

ORIGINAL ARTICLE

Physical Activity Levels of Malaysian Vegetarians and Its Associated Factors: A Cross-Sectional Study

Yuan Kei Ching¹, Mahenderan Appukutty^{2,3}, Wan Ying Gan¹, Yoke Mun Chan^{1,4}, Yit Siew Chin^{1,4}

¹ Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

² Programme of Sports Science, Faculty of Sports Science and Recreation, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

³ Jeffrey Cheah School of Medicine and Health Sciences, Monash University Malaysia, 47500 Sunway, Selangor, Malaysia

⁴ Research Centre of Excellence, Nutrition and Non-Communicable Diseases, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

ABSTRACT

Introduction: Literatures suggest that insufficient physical activity as one of the contributors to non-communicable chronic diseases; nevertheless, data on the physical activity level is sparsely reported among individuals practising a vegetarian diet in Malaysia. The current study aims to determine the prevalence of insufficient physical activity and its association with socio-demographic factors, lifestyle factors and body weight status among 273 individuals practising a vegetarian diet in Klang Valley, Malaysia. **Methods:** A set of self-administered questionnaire was distributed to all vegetarians and their data on physical activity was determined using the Global Physical Activity Questionnaire (GPAQ). **Results:** The average years of practising vegetarianism was 14.2 ± 9.6 years, and most of the vegetarians were practised ovo-vegetarian diet (44.0%). A majority of them were Chinese (54.9%) and female (64.8%), with an average age of 47.5 ± 13.1 years. The prevalence of overweight and obesity were 27.5% and 8.1%, respectively. According to GPAQ, about two in five vegetarians (46.2%) were having insufficient physical activity. Being females, older age, Chinese, married individuals, and those with high total household income level were found to be significantly associated with low physical activity level among Malaysian vegetarians ($p < 0.05$). **Conclusion:** Since insufficient physical activity is one of the factors contributing to non-communicable chronic diseases, it is crucial to educate the importance of physical activity on overall health status, specifically for those who at risk of physically inactive. In addition, future studies can focus the causal associations based on the currently identified factors and physical activity levels, which can help to develop an effective intervention program among Malaysia vegetarians.

Keywords: Physical activity, Vegetarians, Socio-demographic background, Smoking, Alcohol, Body weight status

Corresponding Author:

Mahenderan Appukutty, PhD
Email: mahen@uitm.edu.my
Tel: +603-5544 2933

INTRODUCTION

Physical activity is known as body motions that are generated by the skeletal muscle, which involves energy expenditure (1). Meanwhile, insufficient physical activity is used to describe those who are performing inadequate amounts of physical activity that stated by physical activity guidelines (2). Based on the World Health Organisation (3), an adult aged between 18 years to 64 years shall attain a minimum 150 minutes of moderate-intensity aerobic physical activity per week or 75 minutes of vigorous-intensity aerobic physical activity per week.

Undoubtedly, insufficient physical activity is an increasing lifestyle problem facing by the global

population. Recent statistics showed that over a quarter (28.0%) of individuals aged more than 18 years old were not meeting the WHO recommendations for physical activity (4). About 50.0% of women and 40.0% of men living in the Americas and Eastern Mediterranean regions having insufficient physical activity 2008 (5). Despite the National Health and Morbidity Survey (NHMS) depicted that the prevalence of Malaysian meeting the physical activity guidelines were increased from 56.3% in 2006 to 64.8% in 2011 and 66.9% in 2016 (6), however, Malaysia is ranked as the fattest country in the Southeast Asia region (7). On the other hand, there is no information revealed from the NHMS on physical activities data among vegetarians.

Increased urbanisation has resulted in rapid changing in the environment such as lack of sidewalks and recreation facilities, an increase of road traffic as well as sound and air pollution, which may discourage the participation of individuals' physical activity (5). In addition, insufficient physical activity could be related

to an increase in sedentary behaviour due to the type of occupation, such as white-collar as well as an increase in the use of transportation. Whilst insufficient physical activity is recognised as one of the leading risk factors for global death as well as a significant contributor to 80.0% of cardiovascular disease and 27.0% of diabetes (8). Furthermore, insufficient physical activity may not only affect human body health status, but it can also affect human mental health status as reported in several studies (9,10).

