Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031

Article

Prevalence of metabolic syndrome and its associated factors among vegetarians in Malaysia

Yuan Kei Ching[1], Yit Siew Chin[1,2,] *, Mahenderan Appukutty[4], Wan Ying Gan[1], Vasudevan Ramanchadran[3], and Yoke Mun Chan[1,2]

[1] Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia
[2] Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia Research Centre of Excellence, Nutrition and Non-Communicable Diseases Universiti Putra Malaysia
[3] Malaysia Research Institute on Ageing (MyAgeing)
[4] Programme of Sports Science, Faculty of Sports Science and Recreation, Universiti Teknologi MARA

*Corresponding author: chinys@upm.edu.my; Tel: +603-89472680

Abstract: The prevalence and factors associated with metabolic syndrome (MetS) remain unknown in Malaysian vegetarians. This cross-sectional study aimed to determine the prevalence of MetS among vegetarians in Kuala Lumpur and Selangor and its associated factors. The data on socio-demographic characteristics, vegetarianism practices, lifestyle behaviours, body weight, height, waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood glucose (FBG), and blood lipid profiles were collected from 273 vegetarians. A majority of the respondents were lacto-ovo vegetarians (44.0%), females (64.8%) and Chinese (54.9%). The prevalence of MetS was 24.2%. High BP (48.7%) and high WC (43.6%) were the most common MetS components. Females had lower WC, SBP, DBP, FBG, TG and higher HDL-c ($p < 0.05$) as compared to males. Multiple logistic regression analysis showed that advancing in age (OR = 1.03, 95% CI: 1.00-1.06), and overweight and obesity (OR = 7.90, 95% CI: 4.13-15.11) were the risk factors of MetS after adjusted for sex. This study found that one in four vegetarians had MetS. The present findings emphasize the need to focus among vegetarians with older age. An intervention program to reduce BMI should be established among vegetarians, especially among those vegetarians who were overweight and obese.

Keywords: metabolic syndrome; vegetarian; vegetarianism practices; overweight; lifestyle behaviors

1. Introduction

Metabolic syndrome (MetS) is a constellation of metabolic abnormalities including abdominal obesity, elevated blood pressure (BP) [systolic blood pressure (SBP) or diastolic blood pressure (SBP)], elevated fasting blood glucose (FBG), and dyslipidemia [elevated triglyceride levels (TG) and low high-density lipoprotein cholesterol levels (HDL-c)] that promote the development of cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) [1]. Several MetS diagnosis criteria had been introduced by different organizations from the year 1998 to the year 2009, including the World Health Organization (WHO) in 1998 [2], the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) (NCEP-ATP III) in 2002 [3], the American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) [1] and International Diabetes Federation (IDF) in 2005 [4]. The Joint Interim Statement (JIS) is the latest criteria that introduced by IDF; AHA/NHLBI; American Heart Association (AHA); World Heart Federation (WHF); International Atherosclerosis Society (IAS); and International Association for the Study of Obesity (IASO) in 2009 [5] due to the debates and

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031

controversies on different MetS definition over the years. According to the JIS criteria, MetS is characterized by the presence of at least three of the following components, namely abdominal obesity as defined according to the Asian populations with high waist circumference (≥ 90.0 cm for men and ≥ 80.0 cm for women), low HDL-c (< 1.0 mmol/L for men and < 1.3 mmol/L for women), high TG (≥ 1.7 mmol/L), high FBG (≥ 5.6 mmol/L), and high BP (SBP ≥130 mmHg or DBP ≥ 85 mmHg) [5].

MetS has become a public health concern due to increasing number of non-communicable diseases (NCDs) around the world over the past few decades [6–8]. The prevalence of MetS varied according to different definitions and populations [6,8,9]. For instance, in the Western developed country, the prevalence of MetS increased from 32.9% in 2004 to 34.7% in 2015 in a U.S. nationwide study by NCEP-ATP III [6]. In Korea, the prevalence of MetS increased from 24.9% in 1998 to 31.3% in 2007 by NCEP-ATP III [9]. In Malaysia, the latest prevalence of MetS as defined by JIS was 42.5% in the year 2013 [8]. While the prevalence of MetS was observed in many countries among the general population [7–10], several studies have reported that vegetarians are associated with a lower risk of MetS as compared to the general population [11–13]. For example, the prevalence of MetS among U.S vegetarians (25.2%) were lower than U.S. non-vegetarians (39.7%) [11]. Similarly, the prevalence of MetS among Taiwanese female vegetarians were lower than non-vegetarians by NCEP ATP-III definition (13.3% vs. 20.0%), and IDF definition (6.7% vs. 12.7%), respectively [12]. Likewise, postmenopausal vegetarians had a lower risk of MetS (33.9%) than non-vegetarians (47.9%) in Korea [13]. The existing studies, which compared the prevalence of MetS between vegetarians and non-vegetarians found that vegetarians had lower prevalence of MetS than non-vegetarians [11–14]. Despite the lower prevalence of MetS in vegetarians than non-vegetarians, the MetS issues in vegetarians (6.7%-33.9%) [11–14] should not be neglected. A study is needed to determine the underlying factors that associated with MetS in vegetarians.

To the best of our knowledge, the existing Malaysian vegetarian's studies focussed on reasons for being a vegetarian, nutrient intakes, and CVD risk profiles [15–17]. Yet, there is no published study on MetS among Malaysian vegetarians. Therefore, this study aimed to determine the prevalence of MetS based on the JIS criteria among Malaysian vegetarians. The present study also aimed to determine the associations of socio-demographic characteristics, vegetarianism practices, lifestyle behaviours (alcohol consumption, smoking behaviour, physical activity) and body composition with MetS among vegetarians in selected community centres in Kuala Lumpur and Selangor, Malaysia.

2. Materials and Methods

2.1. Study Design and Study Population

The study was approved by the Ethics Committee for Research involving Human Subjects, Universiti Putra Malaysia (JKEUPM) [Reference number: FPSK (FR16) P023]. The data collection was conducted among Malaysian vegetarians at the selected community centres that located in Kuala Lumpur and Selangor. All the members from the selected community centres were invited to become the respondents of the study. A study information sheet that explained the purpose of the study was distributed to the respondents and signed consents were obtained from all respondents who agreed to participate in the study. Then, respondents who fulfilled the study criteria were requested to fast for at least 8 hours prior the blood withdrawal during the data collection day. Respondents were

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031

88 screened for the study criteria, namely adults aged above 18 years old, practicing vegetarianism for
89 more than 2 years, not pregnant or lactating, and not taking medications in controlling dyslipidemia,
90 diabetes, and hypertension. Respondents were asked to complete a set of self-administered
91 questionnaire. Their body weight, height, WC, BP were measured by the trained researchers.

