrument (Omron, HEM-907, Japan). Blood samples of 5 ml were taken and divided into two different colour tubes; 3 ml in red tube for lipid profile and 2 ml in grey tube for sugar profile. Those blood samples were immediately kept in portable refrigerator at 4°C before send to the medical lab for centrifuged and analysed on the same day as the blood was taken.

DHQ was used to obtain information on food, beverages and other nutrients consumption normally consumed by the respondents throughout the week (Shahar, Earland & Abdul Rahman, 2000). Portion sizes consumed by the individual were taken as an indication based on household measurement and the use of pictures from Food Exchanges and Portion Sizes Atlas in order to quantify the total intake and sugar intake (Shahar *et al.*, 2015). In addition, FFQ on added sugar intake among adults (Nik Shanita *et al.,* 2012) was used as a checklist to complete of high sugary food data and to identify missing details on normally dietary consumptions of other sources of sugar intake daily (Figure 1).

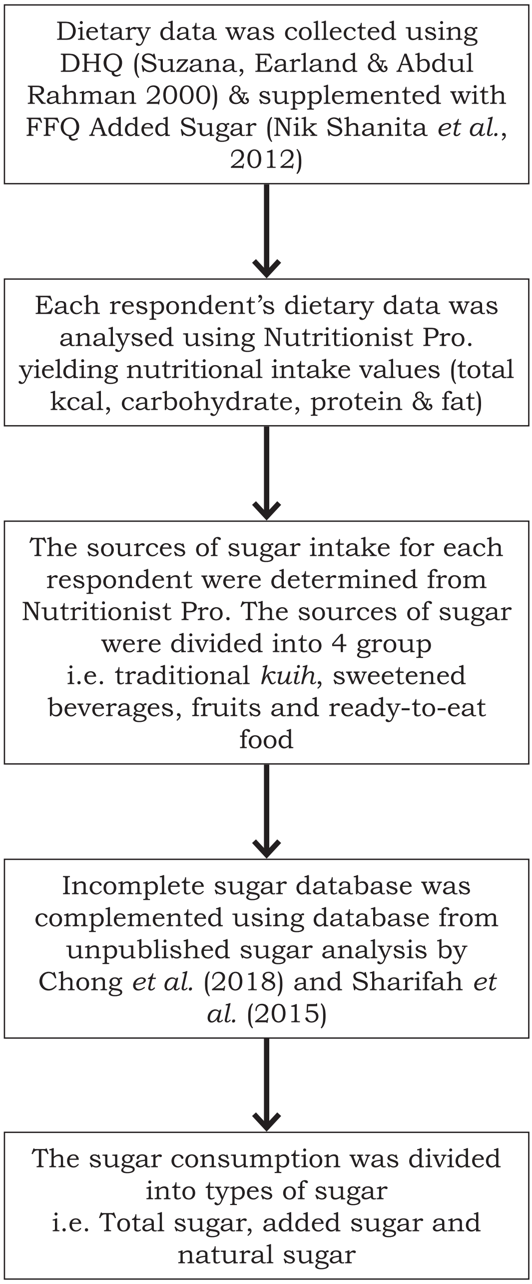

Figure 1. Flowchart of sugar data analysis

The MetSyn criteria suggested by Harmonised by Alberti *et al.* (2009) was used in this study. The criteria were at least any of three out of five risk factors: waist circumference (men: >90 cm; women: >80 cm), blood pressure (>130/85 mmHg), having diabetes mellitus or fasting blood sugar (>5.6 mmol/L), triglyceride (>1.7 mmol/L) or high-density lipoprotein (<1.0 mmol/L for men, <1.3 mmol/L for women). Meanwhile the definition of NCEP-ATP III differs from IDF and Harmonised with respect to the cut-off points of waist circumference used. While the NCEP-ATP continues to use the cut points for US (>102 cm male; >88 cm female), the Harmonised definition allows for national or regional cut points for waist circumference to be used (Table 1).