To the best of our knowledge, kinds of literature suggest the associations of insufficient physical activity with socio-demographic factors, lifestyle factors as well as body weight status elsewhere (11–15). Nonetheless, data on insufficient physical activity and its associated factors remain unclear among individuals practising a vegetarian diet in Malaysia. Furthermore, epidemiological studies have indicated that most of the vegetarians were women, younger, had a higher educational level, and had higher social, economic status than non-vegetarians (16,17). Additionally, some studies revealed that non-vegetarians were at greater risk of obesity than vegetarians (18,19). Considering non-similarities between general population and vegetarians, therefore, the associations of insufficient physical activity with socio-demographic background, lifestyle factors and body weight status that depicted among the general population may be different in vegetarian population. Thus, the present cross-sectional study aimed to identify the prevalence of insufficient physical activity and its association with socio-demographic background, lifestyle factors and body weight status among vegetarians. A better understanding of factors associated with insufficient physical activity is useful in developing intervention strategies to tackle physical inactivity among Malaysian vegetarians.

MATERIALS AND METHODS

The current cross-sectional study consisted of 273 vegetarians in Klang Valley, Malaysia. Details of the study design, study population and recruitment of respondents have been previously described (20,21). In brief, the lists consist of community centres were attained from two headquarters located in Kuala Lumpur, Malaysia. All members who were aged at least 18 years old, practising a vegetarian diet at least two years and above, currently not under the pregnant or lactating stage, and does not take any medicines to control blood lipid, blood glucose and blood pressure were allowed to take part in the current study. All vegetarians who fulfilled inclusion criteria and agreed to take part in the study were required to submit their consents during the day of the data collection.

Height and body weight of respondents were measured according to the International Society for the Advancement of Kinanthropometry (ISAK) method.

Respondents were asked to stand bare feet with normal posture on TANITA Digital Weight Scale HD306 (TANITA Corporation, Arlington Heights, IL, USA) for body weight measurement and SECA 213 portable stadiometer (SECA, Hamburg, Germany) for height measurement. Height and body weight of the respondents were recorded in kilograms (kg) to the nearest 0.1kg and centimetres (cm) to the nearest of 0.1cm, respectively. Body mass index (BMI) of the respondents was generated in kg/m². Body weight status of the respondents was classified into underweight (< 18.5 kg/m²), normal weight (18.5 kg/m² – 24.9 kg/m²), overweight (25.0 kg/m² – 29.9 kg/m²) and obesity (\geq 30.0 kg/m²) according to their BMI based on the WHO cut-off points (22). The present study follows the WHO cut-off points as WHO's cut-offs are widely used in worldwide epidemiology studies (23,24) as well as NHMS (6) in Malaysia.

Information on age, ethnicity, sex, marital status, education level, monthly total household income (low: <RM 2300, medium: RM 2300–5599 and high: >RM 5600) (25), alcohol consumption and smoking behaviour were recorded. For vegetarianism practises, respondents were required to indicate the number of years practising vegetarianism. Respondents were classified into vegans (exclude consumption of all animal-based foods), lacto-vegetarians (consume dairy products by excluding consumption of all animal-based foods); ovo-vegetarians (consume eggs by excluding consumption of all animal-based foods); and lacto-ovo-vegetarians (consume dairy products and eggs by excluding consumption of all animal-based foods) based on their dietary practices (20,26). With regards to cigarette smoking, the Global Adult Tobacco Survey (GATS) was used to determine respondents' smoking behaviours. The Malay and Chinese versions of GATS (6,27) were used in the present study. Respondents were categorised into smokers, past smokers and non-smokers (28).