92 **2.2. Socio-demographic Characteristics**

93 In this section, socio-demographic characteristics such as sex, age, marital status, monthly
94 household income, education levels were self-reported by the respondents. The total household
95 income (in Ringgit Malaysia, RM 1.00 = US Dollar 0.26) was categorized into low (< RM 2,300 or USD
96 598), medium (RM 2,300 to RM 5,599 or USD 598 to USD 1,456) and high (≥ RM 5,600 or USD 1,457)
97 based on Malaysia total household income stated in 10th Malaysia Plan [18].

98 **2.3. Vegetarianism Practices**

99 The respondents were asked to indicate their current vegetarianism practice: (i) vegans who only
100 consume plant-based foods and no meat, fish, poultry, dairy products, and eggs; (ii) lacto-vegetarians
101 who consume dairy products but no eggs, fish, meat, and poultry; (iii) ovo-vegetarians who consume
102 eggs but no dairy products, fish, meat, and poultry; (iv) lacto-ovo-vegetarians who consume dairy
103 products and eggs, but no fish, meat, and poultry [19]. Years of practicing vegetarianism were self-
104 reported by the respondents. In addition, they were asked about the reasons of adopting
105 vegetarianism.

106 **2.4. Lifestyle Behaviours**

107 The lifestyle behaviours of the respondents such as alcohol consumption, smoking behaviour,
108 and physical activity levels were assessed in the present study. The alcohol consumption was
109 assessed through the adapted alcoholic questionnaire in the National Health and Nutrition
110 Examination Survey (NHANES) Food Frequency Questionnaire (FFQ), and classified into two
111 categories, namely alcohol users or non-alcohol users [20]. Smoking behaviour was assessed using a
112 self-administered Global Adult Tobacco Survey (GATS) [21]. The current and past smoking
113 behaviours of the respondents were assessed by three questions in GATS, and classified into three
114 categories, namely smokers, past smokers and non-smokers [21]. Last but not least, the Global
115 Physical Activity Questionnaire (GPAQ) was used to assess the physical activity of the respondents
116 for the past week [22]. The GPAQ consisted of three domains including activities at work, travel to
117 and from places and recreational activities. Metabolic equivalents (METs) scores were calculated for
118 each of the domain, whereby moderate activities contributed 4.0 METs and vigorous activities
119 contributed 8.0 METs scores for activities at work as well as for recreational activities. 4.0 METs score
120 was given for the travel to and from places. Physical activity levels of the respondents were classified
121 into highly active (METs ≥ 3,000 METs), moderately active (METs ≥ 600METs) and inactive (METs <
122 600 METs) based on their METs score [22].

123 **2.5. Anthropometric Assessments**

124 The anthropometric measurements were measured according to the International Standards for
125 Anthropometric Assessment (ISAK) method. The body weight of the respondent was measured
126 using TANITA Digital Weight Scale HD306 (TANITA Corporation, USA) to the nearest 0.1 kg.
127 Meanwhile, the height of the respondent was measured using a portable SECA213 portable

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031

stadiometer (SECA, Germany) to the nearest 0.1 cm. Body mass index (BMI) was calculated as kg/m^2, and their BMI was categorized into underweight, normal, overweight and obesity [23]. The WC of the respondent was measured using a Lufkin tape W606PM (Lufkin, USA) to the nearest of 0.1 cm. The WC cut-off points of ≥ 90.0 cm for men and ≥ 80.0 cm for women were considered to be at-risk of having abdominal obesity [24]. WC was one of the components to define the MetS [5].

2.6. Blood Pressure Assessment

Blood pressure of the respondent was measured using an Omron automatic blood pressure monitor (HEM-7121, USA) for systolic blood pressure (SBP) and diastolic blood pressure (DBP) in mmHg. Respondents were requested to rest and sit on the chair before the measurement. According to the WHO/International Society of Hypertension, respondents were considered at risk of high-normal blood pressure if SBP ≥ 130 mmHg or DBP ≥ 85 mmHg [25]. High BP was one of the components to define the MetS [5].

2.7. Biochemical Assessments

A total of 10ml of venous fasting blood sample was drawn by the registered nurse. Blood samples were kept in the icebox and sent to the laboratory on the same day of data collection for further analysis. Olympus Au analyzer (AU640, USA) was used to determine the blood glucose level and blood lipid profiles (total cholesterol [TC], low-density lipoprotein cholesterol [LDL-c], HDL-c and TG). Respondents were considered at risk of low HDL-c if HDL-c < 1.0 mmol/L for men and < 1.3 mmol/L for women, and high TG if ≥ 1.7 mmol/L according to the NCEP - ATP III [26]. Low HDL-c and high TG were the two components to define the MetS [5]. Meanwhile, respondents with FBG ≥ 5.6 mmol/L were classified as having abnormal blood glucose level as defined by American Diabetic Association in 2003 [27]. High blood glucose was one of the components to define the MetS [5].

2.8. Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics 24.0 (SPSS Inc., Chicago, IL, USA) software. The differences in the variables between respondents with MetS and without MetS were tested using independent samples *t*-test for normally distributed data and Mann-Whitney test for non-normally distributed data. Chi-square analysis was used to determine the association of categorical variables with MetS status. Multiple logistic regression was used to determine the risk factors of MetS after adjusting for sex. The odds ratios (ORs) and 95% confidence intervals (CIs) were determined. The level of significance was set at $p < 0.05$.

3. Results

3.1. General Characteristics

The socio-demographic characteristics, vegetarianism practices, and body compositions of the respondents were presented in Table 1. The present study consisted of 44.0% lacto-ovo vegetarians, followed by lacto-vegetarians (31.5%), vegans (19.0%) and ovo-vegetarians (5.5%). They had practiced vegetarianism for 14.2 ± 9.6 years. No significant difference was found in years of practicing vegetarianism between males (14.7 ± 9.5 years) and females (13.9 ± 9.7 years) ($p > 0.05$). A majority of the respondents practiced vegetarianism due to religious belief (75.8%) (Fig 1). Besides, one-third of the respondents (36.3%) had medium total household income (RM 2,300 to RM 5,599). About half

(54.9%) of the respondents had normal BMI, 27.5% of the respondents were overweight, and 8.1% of the respondents were obese. With regards to the lifestyle behaviours, most of the respondents were non-smokers (95.2%), non-alcohol drinkers (91.9%), and having low PA level (46.2%) (Table 1).