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 22.0 was used to analyse the data. Dietary sugar intakes were analysed using Nutritionist Pro version 4 and transferred to SPSS. Since the sugar databases were still unavailable, the sugar database from sugar analysis by Chong *et al.* (2018) and Sharifah *et al.* (2015) was used which providing total sugar (in grams) for each food that contain high amount of sugar (Figure 1). The added sugar was calculated by formula [(total sugar (grams) – natural sugar (grams)]. Descriptive data was used to obtain frequency and percentage of socio-demographic data, anthropometric data, total added sugar intake, clinical and biochemical parameters. The total added sugar intakes were further divided into four centiles i.e. 25^{th} percentile [<10.3 g (2 tsp)], 50^{th} percentile [10.3-23.8 g (2-5 tsp)], 75^{th} percentile [23.8-47.0 g (5-9 tsp)] and 100^{th} percentiles [>47 g (9 tsp)]. Independent *t*-test and one-way Anova test were performed to identify the significant differences of two or more than two groups of independent variables. Chi-square test was used to identify significant differences for two categorical data. Binary logistic regression test was used to obtain adjusted odds ratio for each parameters according to percentiles of added sugar.

RESULTS

As presented in Table 2, majority of the respondents were aged between 60-74 years old (73.1%), Malays (67.4%), married (85.5%), non-smokers (71.0%) and had hypertension (52.4%). Overall, respondents had normal body mass

Table 1. Definitions of Metabolic Syndrome

Risk Factors	*NCEP-ATP III (2001)*	*IDF (2005)*	*Harmonized (2009)*
Abdominal Obesity	Waist Circumference: ≥102 cm (M) ≥88 cm (W)	Waist Circumference: ≥90 cm (M) ≥80 cm (W)	Waist Circumference: ≥90cm (M) ≥80 cm (W)
High FBS	>6.1 mmol/L or DM	≥5.6 mmol/L or DM	≥5.6 mmol/L or DM
High BP	≥130/85 mmHg	≥130/85 mmHg	≥130/85 mmHg
High TG	≥1.7 mmol/L	>1.7 mmol/L	≥1.7 mmol/L
Low HDL-c	<1.03 mmol/L (M) <1.3 mmol/L (W)	<1.03 mmol/L (M) <1.3 mmol/L (W)	<1.03 mmol/L (M) <1.3 mmol/L (W)
Metabolic Syndrome	*At least 3 of the risk factors*	*Waist Circumference + 2 or more risk factors*	*At least 3 of the risk factors*

M – men; W- women; FBS – fasting blood sugar; DM – diabetes mellitus; BP – blood pressure; TG – triglyceride; HDL- high density lipoprotein

Table 2. Socio-demographic data and health status according to MetSyn (Harmonised, 2009) and added sugar intake of respondents (presented as *n* (%) or mean±SD)

