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How different is the Dietary Intake of Individuals with Metabolic Syndrome?

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CHP, HAS, BNMY and MNMT conceived and designed the experiments. Authors CHP and HAS analyzed the data. Authors CHP and HAS wrote the paper. All authors read and approved the final manuscript.

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ABSTRACT

Background: Metabolic syndrome has turned out to be a chief public health concern, but the role of diet in the etiology of metabolic syndrome is not well understood.
Aims: This study aimed at assessing whether individuals with metabolic syndrome had a specific dietary intake and how it compared with the Recommended Nutrient Intakes for Malaysia and the Medical Nutrition Therapy Guidelines by the Malaysian Dietitians' Association.
Study Design: Cross-sectional study.
Place of Study: Putrajaya, Malaysia.
Duration of Study: Eight weeks.
Methodology: Waist circumference, systolic blood pressure, diastolic blood pressure, triglycerides, HDL cholesterol and fasting plasma glucose were collected in 659 randomly selected subjects. A total of 275 out of 322 subjects with metabolic syndrome completed the self-administered three-day

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food record. Data were analysed with Nutritionist Pro, and were compared with the Recommended Nutrient Intakes for Malaysia (2010), based on age and gender. Metabolic syndrome was defined according to the 'Harmonized' criteria.

Results: Subjects' mean age was 34.51±8.30 years, 202 Females: 73 Males. Comparison of subjects' food records with the Recommended Nutrient Intakes for Malaysia revealed that protein consumption was significantly higher among study subjects compared to the Recommended Nutrient Intakes for Malaysia (62 g/day for males; 55 g/day for females), *P*<.001. All subjects (100%) had low fibre (<20 g/day) intake. Conversely, most subjects (72.0%) had high sodium intake (≥2400 mg/day).

Conclusion: This study highlights the importance of assessing the dietary intake of each individual with metabolic syndrome. There is a discrepancy between the dietary intake among individuals with metabolic syndrome and the Recommended Nutrient Intakes for Malaysia or Medical Nutrition Therapy Guidelines by the Malaysian Dietitians' Association. Notwithstanding, our study cannot declare that diet induces the disease, yet it definitely sheds more light on the need for appropriate and professional dietary measures to be integrated in the management of individuals with metabolic syndrome.

Keywords: Metabolic syndrome; dietary intake; medical nutrition therapy; recommended nutrient intakes.

1. INTRODUCTION

Metabolic syndrome is a cluster of risk factors, including obesity, dyslipidemia, hypertension, glucose intolerance and insulin resistance, that increases the risk for cardiovascular disease and type 2 diabetes mellitus [1,2]. A remarkable increase in the number of people with metabolic syndrome has occurred worldwide [3]. A national survey conducted from January to December 2008 revealed that the overall prevalence of metabolic syndrome was 32.1%, 34.3%, 37.1% and 42.5%, based on definitions from the World Health Organisation, the National Cholesterol Education Program ATP III, the International Diabetes Federation and 'Harmonized', respectively [4]. Identification of particular foods and nutrients associated with metabolic syndrome is imperative for the formulation of dietary recommendations [5]. Further, the combined effect of food and nutrients, which are consumed together, may be synergistic. In this context, dietary intake analysis, which concentrates on macronutrients and their composition, may impart supplementary data to relate diet to disease risk.

Notwithstanding, previous studies have recognised food intake composition and examined their association with metabolic syndrome, but these studies were predominantly from Europe [6,7], Korea [8-11], the Middle East [12-14], North America [15], Samoa [16], and the United States [17,18]. Dietary habits of Asians, including Malaysians, are considerably different from those countries [19].

Despite the evident links to metabolic syndrome, little is known about the dietary intake of individuals with metabolic syndrome. Management for individuals with metabolic syndrome generally includes diet modifications, albeit there is a lack of supporting evidence. Hence, the aim of this study, conducted among government employees with metabolic syndrome, was to analyse their dietary intake and how they compared with the Recommended Nutrient Intakes for Malaysia [20] and the Medical Nutrition Therapy Guidelines by the Malaysian Dietitians' Association [21].

2. METHODOLOGY

2.1 Study Procedure

Subjects were requested to fill in a three-day food record, which was checked for completeness and, where necessary, was clarified by asking the subjects questions. We also collected data that were routinely obtained in a health examination, including anthropometric measures (waist circumference), blood pressure measurement and biochemical data. This study conformed to the principles of the Helsinki Declaration and was approved by the Ethics Committee of the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia (Reference No UPM/FPSK/100-9/2-MJKEtikaPen (JPD_Jan (12) 04). Written informed consent was obtained from each subject. The flow chart of data collection was demonstrated in Fig. 1.