Table 1: General characteristics of vegetarians by sex

Variables	Male (n=96)	Female (n=177)	Total (n=273)	χ^2/t	*p* value
†**Vegetarian classifications**				5.82	0.121
Ovo-vegetarians	6 (6.3)	9 (5.1)	15 (5.5)		
Lacto-vegetarians	37 (38.5)	49 (27.7)	86 (31.5)		
Lacto-ovo-vegetarians	33 (34.4)	87 (49.1)	120 (44.0)		
Vegans	20 (20.8)	32 (18.1)	52 (19.0)		
‡**Years of practicing vegetarianism**					
Mean ± SD	14.7 ± 9.5	13.9 ± 9.7	14.2 ± 9.6	0.66	0.509
‡**Age (years)**					
Mean ± SD	46.0 ± 14.5	48.4 ± 12.3	47.5 ± 13.1	-1.44	0.151
†**Ethnicity**				7.49	0.006*
Chinese	42 (43.8)	108 (61.0)	150 (54.9)		
Indians	54 (56.2)	69 (39.0)	123 (45.1)		
†**Marital status**				5.49	0.064
Single	33 (34.4)	47 (26.6)	80 (29.3)		
Married	57 (59.4)	103 (58.2)	160 (58.6)		
Divorced/Widowed	6 (6.2)	27 (15.2)	33 (12.1)		
†ǂ**Education**				4.49	0.106
Primary education	17 (17.7)	24 (13.6)	41 (15.0)		
Secondary education	43 (44.8)	103 (58.2)	146 (53.5)		
Tertiary education	36 (37.5)	50 (28.2)	86 (31.5)		
†**Total household income**				0.83	0.661
< RM 2,300	30 (31.3)	62 (35.0)	92 (33.7)		
RM 2,300 – RM 5,599	34 (35.4)	65 (36.7)	99 (36.3)		
≥ RM 5,600	32 (33.3)	50 (28.3)	82 (30.0)		
‡**Body weight (kg)**					
Mean ± SD	71.7 ± 12.5	57.3 ± 10.8	62.3 ± 13.4	9.92	0.0001*
‡**Height (cm)**					
Mean ± SD	170.2 ± 6.8	157.3 ± 6.2	161.8 ± 8.9	15.84	0.0001*
†‡**BMI (kg/m²)**					
Mean ± SD	24.8 ± 4.4	23.10 ± 3.9	23.7 ± 4.1	3.37	0.001*
Underweight	6 (6.3)	20 (11.3)	26 (9.5)	5.67	0.129
Normal	50 (52.1)	100 (56.5)	150 (54.9)		
Overweight	28 (29.1)	47 (26.6)	75 (27.5)		
Obesity	12 (12.5)	10(5.6)	22 (8.1)		
†**Alcohol consumption**				0.35	0.556
Yes	9 (9.4)	13 (7.3)	22 (8.1)		
No	87 (90.6)	164 (92.7)	251 (91.9)		
Φ**Smoking behaviour**				-	0.002*
Past smoker	10 (10.4)	3 (1.7)	13 (4.8)		
Non-smoker	86 (89.6)	174 (98.3)	260 (95.2)		
†**Physical activity levels**				7.48	0.024*
Low	37 (38.5)	89 (50.3)	126 (46.1)		
Moderate	33 (34.4)	63 (35.6)	96 (35.2)		
High	26 (27.1)	25 (14.1)	51 (18.7)		

Note:

†Variables were presented as n (%), and tested by Chi –square test with value reported in χ^2 and p

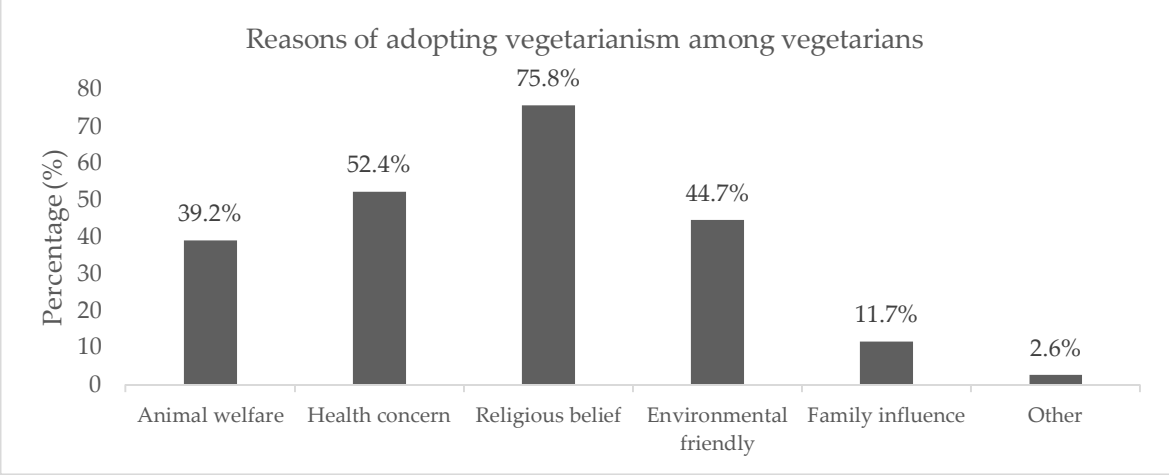
‡Variables were presented as Mean ± SD, and tested by Independent samples t-test with value reported in *t* and p

ǂ Education level merged into three categories to perform valid Chi –square test with value reported in χ^2 and p

ΦVariable was presented as n (%), and reported with Fisher Exact test as more than 20% of the cells have expected count less than 5

*Indicates a significant difference at p <0.05 by Chi –square test, Fisher Exact test or Independent samples *t*-test

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031



Note: Vegetarians were given the option to select more than one reason to indicate the reasons of adopting vegetarianism

Figure 1: Reasons of adopting vegetarianism among vegetarians in the present study

3.2. Prevalence of MetS and Distribution of MetS Components

Based on JIS, the overall prevalence of MetS was 24.2%. The prevalence of MetS among males and females were 29.2% and 21.5%, respectively ($\chi^2 = 2.01$, $p = 0.156$). While 16.5% of the respondents did not fulfil any MetS criteria, Table 2 shows that a majority of them had at least one of the MetS components (mean number of MetS component: 1.8 ± 1.3). High BP (48.7%) and high WC (43.6%) were the two most common MetS components in the present study. The present study revealed that females had lower WC, SBP, DBP, FBG, TG, and higher HDL-c ($p < 0.05$) as compared to males (Table 2).