Parameters	*Metabolic Syndrome*		*Added sugar intake (gram/day)*
	MetSyn (n=423, 40.0%)	*No MetSyn (n=634, 60.0%)*	
Gender[b]			
Men (*n*=525)	203 (38.7)	322 (61.3)	39.9±34.5
Women (*n*=532)	220 (41.4)	312 (58.6)	26.2±25.2
Age group (years)[ab]			
60-74 (*n*=773)	334 (43.2)	439 (56.8)	34.4±30.8
>75 (*n*=284)	89 (31.3)	195 (68.7)	29.9±30.9
Ethnicity[b]			
Malay (*n*=682)	277 (40.6)	405 (59.4)	38.7±32.7[αβ]
Chinese (*n*=324)	122 (37.7)	202 (62.3)	22.4±24.7[α]
Indian (*n*=51)	24 (47.1)	27 (52.9)	24.8±22.4[β]
State[b]			
Johor (*n*=167)	70 (41.2)	100 (58.8)	32.1±33.7
Perak (*n*=266)	108 (40.4)	159 (59.6)	28.1±27.3[α]
Kelantan (*n*=378)	135 (35.7)	243 (64.3)	39.5±32.3[αβ]
Selangor (*n*=242)	110 (45.5)	132 (54.5)	28.8±28.8[β]
Marital status[b]			
Single/separated (*n*=354)	146 (41.2)	208 (58.8)	27.8±26.7
Married (*n*=701)	277 (39.5)	424 (60.5)	35.7±32.5
Smoking status[b]			
Smokers (*n*=164)	66 (40.2)	98 (59.8)	48.1±37.2
Ex/non-smokers (*n*=893)	357 (40.0)	536 (60.0)	30.2±28.8
Diabetes mellitus[ab]			
Yes (*n*=289)	189 (65.4)	100 (34.6)	29.1±30.2
No (*n*=768)	234 (30.5)	534 (69.5)	34.5±31.1
Hypertension[a]			
Yes (*n*=583)	303 (52.0)	280 (48.0)	35.0±31.2
No (*n*=474)	120 (25.3)	354 (74.7)	31.3±30.6
High cholesterol[a]			
Yes (*n*=477)	224 (47.0)	253 (53.0)	31.2±30.1
No (*n*=580)	199 (34.3)	381 (65.7)	34.5±31.5
Heart disease			
Yes (*n*=86)	41 (47.7)	45 (52.3)	32.9±33.5
No (*n*=967)	382 (39.3)	589 (60.7)	33.0±30.7
Added sugar intake (gram/day)	32.3±30.3	34.1±31.9	33.0±30.9
Traditional *kuih* (gram/day)	3.9±6.1	3.8±7.0	3.9±6.7
Sweetened Beverages (gram/day)	28.9±29.8	26.8±27.6	27.7±28.5
Dairy beverages(gram/day)	1.1±4.1	1.5±4.3	1.3±4.2
Fruits (gram/day)	6.3±8.9	5.9±9.2	6.1±9.1
Ready-to-eat (gram/day)	1.3±3.0	1.6±3.6	1.5±3.4

[a] denoted for significant at cross-tab test for two categorical independent variable for MetSyn based on Harmonised definition

[b] denoted for significant at independent *t*-test for two continuous independent variable or two-tailed One Way Anova for more than two continuous independent variable for added sugar intake

[αβ] showed that significant at Schfee post-hoc test for more than two continuous independent variable index (43.5%). However most of the women had a higher BMI (33.6%) and waist circumference (57.7%) compared to men 23.4%, 36.3% respectively) (p<0.0001) (data not shown).

Based on the harmonised criteria, 40.0% of the respondents had MetSyn, especially among respondents aged 60-74 years old (43.2%) and those reported having diabetes mellitus (65.4%), hypertension (52.0%) and high cholesterol (42.0%) (p<0.05) (Table 2). The prevalence was also higher among women, Indian, respondents from Selangor state, living as single or separated and smokers but these differences were not significant (Table 2).

The overall mean intake of total sugar was 40.5±32.0 g/day (≈8 tsp), natural sugar was 7.4±10.4 g/day (≈2 tsp) and added sugar was 33.0±30.9 g/day (≈6 tsp). The intake of habitual added intake was notably high in men, ages 60-74 years, Malays, respondents from Kelantan state, married couples, smokers and having diabetes mellitus (p<0.05) (Table 2). Intake of added sugar among MetSyn respondents were slightly higher (34.1±31.9 g/day) compared to those without MetSyn (32.3±30.3 g/day) but the difference was not significant (p>0.05) (Table 2). However, the highest prevalence of MetSyn (45.2%) was found at 100th percentile of added sugar intake (Figure 2). The highest sources of sugar consumption were sweetened beverages (27.7±28.5 g/day), followed by fruits (6.1±9.1 g/day), traditional *kuih* (3.9±6.7 g/day) and ready-to-eat food (i.e. sweets, honey, biscuits, cookies etc) (1.5±3.4 g/day) (Table 2).