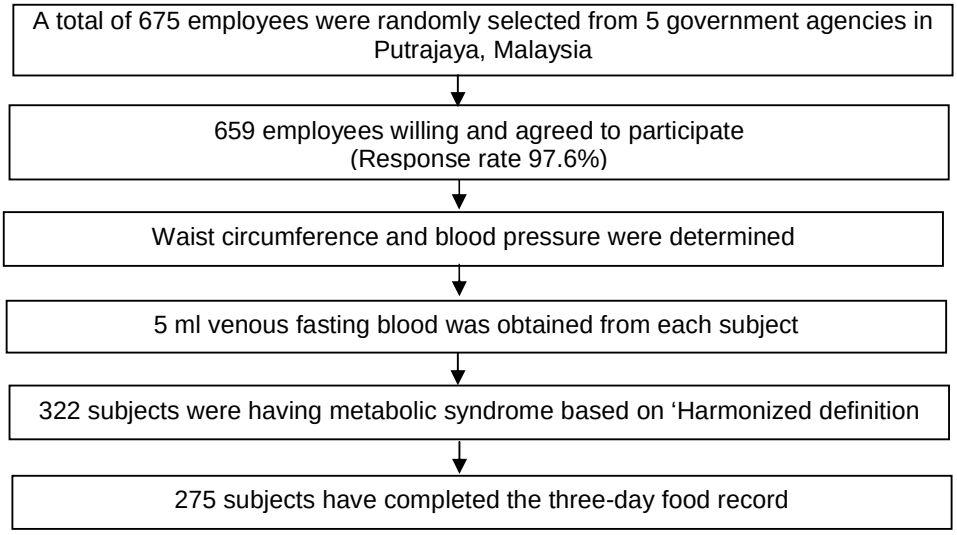

Fig. 1. Flow chart of data collection

2.2 Study Subjects

A total of 675 government employees were randomly selected from a list of 3173 government employees at the five government agencies, using a Table of Random Numbers.

Of the 322 government employees with metabolic syndrome, 275 subjects (73 males and 202 females) aged 18 to 59 years completed the self-administered three-day food record.

2.3 Dietary Assessment

Dietary intake data was obtained through use of a food record for three days (two consecutive weekdays and one weekend day). Each subject was familiarised with portion sizes and the relevant procedures for successfully completing a food record. The records were checked for any mis-recorded or missing information when subjects returned the records.

To estimate compliance with respect to recording everything, a ratio between total daily energy intake (EI) and basal metabolic rate (BMR) was calculated [22]. The basal metabolic rate was obtained from the Lifecorder e-Step activity monitor (Suzuken Company Limited, Nagoya, Japan). A ratio of EI/BMR below 1.2 was used as the cut-off point to identify non-compliance in recording [23].

2.4 Anthropometric Measurement

Waist circumference was measured at the end of normal expiration between the lowest rib and the iliac crest using a non-elastic measuring tape to the nearest 0.1 cm. Waist circumference was categorised as 'normal' (<90 cm for men and <80 cm for women) and 'high risk' (≥90 cm for men and ≥80 cm for women) according to the cut-off points proposed by the 'Harmonized' definition [24].

2.5 Blood Pressure Measurement

Duplicate measurements of blood pressure (in mmHg) were measured two minutes apart with a digital automated blood pressure monitor, Omron HEM-907 (Omron, Japan), after the subjects had rested in a seated position for five minutes [25]. An average of the two readings was taken. The right arm was placed on a table and a cuff was placed on the right upper arm. The mean value of the two measurements was computed. Elevated blood pressure was defined as either elevated systolic blood pressure (≥130 mmHg) or elevated diastolic blood pressure (≥85 mmHg) alone, or a combination of both [24].

2.6 Biochemical Measurements

Blood samples were collected in the morning after subjects had undergone an overnight fast. A total of 5 ml of venous blood was collected with a syringe and needle. All vials were delivered in a cool box packed with dry ice to an accredited pathology laboratory (Gribbles Pathology (M) Sdn Bhd, Bangi, Malaysia) after collection of all blood samples.

2.7 Definition of Metabolic Syndrome

Metabolic syndrome and metabolic risk factors were defined according to the 'Harmonized' criteria [24]. There are five metabolic risk factors according to the 'Harmonized' definition, including waist circumference, HDL cholesterol, triglycerides, fasting glucose, systolic blood pressure and diastolic blood pressure (Table 1).