Table 2: Metabolic risks profile of vegetarians by sex

Variables	Male (n=96)	Female (n=177)	Total (n=273)	$t/\chi^2/U$	*p* value
†**MetS**				2.01	0.156
Yes	28 (29.2)	38 (21.5)	66 (24.2)		
No	68 (70.8)	139 (78.5)	207 (75.8)		
‡**MetS components**					
Mean ± SD	1.8 ± 1.2	1.6 ± 1.2	1.7 ± 1.2	1.57	0.119
†**Number of MetS components**					
0	11 (11.5)	37 (20.9)	48 (17.6)	5.44	0.364
1	36 (37.5)	58 (32.7)	94 (34.4)	-	-
2	21 (21.9)	44 (24.9)	65 (23.8)	-	-
3	16 (16.6)	21 (11.9)	37 (13.6)	-	-
4	11 (11.5)	15 (8.5)	26 (9.5)	-	-
5	1 (1.0)	2 (1.1)	3 (1.1)	-	-
†‡ **WC (cm)**					
Mean ± SD	89.5 ± 11.7	78.4 ± 10.1	82.3 ± 11.9	8.15	0.0001*
High	41 (42.7)	78 (44.1)	119 (43.6)	0.05	0.829
Normal	55 (57.3)	99 (55.9)	154 (56.4)	-	-
†‡ **SBP (mmHg)**					
Mean ± SD	131.8 ± 16.3	125.9 ± 19.2	127.9 ± 18.4	2.56	0.011*
High	53 (55.2)	73 (41.2)	126 (46.2)	4.86	0.027*
Normal	43 (44.8)	104 (58.8)	147 (53.8)	-	-
†‡ **DBP (mmHg)**					
Mean ± SD	79.1 ± 11.0	74.1 ± 10.2	75.9 ± 10.7	3.79	0.0001*
High	30 (31.2)	27 (15.3)	57 (20.9)	9.64	0.002*
Normal	66 (68.8)	150 (84.7)	216 (79.1)	-	-
†**Blood pressure (SBP/DBP) (mmHg)**				8.11	0.004*
High	58 (60.4)	75 (42.4)	133 (48.7)	-	-
Normal	38 (39.6)	102 (57.6)	140 (51.3)	-	-
†Φ **FBG (mmol/L)**					
Median (IQR)	4.9 (4.6-5.5)	4.7 (4.4-5.2)	4.8 (4.4-5.3)	6943.00	0.013*
High	22 (22.9)	28 (15.8)	50 (18.3)	2.10	0.148
Normal	74 (77.1)	149 (84.2)	223 (81.7)	-	-

192 **Table 2: Metabolic risks profile of vegetarians by sex (continue)**

Variables	Male (n=96)	Female (n=177)	Total (n=273)	$t/\chi^2/U$	*p* value
ǂTC (mmol/L)					
Mean ± SD	5.1 ± 1.1	4.8 ± 0.9	4.9 ± 1.0	2.52	0.012*
†ǂHDL-c (mmol/L)					
Mean ± SD	1.6 ± 0.2	1.3 ± 0.3	1.3 ± 0.3	-5.53	0.0001*
Low	18 (18.8)	67 (37.9)	85 (31.1)	10.59	0.001*
Normal	78 (81.2)	110 (62.1)	188 (68.9)	-	-
ǂLDL-c (mmol/L)					
Mean ± SD	3.2 ± 1.1	2.9 ± 0.8	3.0 ± 0.9	2.30	0.022*
†ΦTG (mmol/L)					
Median (IQR)	1.4 (0.9-2.1)	1.0 (0.7-1.4)	1.1 (0.8-1.6)	5898.50	0.0001*
High	36 (37.5)	31 (17.5)	67 (24.5)	13.43	0.0001*
Normal	60 (62.5)	146 (82.5)	206 (75.5)	-	-

193 Note:
194 †Variables were presented as n (%), and tested by Chi –square test with value reported in $\chi^2$and p
195 ǂVariables were presented as Mean ± SD, and tested by Independent samples *t*-test with value reported in *t* and p
196 ΦVariable was presented in Median (IQR), and was tested by Mann-Whitney test with value reported in *U* and p
197 * Indicates a significant difference at p <0.05 by Chi –square test, Mann-Whitney test or Independent samples t-test

198 ### 3.3. Factors Associated with MetS

199 As shown in Table 3, a high prevalence of MetS was observed among lacto-vegetarians (32.6%),
200 followed by vegans (25.0%), lacto-ovo-vegetarians (19.2%), and ovo-vegetarians (13.3%). There was
201 a statistically significant difference in the numbers of years of practicing vegetarianism between
202 respondents with MetS (17.9 ± 11.2 years) and without MetS (13.0 ± 8.8 years) (*t*= -3.20, p=0.0001). In
203 addition, the age of respondents with MetS (51.1 ± 10.6 years) was statistically significant higher than
204 those without MetS (46.4 ± 13.6 years) (*t*=-2.89, p=0.002). MetS was reported to be higher among
205 respondents who were Indians (34.1%), married (30.0%), and overweight/obese (49.5%) as compared
206 to their counterparts (p < 0.05). In contrast, there were no statistically significant differences in
207 education levels, total household incomes, vegetarian categories, physical activity levels, alcohol
208 consumption and smoking behaviour by MetS status (p > 0.05). The multiple logistic regression
209 analysis in the present study showed that advancing in age (OR = 1.03, 95% CI: 1.00-1.06), and being
210 overweight and obese (OR = 7.90, 95% CI: 4.13-15.11) were associated with MetS after adjusted for
211 the sex. The multiple logistic regression model in the present study is able to classify 79.1% correctly
212 and able to explain 29.5% of the variances in the MetS (Table 4).

213 **Table 3: Factors associated with MetS**

Variables	With MetS (n=66)	Without MetS (n=207)	Total (n=273)	χ^2/t	*p* value
†Vegetarian classifications				5.92	0.116
Ovo-vegetarians	2 (13.3)	13 (86.7)	15 (5.5)		
Lacto-vegetarians	28 (32.6)	58 (67.4)	86 (31.5)		
Lacto-ovo- vegetarians	23 (19.2)	97 (80.8)	120 (44.0)		
Vegans	13 (25.0)	39 (75.0)	52 (19.0)		
ǂYears of practicing vegetarianism					
Mean ± SD	17.9 ± 11.2	13.0 ± 8.8	14.2 ± 9.6	-3.20	0.0001*
ǂAge (years)					
Mean ± SD	51.1 ± 10.6	46.4 ± 13.6	47.5 ± 13.1	-2.89	0.004*
†Sex				2.01	0.156
Male	28 (29.2)	68 (70.8)	96 (35.2)		
Female	38 (21.5)	139 (78.5)	177 (64.8)		
†Ethnicity				12.14	0.0001*
Chinese	24 (16.0)	126 (84.0)	150 (54.9)		
Indian	42 (34.1)	81 (65.9)	123 (45.1)		
†Marital status				7.86	0.020*
Single	11 (13.8)	69 (86.3)	80 (29.3)		
Married	48 (30.0)	112 (70.0)	160 (58.6)		
Divorced/Widowed	7 (21.2)	26 (78.8)	33 (12.1)		

214

Table 3: Factors associated with MetS (continue)