The Global Physical Activity Questionnaire (GPAQ) (29) was used to collect the information of three domains of physical activity, namely activities at work, recreational activities and travel to and from places for the past week. The Malay and Chinese versions of the GPAQ (30,31) were used in the present study. Respondents were required to choose "No" if they did not perform any physical activity for Question 1, 4, 7, 10 and 13. Otherwise, respondents were asked to write the frequency (number of days/week), intensity (vigorous-intensity or moderate-intensity) and duration (minutes/day) for each of the physical activities. The physical activity levels of the respondents were determined using metabolic equivalent (MET), with the total MET-minutes/week for the past week was calculated based on the multiplication of MET value according to the frequency (days/week) and duration (min/day) for each domain. Respondents were classified as having insufficient physical activity if they have less than 600 MET-minutes/week, whilst for

those who had at least 600 MET-minutes/week to 2999 MET-minutes/week were categorised as moderately active. Lastly, respondents were classified under highly active when achieved equal or more than of 3000 MET minutes/week.

IBM SPSS Statistics Software (Version 24.0; Inc, Chicago, IL) was used to conduct statistical analysis for the current study. Descriptive analysis was used to indicate the distribution of the vegetarians by sex, ethnicity, highest education level, total household income, vegetarians' categories, alcohol consumption, smoking behaviour, body weight status and physical activity levels of the respondents. Data were considered as normally distributed if the variables fall within skewness of ± 2 . Otherwise, data were treated as non-normally distributed (32). Chi-square analysis was used to determine the association of socio-demographic characteristics, lifestyle behaviours and body weight status with physical activity levels of the respondents. For continuous variables such as age and total MET-minutes/week for the past week, one-way ANOVA analysis was used to determine the differences between respondents with insufficient physical activity, moderately active and highly active. The level of significance was set at $p < 0.05$.

RESULTS

Table I depicts the descriptions of socio-demographic characteristics, vegetarianism practises and body weight status among vegetarians. The average age of 47.5 ± 13.1 years. The current study consists of 273 vegetarians, with more than half of them were females (64.8%). Of those who participated in the present study, 54.9% were Chinese, and 45.1% were Indians. Over half (58.6%) of the vegetarians were married and had obtained a secondary level of education (53.5%). Vegetarians in this study had practised vegetarianism for 14.2 ± 9.6 years, with about two in five of them were practising lacto-ovo vegetarian diet (44.0%). In terms of body weight status, the present study revealed that the prevalence of overweight and obesity among vegetarians were 27.5% and 8.1%, respectively.

Table II shows the lifestyle behaviours (smoking behaviour and alcohol consumption) as well as physical activity levels of the vegetarians. Only a small portion of the vegetarians were smokers (4.8%) and alcohol users (8.1%). Based on the GPAQ classifications, there were only 18.7% of the vegetarians were achieved a high physical activity level.

Table III depicts the association between all variables and physical activity levels of the respondents. The present study found that younger vegetarians were more physically active as compared to their counterparts ($F=3.53$, $p=0.031$). Insufficient physical activity was reported to be more prevalent among vegetarians

Table I: General characteristics of vegetarians

Variable	Mean \pm SD	n (%)
Age		
Mean \pm SD	47.5 \pm 13.1	
Sex		
Male		96 (35.2)
Female		177 (64.8)
Ethnicity		
Chinese		150 (54.9)
Indians		123 (45.1)
Marital status		
Single		80 (29.3)
Married		160 (58.6)
Divorced/Widowed		33 (12.1)
Education		
Primary education		41 (15.0)
Secondary education		146 (53.5)
Tertiary education		86 (31.5)
Total household income		
<RM 2300		92 (33.7)
RM 2300–5599		99 (36.3)
\geq RM 5600		82 (30.0)
Vegetarian classifications		
Lacto-ovo-vegetarians		120 (44.0)
Ovo-vegetarians		15 (5.5)
Lacto-vegetarians		86 (31.5)
Vegans		52 (19.0)
Years of practising vegetarianism		
Mean \pm SD	14.2 \pm 9.6	
Body weight (kg)		
	62.3 \pm 13.4	
Height (cm)		
	161.8 \pm 8.9	
BMI		
	23.7 \pm 4.1	
Underweight		26 (9.5)
Normal weight		150 (54.9)
Overweight		75 (27.5)
Obesity		22 (8.1)