There were significant mean differences for systolic reading (p<0.05), total cholesterol (p<0.05), LDL-c (p<0.01) between added sugar at 25th and 100th percentiles in men (Table 3). Meanwhile for women, there were also significant mean differences for diastolic (p<0.05), total cholesterol (p<0.001) and LDL-c (p<0.001) according to percentiles of added sugar intake (25th, 50th and 75th), with the highest level observed at the 100th percentile of added sugar intake (Table 3).

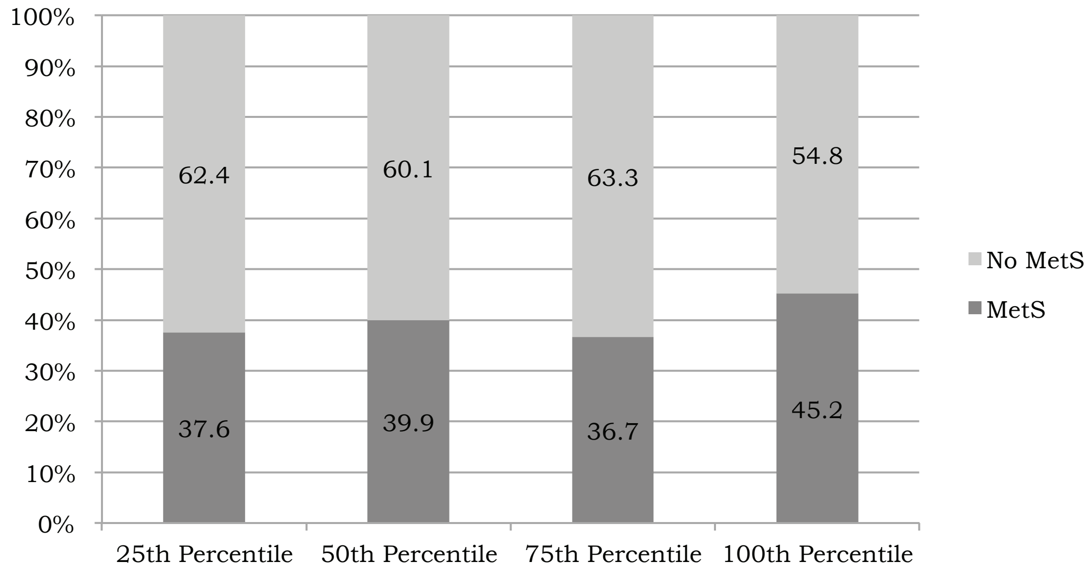

Figure 2. Prevalence of MetSyn based on percentile of added sugar intake

Table 3. Anthropometric, biochemical and clinical data according to percentile of added sugar intake and gender

Parameters	*25^{th} percentile <2 tsp (<10.3 gram) (N=264)*	*50^{th} Percentile 2-5 tsp (10.3-23.8 g) (N=265)*	*75^{th} Percentile 5-9 tsp (23.8-47.1 g) (N=271)*	*100^{th} Percentile >9 tsp (>47.1 g) (N=258)*
Men				
Body mass index	24.42±4.07	24.38±3.99	24.01±4.16	24.39±4.54
Waist circumference	87.32±10.77	86.90±12.66	84.93±10.99	85.81±12.68
Waist-hip ratio	0.94±0.180	0.94±0.157	0.92±0.07	0.91±0.08
Blood pressure				
Diastolic	139.74±22.17	138.08±20.37	139.04±20.57	142.89±23.68
Systolic [a]	72.55±12.07 [β]	74.47±12.81	74.18±12.19	77.40±13.8 [β]
Fasting blood sugar	6.43±2.30	6.46±2.70	6.22±2.29	6.24±2.22
Total cholesterol [a]	4.99±1.35 [β]	5.23±1.12	5.36±1.26	5.49±1.19 [β]
LDL-c [a]	2.95±1.20 [β]	3.15±1.01	3.32±1.14	3.44±1.06 [β]
HDL-c	1.33±0.36	1.33±0.44	1.31±0.35	1.27±0.30
Triglycerides	1.51±0.82	1.65±0.95	1.59±0.90	1.71±0.87
TC:HDL [a]	3.95±1.33 [β]	4.20±1.28	4.27±1.27	4.49±1.28 [β]
Women				
Body mass index	25.02±4.80	24.77±5.61	24.76±4.54	26.30±4.76
Waist circumference	82.27±11.76	83.43±14.57	82.54±11.82	83.05±13.38
Waist-hip ratio	0.87±0.102	0.88±0.09	0.87±0.08	0.87±0.10
Blood pressure				
Diastolic [b]	141.35±22.51	135.78±21.36	136.59±20.15 [β]	142.53±22.86 [β]
Systolic	72.07±13.24	71.30±12.13	72.86±13.78	73.61±10.36
Fasting blood sugar	6.28±2.36	6.15±2.26	5.99±1.98	6.24±2.73
Total cholesterol [b]	5.24±1.03 [βρ]	5.43±0.95	5.61±1.04 [β]	5.85±1.11 [ρ]
LDL-c [b]	3.06±0.95 [βρ]	3.28±0.91	3.43±0.99 [β]	3.57±1.00 [ρ]
HDL-c	1.47±0.33	1.49±0.34	1.53±0.36	1.51±0.39
Triglycerides	1.54±0.79	1.48±0.67	1.50±0.81	1.74±0.87
TC:HDL	3.70±0.94	3.86±1.18	3.85±1.06	4.06±1.05