Variables	With MetS (n=66)	Without MetS (n=207)	Total (n=273)	χ^2/ t	p value
†ǂ**Education**				0.760	0.684
Primary education	11 (26.8)	30 (73.2)	41 (15.0)		
Secondary education	37 (25.3)	109 (74.7)	146 (53.5)		
Tertiary education	18 (20.9)	68 (79.1)	86 (31.5)		
†**Total household income**				0.80	0.670
< RM 2,300	23 (25.0)	69 (75.0)	92 (33.7)		
RM 2,300 – RM 5,599	26 (26.3)	73 (73.7)	99 (36.3)		
≥ RM 5,600	17 (20.7)	65 (79.3)	82 (30.0)		
Φ**Smoking behaviour**				-	0.522
Non-smoker	62 (23.8)	198 (76.2)	260 (95.2)		
Past smoker	4 (30.8)	9 (69.2)	13 (4.8)		
†**Alcohol consumption**				0.03	0.869
Yes	5 (22.7)	17 (77.3)	22 (8.1)		
No	61 (24.3)	190 (75.7)	251 (91.9)		
†**Physical activity**				2.34	0.311
Low	26 (20.6)	100 (79.4)	126 (46.2)		
Moderate	24 (25.0)	72 (75.0)	96 (35.1)		
High	16 (31.4)	35 (68.6)	51 (18.7)		
†ǂ**BMI category**					
Mean ± SD	27.3 ± 3.7	22.6 ± 3.6	23.7 ± 4.1	-9.08	0.0001*
Underweight/ Normal weight	18 (10.2)	158 (89.8)	176 (64.5)	52.57	0.0001*
Overweight/ Obesity	48 (49.5)	49 (50.5)	97 (35.5)		

Note:
†Variables were presented as n (%), and tested with Chi –square test with value reported in χ^2 and p
ǂVariables were presented as Mean ± SD, and tested with Independent samples t-test with value reported in t and p
ΦVariable was presented as n (%), and reported with Fisher Exact test as more than 20% of the cells have expected count less than 5
ǂ Education level merged into three categories to perform valid Chi –square test with value reported in χ^2 and p
* Indicates a significant difference at p <0.05 by Chi –square test, Fisher Exact or Independent samples t-test

Table 4: Logistic regression analysis of MetS risk factors among vegetarians

Predictor Variables	Univariate logistic regression		Multiple logistic regression	
	Crude OR (95% CI)	p value	Adjusted OR (95% CI) Φ	p value
Vegetarian classifications				
Ovo-vegetarians	1.00	1.00	-	-
Lacto-vegetarians	3.14 (0.66-14.87)	0.150	-	-
Lacto-ovo- vegetarians	1.54 (0.33-7.31)	0.586	-	-
Vegans	2.17 (0.43-10.90)	0.348	-	-
Years of practicing vegetarianism	1.05 (1.02-1.08)	0.001	-	-
Age	1.03 (1.01-1.05)	0.013	1.03 (1.00-1.06)	0.041*
Sex				
Male	1.51 (0.85-2.66)	0.157	-	-
Female	1.00	1.00	-	-
Ethnicity				
Chinese	1.00	1.00	-	-
Indian	2.72 (1.53-4.83)	0.001	-	-
Marital status				
Single	1.00	1.00	-	-
Married	2.69 (1.31-5.53)	0.007	-	-
Divorced/Widowed	1.69 (0.59-4.82)	0.328	-	-
Education levels				
Primary education	1.39 (0.58-3.29)	0.460	-	-
Secondary education	1.28 (0.68-2.43)	0.446	-	-
Tertiary education	1.00	1.00	-	-
Total household income				
Low	1.28 (0.63-2.60)	0.505	-	-
Middle	1.36 (0.68-2.73)	0.385	-	-
High	1.00	1.00	-	-
Smoking behaviourǂ				
Non-smoker	-	-	-	-
Past smoker	-	-	-	-
Alcohol consumption				
No	1.00	1.00	-	-
Yes	-	-	-	-

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031

Table 4: Logistic regression analysis of MetS risk factors among vegetarians (continue)

Predictor Variables	Univariate logistic regression		Multiple logistic regression	
	Crude OR (95% CI)	p value	Adjusted OR (95% CI) ᶲ	p value
Physical activity levels				
Low	0.57 (0.27-1.18)	0.131	-	-
Moderate	0.73 (0.34-1.54)	0.409	-	-
High	1.00	1.00	-	-
BMI categories				
UW/NW	1.00	1.00	1.00	1.00
OW/OB	8.60 (4.58-16.14)	0.0001	7.90 (4.13-15.11)	0.0001*

Note:
OR: Odds ratios; BMI: Body Mass Index; UW: Underweight; NW: Normal weight; OW: Overweight; OB: Obesity
ᶲAdjusted for sex
ǂSmoking behaviour was excluded from the logistic regression as more than 20% of the cells have expected count less than 5
*Indicates a significant difference at $p < 0.05$ in multiple logistic regression
Summary: Nagelkerke R Square = 0.295; Model $\chi^2 = 60.05$, $p<0.05$

4. Discussion

To the best of our knowledge, this is the first study that determined the prevalence of MetS among vegetarians in Malaysia and its associated factors. In the present study, the overall prevalence of MetS among Malaysian vegetarians was 24.2%. The prevalence of MetS in Malaysian vegetarians were lower than the overall prevalence of MetS in Malaysia general population (42.5%) [8]. Notably, the prevalence of MetS in Malaysian vegetarians were lower than Korean postmenopausal vegetarians (33.9%) [13], and US vegetarians (25.2%) [11], but higher than Taiwanese vegetarians (13.3%) [12]. The discrepancies of the prevalence could be due to the different MetS definitions used between studies [11–14,28]. The present study showed that high BP (48.7%) and big WC (43.6%) were found to be the most common MetS components. In contrast, Chiang and colleagues [12] found that low HDL-c (35.8%) and high BP (32.0%) were the most prevalent MetS components in Taiwanese female vegetarians. The inconsistent findings could be due to the variations in the MetS definitions and respondents' characteristics as the previous study [12] involved only female vegetarians. However, the present study consisted of both male and female vegetarians.

In spite of the previous study reported that vegetarians had lower risk of obesity [29], 35.6% of the vegetarians in the present study were overweight and obese. Based on National Health and Morbidity Survey 2015 (NHMS 2015) [30], the prevalence of overweight and obesity among the general population in Malaysia was 47.7%. About half of the vegetarians (43.6%) in the present study were abdominally obese, which were comparable to the prevalence of abdominal obesity among the general population in Malaysia (48.6%) in NHMS 2015 [30]. In addition, the prevalence of abdominal obesity among vegetarians in the present study was even higher than the world prevalence (13.0%) in 2014 [31]. Abdominal obesity was associated with the risk of developing the non-communicable disease such as CVD [32]. These findings highlight there is an urgent need of weight management program needed for vegetarians.

Despite the prevalence of MetS in males (29.2%) were higher than females (21.5), but there was no significant difference between the sexes ($p = 0.156$). The present study found that the WC, SBP, DBP, TG, and low-HDL-c were significantly different between males and females. Males had a higher WC, TG, FBG, BP but a lower HDL-c than females. The present findings were consistent with a past study that conducted by Chee et al. [33] among Malaysian employee. The plausible mechanism to explain these results is that the endogenous hormones of females are less atherogenic and has less effect on insulin resistance which provided the protective effects towards the MetS components [34].