Table II: Distribution of vegetarians by lifestyle behaviours and physical activity levels

Variable	Median (IQR)	n (%)
Cigarette smoking		
Past smokers		13 (4.8)
Non-smokers		260 (95.2)
Alcohol consumption		
Alcohol users		22 (8.1)
Non-alcohol users		251 (91.9)
Overall MET-minutes/week	600.0 (1680.0)	
Median (IQR)		
Physical activity level		
Insufficient physical activity		126 (46.2)
Moderately active		96 (35.1)
Highly active		51 (18.7)

Table III: Factors associated with physical activity levels among Malaysian vegetarians

Variable	Insufficient physical activity (n=126)	Moderately active (n=96)	Highly active (n=51)	χ^2/F	p-value
Age					
Mean \pm SD	48.5 \pm 11.0	48.5 \pm 14.2	43.2 \pm 14.9	3.53	0.031*
Sex					
				7.48	0.024*
Male	37 (38.5)	33 (34.4)	26 (27.1)		
Female	89 (50.3)	63 (35.6)	25 (14.1)		
Ethnicity					
				9.87	0.007*
Chinese	74 (49.3)	58 (38.7)	18 (12.0)		
Indians	52 (42.3)	38 (30.9)	33 (26.8)		
Marital status					
				12.08	0.017*
Single	33 (41.2)	25 (31.3)	22 (27.5)		
Married	79 (49.3)	62 (38.8)	19 (11.9)		
Divorced/Widowed	14 (42.4)	9 (27.3)	10 (30.3)		
Education					
				2.96	0.565
Primary education	20 (48.8)	15 (36.6)	6 (14.6)		
Secondary education	61 (41.8)	55 (27.7)	30 (20.5)		
Tertiary education	45 (52.4)	26 (30.2)	15 (17.4)		
Total household income					
				11.23	0.024*
<RM 2300	40 (43.4)	33 (35.9)	19 (20.7)		
RM 2300–5599	37 (37.4)	38 (38.4)	24 (24.2)		
\geq RM 5600	49 (59.7)	25 (30.5)	8 (9.8)		
Cigarette smoking					
				3.63	0.163
Past smokers	4 (30.7)	4 (30.8)	5 (38.5)		
Non-smokers	122 (46.9)	92 (35.4)	46 (17.7)		
Alcohol consumption					
				0.29	0.866
Alcohol users	10 (45.5)	7 (31.8)	5 (22.7)		
Non-alcohol users	116 (46.2)	89 (35.5)	46 (18.3)		
BMI					
				3.23	0.199
Underweight/Normal weight	87 (49.4)	61 (34.7)	28 (15.9)		
Overweight/Obesity	39 (40.2)	35 (36.1)	23 (23.7)		

Note:
Indicates a significant difference at $p < 0.05$.

who were females ($\chi^2=7.48$, $p=0.024$), Chinese ($\chi^2=9.85$, $p=0.007$), married ($\chi^2=12.08$, $p=0.017$) and high total household income level ($\chi^2=11.23$, $p=0.024$) as compared to their counterparts ($p < 0.05$). Nevertheless, no significant associations were found between education level, smoking behaviour, alcohol consumption and body weight status with insufficient physical activity ($p > 0.05$).

DISCUSSION

Overall, insufficient physical activity was prevalent among individuals practising a vegetarian diet in Malaysia, whereby about one in five of Malaysian vegetarians were having insufficient physical activity as defined according to GPAQ guidelines. Despite vegetarians were seeming as a healthier group as compared to the general population, the prevalence of insufficient physical activity is higher than the general population as reported in the Malaysia NHMS 2015 (33.5%) (6) and the Singapore Health Survey 2012 (26.2%) (33). Though the present study did not

compared with omnivorous diet individuals for physical activity or performance, but it is reported that those practising vegetarian diets has no differences in term of exercise capacity when compared to omnivorous diet (34,35). The variation in the prevalence of insufficient physical activity may depend on sampling methodology and culture differences. More prospect local studies involving vegetarians are needed in Malaysia.