2.8 Statistical Analysis

Nutritionist Pro (First Data Bank) was used to analyse dietary data. Data was analysed using SPSS version 20. Nominal or ordinal variable values were depicted as frequency and percentage, while interval or ratio variable values were presented as mean ± standard deviation. One sample *t*-test was used to test whether there was a significant difference between the sample means and the Recommended Nutrient Intakes for Malaysia [20] and the Medical Nutrition Therapy Guidelines by the Malaysian Dietitians' Association [21].

3. RESULTS

Of the 322 government employees with metabolic syndrome, 275 subjects (73 males and 202 females) aged 34.51±8.30 years completed the self-administered three-day food record (response rate 85.4%). Table 2 shows the distribution of subjects based on individual metabolic risks.

Based on Table 3, a comparison of the subjects' food records with the Recommended Nutrient Intakes for Malaysia revealed that protein consumption was significantly higher among study subjects compared to the Recommended Nutrient Intakes for Malaysia (62 g/day for males; 55 g/day for females), (P<.001). On the other hand, the carbohydrate intake was significantly higher among females study subjects compared to the Recommended Nutrient Intakes for Malaysia (180 g/day to 230 g/day). Furthermore, fat consumption was within the range based on Recommended Nutrient Intakes for Malaysia (54 g/day to 82 g/day for males; 46 g/day to 70 g/day for females). All subjects (100%) had low fibre (<20 g/day) intake. Conversely, most subjects (72.0%) had high sodium intake (≥2400 mg/day), as portrayed in Table 4.

4. DISCUSSION

Dietary intake data was obtained using a food record for three days, which were composed of two consecutive weekdays and one weekend day [26-33]. Keeping a food record for three days has proven to be the best approach for assessing actual nutrient intake [34-36]. The choice of the number of days is typically dependent upon pragmatic considerations such as the willingness of the subject to be compliant [37]. Recording all food consumed for more than one or two consecutive days is a notorious behaviour modification method for reducing food intake. In spite of this, a food record is often employed as the gold standard for validating other dietary assessment methods when observation is not possible [38].

However, all methods for assessing dietary intake are subject to a large error sample, especially in overweight or obese populations, in whom a tendency to underestimate food consumption has been demonstrated [39]. The rate of under-reporting of total calorie intake was 3.3% (n=9) of the total subjects: 7 of the under-reporters were male, while another 2 were female.

According to the Medical Nutrition Therapy Guidelines (MNT) by the Malaysian Dietitians' Association [21], 50 to 60% of total energy intake from carbohydrate [40], is recommended. Lower intake of 50% should be considered for individuals with metabolic syndrome who have elevated triglycerides or low HDL cholesterol [41]. Nevertheless, fat consumption should not be less than 25% of total energy intake in order to avoid replacement with excess carbohydrate, which might result in higher triglycerides and lower HDL cholesterol.

In this study, it was demonstrated that individuals with metabolic syndrome record a diet richer in protein (%) and poorer in fibre (g) when compared to the recommendations. Fibre consumption was lower than recommended (20 g/day to 30 g/day) in all the subjects, which may have contributed to fat accumulation and insulin resistance.

A study conducted by Aljada and colleagues demonstrated that high dietary fat consumption is related to the activation of the proinflammatory transcription factor (nuclear factor kappa-beta) and oxidative stress [42]. On the contrary, high fruit and fibre consumption has no proinflammatory capacity compared with a diet rich in fat, even if the diet has a similar calorie content [43].

Table 1. Five metabolic risk factors according to 'Harmonized' definition

Clinical measure	Insulin resistance	Body weight	Lipid	Blood pressure	Glucose
Harmonized (Alberti et al., 2009) [24]	None, but any three of the five risk factors	Increased waist circumference (Gender- and ethnicity-specific)	TG ≥1.7 mmol/L or on TG treatment HDL cholesterol <1.0 mmol/L in men or <1.3 mmol/L in women or on HDL cholesterol treatment	≥130/ 85 mmHg or on hypertensive treatment	FPG≥5.6 mmol/L or diabetes

Table 2. Distribution of subjects based on individual metabolic risks

Metabolic Risk Factors	Number of subjects(Percentages) n (%)	
	Yes	No
Abdominal obesity	265 (96.4)	10 (3.6)
Elevated systolic blood pressure	198 (72.0)	77 (28.0)
Elevated diastolic blood pressure	102 (37.1)	173 (62.9)
Elevated blood pressure	221 (80.4)	54 (19.6)
Low HDL cholesterol	219 (79.6)	56 (20.4)
Elevated triglycerides	135 (49.1)	140 (50.9)
Elevated plasma glucose	49 (17.8)	226 (82.2)