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2018, 15, 2031; doi:10.3390/ijerph15092031

The present study failed to associate between lifestyle behaviours and MetS in Malaysian vegetarians. Unlike a previous study that reported a significant association between smoking behaviour and alcohol consumption and MetS among the general population [35,36], the present study did not observe any association of smoking behaviour and alcohol consumption with MetS. In the present study, a majority of the vegetarians were non-smokers (95.2%), and non-alcohol drinkers (91.9%). These lifestyle behaviours could be related to the religious belief, as religious belief (75.8%) was the main reason of their current vegetarianism practice in the present study. Religious belief teaches their followers to use alcohol moderately [37] and avoid unhealthy lifestyle such as smoking [38]. Besides that, physical activity of the vegetarians was not associated with MetS in the present study. This finding was consistent with a past study conducted in Nigerian adults [39], and they suggested that intervention on physical activity alone may not be effective in reducing the risk of MetS.

Despite the prevalence of MetS has been reported [11–14], the factors that contribute to the development of MetS in vegetarians remain unknown. The present study showed that the risk of MetS increased by 1.03 times for every one year increased in age, which similar to a past study in Malaysia [33]. Likewise, Gharipour and colleagues [40] found that the individuals with 65 years and older were four times more likely to develop MetS than the younger individuals. There are a few reasons to explain the relation between age and MetS. According to Lovre and colleagues [41], aging is accompanied by the decreased in lean mass, which may predispose the individuals to the increased of total fat and insulin resistance that were positively associated with the metabolic dysfunction. As the age increased, the adipose tissue deposited from subcutaneous areas to the visceral areas in the human body [42]. The accumulation of adipose tissue in the visceral area contributes to adipose tissue dysfunction, which may affects the insulin sensitivity, and further increases the risk of inflammation and MetS [42]. Besides, as age increased, the blood vessels gradually reduced in elasticity and gained in resistance, which restrained the blood flow in the human body. Indeed, a poor blood circulation increased the fat accumulation in the abdomen area and increased the secretion of free fatty acids into the bloodstream. This increased the susceptibility to insulin resistance and high TG that were positively correlated with MetS [43]. Considering the estimation of elderly population in Malaysia is projected to increase from 5.0% in 2010 to 14.5% in 2040 [44], it is crucial to develop an intervention program as a preventive strategy for the MetS development in the later stage of life.

Last but not least, overweight and obese vegetarians were 7.90 times more likely to have MetS. This result was in accordance with a few past studies [45,46] as they found that overweight and obese individuals had a higher risk of developing MetS than underweight and normal weight individuals. In addition, Carnethon and colleagues [47] found that the risk of MetS increased by 23.0% for every additional 4.5kg weight gained, and they suggested that obesity is an easily observed and measurable risk factor for the MetS. Inflammation may be the key factor to link between the obesity and MetS. This can be explained by the high amount of macrophages accumulation around the dead adipocytes in the inflamed adipose tissue [48]. The high amount of proinflammatory substance such as cytokine was released from the inflamed adipose tissue, which positively correlated with the development of MetS, atherosclerosis, and T2DM [49]. In other words, inflammation in adipose tissue may be a significant contributor to MetS, especially for those who were obese. Given the high prevalence of overweight and obesity in vegetarians in the present study, there is an urgent need to develop a weight management program in vegetarians.

The strength of the present study is the first vegetarian study that focuses on MetS and its associated factors, which may serve as a baseline data for the future researchers. There are a few limitations need to take into consideration. First, this study is a cross-sectional study which unable to detect the causal effect of the studied factors towards the development of MetS. Longitudinal cohort studies are recommended to clarify the causal relationship between the studied factors with MetS in vegetarians. Besides, non-vegetarians were not included in the present study as our study aimed to determine the risk factors for MetS in vegetarians. Future study may compare the effects of practicing vegetarianism on MetS and its associated factors between vegetarians and non-vegetarians in Malaysia.

5. Conclusions

Overall, the prevalence of Mets among vegetarians were 24.2%. This study showed that vegetarians advancing in age was 1.03 times and being overweight and obese was 7.90 times to be considered at greater risk of MetS. Hence, an intervention program to reduce BMI should be established among vegetarians, especially among those older vegetarians who were overweight and obese.

Author Contributions: Conceptualization, Y.K.C., Y.S.C., A.M., W.Y.G., R.V., and Y.M.C.; Methodology Y.K.C., Y.S.C., A.M., W.Y.G., R.V., and Y.M.C.; Validation, Y.K.C.; Formal Analysis, Y.K.C.; Investigation, Y.K.C; Resources, Y.K.C., Y.S.C., A.M., W.Y.G., R.V., and Y.M.C.; Data Curation, Y.K.C., Y.S.C., A.M., and W.Y.G.; Writing-Original Draft Preparation, Y.K.C.; Writing-Review & Editing, Y.S.C., A.M., W.Y.G., R.V., and Y.M.C.; Visualization, Y.K.C., Y.S.C.; Supervision, Y.S.C., A.M., W.Y.G., R.V., and Y.M.C.; Project Administration, Y.K.C., Y.S.C., A.M.; Funding Acquisition, Y.S.C.

Funding: This research was funded by Putra Graduate Initiative (IPS) (Grant Number: GP-IPS/2017/9533200), Universiti Putra Malaysia.

Acknowledgments: The authors would like to thank all vegetarians in this study, and the staff from the community centers who involved in the data collection. Meanwhile, the authors would like to take this opportunity to express our gratitude to the researchers, especially Kok Hong who helped during the data collection of the study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Grundy, S.; Cleeman, J.; Daniels, S.; Donato, K.; Eckel, R.; Franklin, B.; Gordon, D.; Krauss, R.; Savage, P.; Smith, S.; Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC, S. J. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. *Circulation* **2005**, *112*, 2735–2752, doi:10.1161/CIRCULATIONAHA.105.169404.
2. Alberti, K. G.; Zimmet, P. . Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet. Med.* **1998**, *15*, 539–53, doi:10.1002/(SICI)1096-9136(199807)15:7<539::AID-DIA668>3.0.CO;2-S.
3. National Cholesterol Education Program, N. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III): Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Chol. *Circulation* **2002**, *106*, 3143–3421.