[a] denoted significant at two-tailed One Way Anova for continuous independent variable for men
[b] denoted significant at two-tailed One Way Anova for continuous independent variable for women
[βρ] showed significant using Tukey post-hoc for more than two continuous independent variable
The unit used for BMI – kg/m^2, WC – cm, BP – mmHg, FBS, TC, LDL-c, HDL-c, TG – mmol/L

Binary logistic regression results in Table 4 showed that the risk of high cholesterol increased two-folds for added sugar intake at 100^{th} percentile [adjOR 2.07 (95% CI 1.40-3.07) (p<0.001)]. Similarly, the risk of high triglyceride was increased by 1.8 fold for added sugar intake at 100^{th} percentile [adjOR 1.80 (95% CI 1.21-2.68) (p<0.001)]. Further, high total sugar intake (added + natural sugar) at 50^{th} percentile [adjOR 0.68 (95% CI 0.48-0.98) (p<0.05)] increased the blood pressure by 0.68 fold. The total sugar intake at 50^{th} percentile [adjOR 1.69 (95% CI 1.17-2.44) (p<0.01)], at 75^{th} percentile [adjOR 1.48 (95% CI 1.02-2.13) (p<0.05)] and at 100^{th} percentile [adjOR 2.28 (95% CI 1.55-3.36) (p<0.001)] also increased the risk of high total cholesterol level.