The healthy and effective approach for long-term weight loss is a reduced-calorie diet, comprising of a modest deficit of 500 to 1000 kcal/day. Sustained dietary modifications may require sufficient micronutrient consumption, such as registered dietitian's intervention to safeguard a iron, calcium and folate, while decreasing calorie intake. A prospective cohort study [44] has demonstrated that a Mediterranean-style diet was inversely related to the cumulative metabolic syndrome incidence. A Mediterranean-style diet enhances the mental and physical domains of health-related quality of life, such as vitality, physical health, physical function, emotional role and self-perception of health [45] and it reduces the odds of glucose, LDL-cholesterol levels [46], triglycerides and low HDL-cholesterol values [47]. In addition, the Dietary Approaches to Stop Hypertension (DASH) diet combined with lifestyle interventions in the PREMIER study [48] improved blood pressure. Furthermore, a protein intake of 10% to 35% of total calorie consumption is suggested by the Institute of Medicine for the general population. A diet rich in complex carbohydrates with 14 g of fibre per 1000 calories daily and low in added sugars, ≤25% of calorie consumption, is suggested for individuals at risk of or with metabolic syndrome [49].

Afshin and colleagues [50] carried out a comparative risk assessment analysis to approximate the mortality of cardiometabolic disease attributable to 4 metabolic and 11 dietary risk factors in 20 countries of the adult population in the Middle East. The findings demonstrated that a suboptimal diet was the principal risk factor for cardiometabolic disease among 11 countries in the Middle East, equivalent to 48% to 72% of cardiometabolic disease mortalities. Suboptimal systolic blood pressure was the principal risk factor for cardiometabolic disease mortalities among 8 countries in the Middle East, accounting for 45% to 68% of cardiometabolic disease mortalities. Suboptimal fasting plasma glucose and body mass index were the third and fourth principal risk factors for cardiometabolic disease death in most Middle East countries. Low consumption of fruits was responsible for 8% to 21% of cardiometabolic disease mortalities, and low consumption of whole grains accounted for 7% to 22% of cardiometabolic disease mortalities among individual dietary factors. These findings emphasise significant differences and similarities in the effect of the metabolic and dietary risk factors on cardiometabolic disease death in Middle Eastern countries, and they inform policy decisions in preventing cardiometabolic disease.

Table 3. Comparison between the sample means with recommended nutrient intakes for Malaysia (Ministry of Health, 2005) and Medical Nutrition Therapy (MNT) Guidelines by Malaysian dietitians' association (2005) using one sample *t*-test

Nutrients	Age	Male (n=73)				Female (n=202)				
		Mean±SD	RNI	*P*-value	MNT	*P*-value	Mean±SD	RNI	*P*-value	MNT	*P*-value
Energy (kcal)											
	19-<30	2110.19±194.15	2440	<.001			2249.46±254.44	2000	<.001		
	30-<51	2350.13±372.55	2460	.049			2270.57±72.39	2180	<.001		
	51-<60	2296.67±515.35	2460	.518			2289.81±258.91	2180	.090		
Carbohydrate (g)		327.77±55.34	200	<.001			327.40±3.01	180	<.001		
			330	.732				230	<.001		
Carbohydrate (%)		57.70±5.97	55	<.001	50	<.001	57.92±5.01	55	<.001	50	<.001
			70	<.001	60	.002		70	<.001	60	<.001
Sugars (%)		6.88±3.25	<15				6.64±3.25	<15			
Protein (g)		82.70±18.76	62	<.001			80.64±14.42	55	<.001		
Protein (%)		14.54±2.53			15	.124	14.23±1.93			15	<.001
					20	<.001				20	<.001
Fat (g)		73.67±17.54	54	<.001			71.91±16.08	46	<.001		
			82	<.001				70	.092		
Fat (%)		29.01±4.56	20	<.001	25	<.001	28.49±5.10	20	<.001	25	<.001
			30	.067	30	.067		30	<.001	30	<.001
PUFA (%)		5.10±2.41	6	.002			5.16±2.13	6	<.001		
			10	<.001				10	<.001		
MUFA (%)		5.58±2.34	12	<.001			5.53±2.01	12	<.001		
			15	<.001				15	<.001		
SFA (%)		6.38±2.55	<10				5.72±2.29	<10			
Fiber (g)		6.60±2.97	20	<.001			6.83±3.20	20	<.001		
			30	<.001				30	<.001		
Sodium (mg)		3099.65±1117.57			<2400		2962.03±925.62			<2400	