4. Alberti, K. G. M.; Zimmet, P.; Shaw, J. The metabolic syndrome—a new worldwide definition. *Lancet* **2005**, *366*, 1059–1062, doi:10.1016/S0140-6736(05)67402-8.
5. Alberti, K. G.; Eckel, R. H.; Grundy, S. M.; Zimmet, P. Z.; Cleeman, J. I.; Donato, K. A.; Fruchart, J. C.; James, W. P.; Loria, C. M.; Smith Jr., S. C. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International. *Circulation* **2009**, *120*, 1640–1645, doi:10.1161/CIRCULATIONAHA.109.192644.
6. Aguilar, M.; Bhuket, T.; Torres, S.; Liu, B.; Wong, R. Prevalence of the metabolic syndrome in the United States, 2003-2012. *JAMA* **2015**, *313*, 1973–1974, doi:10.1001/jama.2015.4260.
7. Mohamud, W. N. W.; Ismail, A. al S.; Khir, A. S. M.; Ismail, I. S.; Musa, K. I.; Kadir, K. A.; Kamaruddin, N. A.; Yaacob, N. A.; Mustafa, N.; Ali, O.; Isa, S. H. M.; Bebakar, W. M. W. Prevalence of metabolic syndrome and its risk factors in adult Malaysians: Results of a nationwide survey. *Diabetes Res. Clin. Pract.* **2012**, *96*, 91–97, doi:10.1016/j.diabres.2011.11.020.
8. Ramli, A. S.; Daher, A. M.; Noor Khan Nor-Ashikin, M.; Mat-Nasir, N.; Keat Ng, K.; Miskan, M.; Ambigga, K. S.; Ariffin, F.; Yasin Mazapuspavina, M.; Abdul-Razak, S.; Abdul-Hamid, H.; Abd-Majid, F.; Abu-Bakar, N.; Nawawi, H.; Yusoff, K.; Ramli, A. S.; Daher, A. M.; Noor Khan Nor-Ashikin, M.; Mat-Nasir, N.; Keat Ng, K.; Miskan, M.; Ambigga, K. S.; Ariffin, F.; Yasin Mazapuspavina, M.; Abdul-Razak, S.; Abdul-Hamid, H.; Abd-Majid, F.; Abu-Bakar, N.; Nawawi, H.; Yusoff, K. JIS Definition Identified More Malaysian Adults with Metabolic Syndrome Compared to the NCEP-ATP III and IDF Criteria. *Biomed Res. Int.* **2013**, *2013*, doi:10.1155/2013/760963.
9. Lim, S.; Shin, H.; Song, J. H.; Kwak, S. H.; Kang, S. M.; Yoon, J. W.; Choi, S. H.; Cho, S. Il; Park, K. S.; Lee, H. K.; Jang, H. C.; Koh, K. K. Increasing prevalence of metabolic syndrome in Korea: The Korean National Health and Nutrition Examination Survey for 1998-2007. *Diabetes Care* **2011**, *34*, 1323–1328, doi:10.2337/dc10-2109.
10. Rampal, S.; Mahadeva, S.; Guallar, E.; Bulgiba, A.; Mohamed, R.; Rahmat, R.; Arif, M. T.; Rampal, L. Ethnic Differences in the Prevalence of Metabolic Syndrome: Results from a Multi-Ethnic Population-Based Survey in Malaysia. *PLoS One* **2012**, *7*, 8–10, doi:10.1371/journal.pone.0046365.
11. Rizzo, N. S.; Sabaté, J.; Jaceldo-Siegl, K.; Fraser, G. E. Vegetarian dietary patterns are associated with a lower risk of metabolic syndrome: the adventist health study 2. *Diabetes Care* **2011**, *34*, 1225–1227, doi:10.2337/dc10-1221.
12. Chiang, J. K.; Lin, Y. L.; Chen, C. L.; Ouyang, C. M.; Wu, Y. T.; Chi, Y. C.; Huang, K. C.; Yang, W. S. Reduced risk for metabolic syndrome and insulin resistance associated with ovo-lacto-vegetarian behavior in female Buddhists: a case-control study. *PLoS One* **2013**, *8*, e71799, doi:10.1371/journal.pone.0071799.
13. Kim, M. .; Bae, Y. . Postmenopausal vegetarians' low serum ferritin level may reduce the risk for metabolic syndrome. *Biol. Trace Elem. Res.* **2012**, *149*, 34–41, doi:10.1007/s12011-012-9405-x.
14. Hung, K.; Pei, D.; Kuo, H.; Chen, T.; Lin, C.; Wu, C.; Hsia, T.; Su, C.; Hsiao, F.; Lu, C. The comparison of the metabolic syndrome between Chinese vegetarians and omnivores. *Diabetes Metab. Syndr. Clin. Res. Rev.* **2008**, *2*, 99–104, doi:10.1016/j.dsx.2008.02.002.
15. Tee, T. S. Vegetarianism among Young Adults in the Klang Valley. *J. Hosp. Tour.* **2012**, *9*, 55–

61.

16. Khor, G. L.; Voon, P. C.; Tee, E. S.; Hage, B. H. H.; Wahlqvist, M. L. Cardiovascular risk factors among Malaysian urban vegetarians. *J. Community Nutr.* **2000**, *2*, 110–118.
17. Wong, Y. S.; Shalini, S.; Farah Liana, M. R.; Wan Nurul Amera, W. M. S.; Mohd Naqiuddin, M. Y.; Norhazlina, A. W.; Zaleha, M. I. Nutrient intake pattern of vegetarians and non-vegetarians in Kuala Lumpur, Malaysia. *Pakistan J. Nutr.* **2013**, *12*, 371–376, doi:10.3923/pjn.2013.371.376.
18. The Economic Planning Unit, T. E. P. U. *Tenth Malaysia Plan 2011-2015*; 2010;
19. Craig, W.; Mangels, A. Position of the American Dietetic Vegetarian Diets. *J Am Diet Assoc* **2009**, *109*, 1266–1282, doi:10.1016/j.jada.2009.05.027.
20. Centers for Disease Control and Prevention NHANES Food Questionnaire Available online: https://epi.grants.cancer.gov/diet/usualintakes/FFQ.English.June0304.pdf (accessed on Oct 10, 2016).
21. Global Adult Tobacco Survey Collaborative Group *Tobacco questions for surveys: A subset of key questions from the Global Adult Tobacco Survey (GATS), 2nd edition*; Atlanta, GA: Centers for Disease Control and Prevention, 2011;
22. Armstrong, T.; Bull, F. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). *J. Public Health (Bangkok).* **2006**, *14*, 66–70, doi:10.1007/s10389-006-0024-x.
23. World Health Organization Obesity: Preventing and managing the global epidemic - report of a WHO consultation. **2000**, 268, doi:9241208945.
24. WHO/IASO/IOTF *The Asia-Pacific perspective: redefining obesity and its treatment*; World Health Organization, 2000; ISBN 0957708211.
25. World Health Organization; Hypertension International Society Guidelines for Management of Hypertension. *J. Hypertens.* **1999**, 17:151-185.
26. Grundy, S. M.; Becker, D.; Clark, L. T.; Cooper, R. S.; Denke, M. A.; James Howard, W.; Hunninghake, D. B.; D, R. I.; Luepker, R. V; McBride, P.; McKenney, J.; Pasternak, R. C.; Stone, N. J.; Horn, L. Van Executive Summary of the Third Report (NCEP) Expert Panel on Detection , Evaluation , and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA* **2001**, *285*, 2486–2497.
27. Genuth, S.; Alberti, K. G. M. .; Bennett, P.; DeFronzo, R.; Kitzmiller, J.; Knowler, W. C.; Nathan, D.; Palmer, J.; Rizza, R.; Saudek, C.; Shaw, J.; Steffes, M.; Stern, M.; Tuomilehto, J.; Zimmet, P. Follow-up Report on the Diagnosis of Diabetes Mellitus. *Diabetes Care* **2003**, *26*, 3160–3167.
28. Shang, P. H.; Shu, Z.; Wang, Y. F.; Li, N.; Du, S. M.; Sun, F.; Xia, Y. Y.; Zhan, S. Y. Veganism does not reduce the risk of the metabolic syndrome in a Taiwanese cohort. *Asia Pac J Clin Nutr* **2011**, *20*, 404–410.
29. Newby, P.; Tucker, K.; Walk, A. Risk of overweight and obesity among semivegetarian, lactovegetarian, and vegan women. *Am. J. Clin. Nutr.* **2005**, *81*, 1267–1274.
30. Institute for Public Health *National Health and Morbidity Survey 2015 (NHMS 2015). Vol. II: Non-Communicable Diseases, Risk Factors & Other Health Problems*; 2015; Vol. II;
31. World Health Organization *World Health statistics 2014*; 2014; ISBN 978 92 4 156471 7.
32. Barroso, T.; Marins, L.; Alves, R.; Gonçalves, A.; Barroso, S.; Rocha, G. Association of central obesity with the incidence of cardiovascular diseases and risk factors. *Int. J. Cardiovasc. Sci.*