Table 4. Health risk associated with percentile of added and total sugar intake

Parameters	*25th percentile (<2 tsp a/ <4 tsp b)*	*50th Percentile (2-5 tsp a/ 4-6 tsp b)*	*75th Percentile (5-9 tsp a/ 6-9 tsp b)*	*100th Percentile (>9 tsp ab)*
Added sugar				
Overweight	1.0	1.01 (0.63-1.61)	0.62 (0.38-1.01)	1.22 (0.71-2.11)
Abdominal obesity	1.0	1.08 (0.75-1.54)	1.07 (0.73-1.55)	0.97 (0.64-1.47)
High blood pressure	1.0	0.72 (0.46-1.12)	0.78 (0.49-1.25)	0.86 (0.53-1.41)
High fasting blood sugar	1.0	0.59 (0.25-1.34)	0.45 (0.17-1.10)	0.43 (0.17-1.12)
High total cholesterol	1.0	1.38 (0.96-1.99)	1.45 (0.99-2.10)	2.07 (1.40-3.07)***
High LDL-c	1.0	1.11 (0.74-1.66)	1.42 (0.92-2.19)	1.44 (0.92-2.24)
Low HDL-c	1.0	1.51 (0.88-2.60)	0.88 (0.49-1.60)	1.06 (0.60-1.87)
High triglyceride	1.0	1.44 (0.98-2.11)	1.45 (0.98-2.13)	1.80 (1.21-2.68)***
Total sugar				
Overweight	1.0	0.80 (0.50-1.29)	0.65 (0.40-1.08)	0.92 (0.53-1.60)
Abdominal obesity	1.0	1.18 (0.77-1.83)	1.25 (0.79-1.97)	1.05 (0.62-1.77)
High blood pressure	1.0	0.68 (0.48-0.98)*	0.78 (0.53-1.14)	0.98 (0.66-1.45)
High fasting blood sugar	1.0	1.04 (0.72-1.52)	0.88 (0.61-1.29)	0.85 (0.57-1.25)
High total cholesterol	1.0	1.69 (1.17-2.44)**	1.48 (1.02-2.13)*	2.28 (1.55-3.36)***
High LDL-c	1.0	1.21 (0.80-1.81)	1.26 (0.83-1.93)	1.45 (0.94-2.25)
Low HDL-c	1.0	1.02 (0.60-1.71)	0.77 (0.45-1.33)	0.73 (0.43-1.24)
High triglyceride	1.0	0.92 (0.63-1.33)	0.96 (0.66-1.40)	1.38 (0.95-2.01)

[a] denoted for percentile of added sugar intake
[b] denoted for percentile of total sugar intake
*p<0.05; **p<0.01; ***p<0.001 significant using binary logistic regression (adjusted for age, gender, ethnicity and medication – for biochemical and clinical parameters)

DISCUSSION

This study found that almost 40% of multi-ethnic Malaysian older adults had MetSyn as assessed using the harmonised criteria. The harmonised definition was used as it does not include abdominal obesity as a mandatory criterion, but instead it captures a wider scope of MetSyn by including three or more risk factor i.e. abdominal obesity, high fasting blood sugar, hypertension, low HDL-c or high triglyceride.

The prevalence of MetSyn using IDF in this study was 30.9%. This findings were lower compared to other studies on Malaysian older adults from low cost housing areas (Johari and Shahar 2014), and adults ≥40 years (Rampal *et al.*, 2012) of 43.4% and 44.6% respectively using the same definition. The differences may be due to the fact that IDF definitions used waist circumference as compulsory and the percentages of respondents having abdominal obesity in respective studies might be higher compared to this study. However, both studies did not provide the information on the percentage of respondents who had abdominal obesity hence; it was difficult to distinguish the main component that contributes to MetSyn.

The figure was also lower compared to prevalence of MetSyn among adults in Malaysia (37.1%) (Mohamud *et al.,* 2011) but higher than adults in other Asian countries i.e. China (18.2%) (Liu *et al.*, 2013), Nepal (22.5%) (Sharma *et al.*, 2011) and India (25.8%) (Deepa *et al.,* 2007) using IDF definition. Older adults have a higher risk of having

MetSyn compared to younger adults as aging increased risk of cardiovascular or coronary diseases (Lind *et al.,* 2018). However, there was still a paucity of studies regarding the prevalence of MetS in older person because it is known that different age groups have different body compositions and body fat is increasing while muscles decreasing at a certain age (Denys *et al.,* 2009). Using the IDF definition the prevalence of MetSyn among older adults in China was comparable (30.5%) (He *et al*., 2006).

The prevalence of MetSyn in this current study was higher among women compared to men. This finding was similar from a study from Johari & Shahar (2014). Women were at higher risk of having abdominal obesity than men especially with increase in age (Wang *et al*., 2010). Besides that, Indians showed the highest prevalence of MetSyn compared to other ethnic groups. This was postulated to be associated with environmental and genetic factors (Mohamud *et al.,* 2011).

The mean sugar intake by the older adults in this study was 40 g (8 tsp) which is comparable to MANS study among Malaysian adults (37 g or 7 tsp) (Norimah *et al*., 2008). Men consumed higher amount of sugar (40 g) compared to women (26 g) probably due to bigger body size and higher daily energy requirements. The sources of sugar that were most consumed among respondents were sweetened beverages which included added sugar and sweetened condensed milk that were mixed in tea and coffee and also from traditional *kuih*.