Table 4. Distribution of subjects based on recommended nutrient intakes for Malaysia (Ministry of Health, 2005) and Medical Nutrition Therapy (MNT) Guidelines by Malaysian Dietitians' Association (2005)

	Recommended nutrient intakes for Malaysia				Medical Nutrition Therapy (MNT) Guidelines			
		Male (n=73)	Female (n=202)	Total (n=275)		Male (n=73)	Female (n=202)	Total (n=275)
Carbohydrate (%)	<55	21 (28.8)	53 (26.2)	74 (26.9)	<50	5 (6.8)	13 (6.4)	18 (6.5)
	55-70	51 (69.9)	149 (73.8)	200 (72.7)	50-60	44 (60.3)	117 (57.9)	161 (58.5)
	>70	1 (1.4)	0 (0.0)	1 (0.4)	>60	24 (32.9)	72 (35.6)	96 (34.9)
Sugars (%)	<15	70 (95.9)	200 (99.0)	270 (98.2)				
	≥15	3 (4.1)	2 (1.0)	5 (1.8)				
Protein (%)					<15	46 (63.0)	137 (67.8)	183 (66.5)
					15-20	26 (35.6)	65 (32.2)	91 (33.1)
					>20	1 (1.4)	0 (0.0)	1 (0.4)
Fat (%)	<20	2 (2.7)	8 (4.0)	10 (3.6)	<25	15 (20.5)	50 (24.8)	65 (23.6)
	20-30	46 (63.0)	118 (58.4)	164 (59.6)	25-30	33 (45.2)	76 (37.6)	109 (39.6)
	>30	25 (34.2)	76 (37.6)	101 (36.7)	>30	25 (34.2)	76 (37.6)	101 (36.7)
PUFA (%)	<6	50 (68.5)	132 (65.3)	182 (66.2)				
	6-10	21 (28.8)	67 (33.2)	88 (32.0)				
	>10	2 (2.7)	3 (1.5)	5 (1.8)				
MUFA (%)	<12	72 (98.6)	201 (99.5)	273 (99.3)				
	12-15	1 (1.4)	1 (0.5)	2 (0.7)				
	>15	-	-	-				
SFA (%)	<10	68 (93.2)	193 (95.5)	261 (94.9)				
	≥10	5 (6.8)	9 (4.5)	14 (5.1)				
Fiber (g)	<20	73 (100.0)	202 (100.0)	275 (100.0)				
	20-30	-	-	-				
	>30	-	-	-				
Sodium (mg)					<2400	18 (24.7)	59 (29.2)	77 (28.0)
					≥2400	55 (75.3)	143 (70.8)	198 (72.0)

The distribution of calorie from macronutrients in the diets of subjects as observed in this study (Carbohydrate: 57% for males and 58% for females; Protein: 14% for males and 14% for females; Fat: 29% for males and 28% for females) is comparable to that of the diets of Malaysians (Carbohydrate: 59%; Protein: 14%; Fat: 27%). Mean carbohydrate intake of Malaysian adults was about 232 g (59% of the total calorie intake). Malaysian adults reported a mean protein intake of 59 g, which contributed to 14% of total calorie intake. On the other hand, mean fat intake was approximately 50 g for the whole population [51]. In addition, The findings from the dietary survey among type 2 diabetes patients attending an outpatient clinic in Malaysia revealed a similarity in macronutrient contribution to the total calorie intake (Carbohydrate: 57%; Protein: 15%; Fat: 28%) [52]. The study subjects' sodium intake (about 3100 mg for males and 2962 mg for females) was higher than that of Malaysian adults' mean sodium intake, which was approximately 2575 mg. The mean sodium intake was higher in males than females by about 500 mg [51].

This study had some limitations that warrant indication. First, findings originating from a cross-sectional study do not necessarily signify causality. Second, this study was carried out among government employees. Therefore, the findings obtained may not be applied to the general population.

5. CONCLUSION

This cross-sectional study among government employees further highlights the importance of assessing the dietary intake of each individual with metabolic syndrome. There is a discrepancy between the dietary intake composition among individuals with metabolic syndrome and the Recommended Nutrient Intakes for Malaysia or the Medical Nutrition Therapy Guidelines from the Malaysian Dietitians' Association. Notwithstanding, our study cannot declare that diet induces the disease, yet it definitely sheds more light on the need for appropriate and professional dietary measures to be integrated in the management of individuals with metabolic syndrome.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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