2017, *30*, 416–424, doi:10.5935/2359-4802.20170073.

33. Chee, H. .; Hazizi, A. .; Barakatun Nisak, M. .; Mohd Nasir, M. . Metabolic Risk Factors among Government Employees in Putrajaya , Malaysia. **2014**, *43*, 1165–1174.
34. Anish, T.; Shahulhameed, S.; Vijayakumar, K.; Joy, T.; Sreelakshmi, P.; Kuriakose, A. Gender difference in blood pressure, blood sugar, and cholesterol in young adults with comparable routine physical exertion. *J. Fam. Med. Prim. Care* **2013**, *2*, 200, doi:10.4103/2249-4863.117424.
35. Mohamud, W. N. W.; Ismail, A. A.-S.; Sharifuddin, A.; Ismail, I. S.; Musa, K. I.; Kadir, K. A.; Kamaruddin, N. A.; Yaacob, N. A.; Mustafa, N.; Ali, O.; Harnida, S.; Bebakar, W. M. W. Prevalence of metabolic syndrome and its risk factors in adult Malaysians: results of a nationwide survey. *Diabetes Res. Clin. Pract.* **2011**, *91*, 239–45, doi:10.1016/j.diabres.2010.11.025.
36. Yu, S.; Guo, X.; Yang, H.; Zheng, L.; Sun, Y. An update on the prevalence of metabolic syndrome and its associated factors in rural northeast China BMC Public Health. *BMC Public Health* **2014**, *14*, 877.
37. Newman, I.; Shell, D. F.; Li, T.; Innadda, S. Buddhism and Adolescent Alcohol Use in Thailand. *Subst. Use Misuse* **2006**, *41*, 1789–1800, doi:10.1080/10826080601006490.
38. Wasserman, I.; Trovato, F. The influence of religion on smoking and alcohol cumpsiton: Aberta case study. *Int. Rev. Mod. Sociol.* **2014**, *26*, 43–56.
39. Oguoma, V. M.; Nwose, E. U.; Skinner, T. C.; Richards, R. S.; Digban, K. A.; Onyia, I. C. Association of physical activity with metabolic syndrome in a predominantly rural Nigerian population. *Diabetes Metab. Syndr. Clin. Res. Rev.* **2016**, *10*, 13–18, doi:10.1016/j.dsx.2015.08.010.
40. Gharipour, M.; Sadeghi, M.; Hosseini, M.; Andalib, E.; Boroujeni, M. B.; Sarrafzadegan, N. Effect of age on the phenotype of metabolic syndrome in developing country. *Adv. Biomed. Res.* **2015**, *4*, doi:10.4103/2277-9175.157796.
41. Lovre, D.; Lindsey, S. H.; Mauvais-Jarvis, F. Effect of menopausal hormone therapy on components of the metabolic syndrome. *Ther. Adv. Cardiovasc. Dis.* **2017**, *11*, 33–43, doi:10.1177/1753944716649358.
42. Palmer, A. K.; Kirkland, J. L. Aging and adipose tissue: Potential interventions for diabetes and regenerative medicine. *Exp. Gerontol.* **2016**, *86*, 97–105, doi:10.1016/j.exger.2016.02.013.
43. Tsai, T. Y.; Cheng, J. F.; Lai, Y. M. Prevalence of metabolic syndrome and related factors in Taiwanese high-tech industry workers. *Clin. 66(9)* **2011**, *66*, 1531–1535, doi:10.1590/S1807-59322011000900004.
44. Department of Statistics Malaysia *DEPARTMENT OF STATISTICS MALAYSIA PRESS RELEASE POPULATION PROJECTION (REVISED), MALAYSIA , 2010-2040*; 2016;
45. Esteghamati, A.; Khalilzadeh, O.; Anvari, M.; Ahadi, M.; Abbasi, M.; Rashidi, A. Metabolic syndrome and insulin resistance significantly correlate with body mass index. *Arch. Med. Res.* **2008**, *39*, 803–808, doi:10.1016/j.arcmed.2008.08.004.
46. Park, Y.; Zhu, S.; Palaniappan, L.; Heshka, S.; Carnethon, M.; Heymsfield, S. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. *Arch. Intern. Med.* **2003**, *163*, 427–436, doi:10.1007/978-3-7091-1331-8.
47. Carnethon, M. R.; Loria, C. M.; Hill, J. O.; Sidney, S.; Savage, P. J.; Liu, K. Risk factors for the metabolic syndrome: the Coronary Artery Risk Development in Young Adults (CARDIA) study, 1985–2001. *Diabetes Care* **2004**, *27*, 2707–2715, doi:10.2337/diacare.27.11.2707.

482 48. Cinti, S., Mitchell, G., Barbatelli, G., Murano, I., Ceresi, E., Faloia, E., Wang, S., Fortier, M.,
483 Greenberg, A.S., Obin, M. S. Adipocyte death defines macrophage localization and function
484 in adipose tissue of obese mice and humans. *J. Lipid Res.* **2005**, *46*, 2347–2355,
485 doi:10.1194/jlr.M500294-JLR200.
486 49. Kang, Y.; Kim, J.; Joung, K.; Lee, J.; You, B.; Choi, M.; Ryu, M.; Ko, Y.; Lee, M.; Lee, J.; Ku, B.
487 The roles of adipokines, proinflammatory cytokines, and adipose tissue macrophages in
488 obesity-associated insulin resistance in modest obesity and early metabolic dysfunction. *PLoS*
489 *One* **2016**, *11*, e0154003, doi:10.1371/journal.pone.0154003.
490