The results indicated that sugar intake showed no association with body mass index, waist circumference, hip circumference and waist-hip ratio. This could be due to obesity is having multi-factorial etiology involving genetic and environment factors (Hu, 2013).

In this study, sugar consumption was found to be associated with blood pressures and lipid profiles. Blood pressure increased by 0.68 folds when the total sugar intake at 75th percentile (5-9 tsp). A direct association between intake of sugar-sweetened beverages or fructose and blood pressure was consistent which showed that from animal data indicate direct pressor effects of glucose, fructose, and sucrose on BP (Brown *et al.,* 2011). The relations between sugar consumption especially in fructose-form sugar may escalated blood pressure through few possible mechanisms (Cohen *et al.,* 2012) which were increase level of serum uric acid that further cause for smooth muscle to constrict; increase sodium absorption in gut making more salt retention in the body; activation of vasoconstrictor and deactivation of vasodilator of vascular; and stimulate the sympathetic nervous system that eventually increase the blood pressure. Also a prospective study by Te Morenga *et al.* (2014) reported an association between sugar consumption (for eight weeks) with blood pressure which possible association between adiposity (from extra caloric from sugar consumption) and both lipid and blood pressure. Excessive sugar consumption may lead to insulin resistance, impaired glucose tolerance and diabetes mellitus (Ferrier *et al.,* 2014).

Sugar intake appears to be associated with increased triglyceride levels, however, relative to the other effects towards high-density lipoprotein and low-density lipoprotein levels which remain unclear (Johnson *et al.,* 2009). This study demonstrated that the risk of TC was increased with increment of total sugar consumption at percentile 50th, 75th and 100th by 1.69 fold, 1.48 fold and 2.28 fold respectively. In addition, added sugar consumption at 100th percentile (>47 g/>9 tsp) also increased the risk of high cholesterol and high triglyceride by 2.07 folds and 1.80 folds respectively. The metabolism of excessive sugar consumption are stored in liver and muscle as glycogen and when it is full it will be stored in adipocyte as fatty acids (Ferrier *et al.,* 2014). Lipogenesis is the process of synthesising fatty acids from other source than fat such as simple sugars from acetyl-coA metabolism. Further, a systematic review done by Te Morenga *et al.* (2014) proved that excessive intake of sugar can increased the level of TG, TC, LDL-c and reduce HDL-c significantly, was observed from studies conducted more than five years and involving large sample size.

This study found a lack of significant association between excessive intake of sugar and risk of MetSyn. This could be due to the cross-sectional study design and small sample size. Other studies conducted over a longer duration and using larger sample size had shown significant association between sugar intake and MetSyn (Palmer *et al.,* 2008). MetSyn is a complex interaction with a multifactorial combination involving biochemical, physiology, clinical, metabolic factors and environment factors (Kaur, 2014). Despite the limitation, this study provides information on sugar consumption among multi-ethnic Malaysian older adults and its effect on selected blood markers.

CONCLUSION

This study showed no significant association between excessive sugar consumption and MetSyn among older adults. However, a higher sugar intake was associated with high blood pressure and undesirable lipid profile. The effects of long term excessive consumption of sugar on health outcomes in older persons should be investigated.

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Authors' contributions

NurZetty Sofia Z, led the data collection, conducted the study, data analysis and interpretation, prepared the draft of the manuscript and reviewed the manuscript; Suzana S, principal investigator, conceptualized and design the study, advised on data analysis and interpretation and reviewed the manuscript; Nik Shanita S, advised on sugar intake data analysis and reviewed the manuscript; Hasnah H, advised on sugar analysis food lab and reviewed the manuscript; Mohd Azahadi O, advised on data analysis and interpretation.

Conflict of interest

The authors have no conflict of interest to disclose in this work.

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