Younger vegetarians were engaged in more physical activity than older vegetarians. A similar trend of physical activity pattern had been observed in the local context (15,36) as well as in Singapore (33). Shortness of breath and joint pain during exercise, reluctance to go out alone or during afternoon time and lack of transport were identified as barriers for older individuals to take part in physical activity (37). Despite this, older adults with osteoarthritis who engaged in physical activity have a better overall physical function and experienced less joint pain than those who less engaged in physical activity (38). The previous findings from the previous study indicate that engage in physical activity can maintain

or improve function and mobility of older adults (38). The effectiveness of physical activity towards joint pain alleviation should be conveyed to older adults through a national campaign. Besides, various modification can be done to improve the participation of older adults in physical activity as shorten the duration of physical activity or alter the type and intensity of the physical activity.

Consistent with previous research (15,33), females engaged in less physical activity than males in the current study. Multiple elements such as lack of time, unsafe neighbourhoods, parenting/caregiving could be possible contributors to insufficient physical activity among female (15). Another plausible reason to explain the insufficient physical activity due to females travel less frequently than males. A previous study found that being a frequent traveller is associated with higher level of physical activity (39). Since male's daily activities involve more travelling activities, therefore males are usually having a higher level of physical activity than female (39). Considering family commitments given by females, more home TV fitness programmes should be made available to increase female participation in physical activity (40). With the home TV fitness programmes, females can achieve the minimum amount of physical activity without joining the fitness centre or recreation park, which is time-saving and more convenient for females.

We observed that Chinese vegetarians were having insufficient physical activity as compared to Indian vegetarians, which is consistent with Malaysia nationwide study (6). Similarly, Tam and colleagues (36) found that Chinese were the least highly active group as compared to other ethnic groups such as Indian and Malay in Malaysia. The lower participation of Chinese in physical activity could be related to Malaysian Chinese culture, which discourages exercise (36). Besides, Indians were most likely to engage in physical activities such as gardening, fishing, or carpentry activities (36), which increase the overall MET-minutes/week.

Similar to the previous studies (33,40), marital status was found to be significantly associated with insufficient physical activity. We noticed that a higher proportion of vegetarians who were currently married engaged in less physical activity than their counterparts. One of the possible explanations to explain this phenomenon could be related to the children and family commitments of married adults (33). For instance, married adults need to spend more times to take care of their children, spouse or household activities, which make them to less engage in structured exercise. As compared to married adults, single adults have more time to participate in the exercise as there are having fewer family commitments and flexible schedule than married adults. Based on the current finding, it is necessary to promote the participation of physical activity among married individuals. Indeed,

more childcare centres should be made available in the residential areas to reduce married individual's family commitments (40). With that, married individuals can send their children to the nearby childcare centre during the daytime, whereby they can utilise their daily time for physical activities effectively.

Consistent with the previous study (40), the prevalence of highly active was lower among those with high total household income level. A plausible reason is due to high-income individuals have shorter working hours as compared to low-income individuals. Therefore, high-income earners tend to replace their working times with more leisure-time physical activities, making them have sedentary behaviour (40). Additionally, most of the works of low-income individuals involve manual jobs such as cleaners, contractors and production workers, which increase their METs. In contrast, individuals with higher-income works in an office setting which require low METs. Thus, it is not surprising that lower-income individuals reported with higher physical activity level than those with higher income. With regards to policy implementation, the government should organise health awareness programmes, primarily focus on higher income individuals.

The current study had a few limitations should be considered. Firstly, this was a cross-sectional study, which did not allow us to determine the direction of the association between studied factors and physical activity levels. The future prospective study can design the framework based on the currently identified factors. Secondly, the self-reported data of physical activity may not be accurate due to recall bias, which may underestimate or over-estimate the prevalence of physical activity. Nevertheless, the present study is the fore research to describe the situation of physically inactive and its associated factors among individuals practising vegetarian diet in Malaysia. The results of the present study may provide useful baseline data for the government sector or healthcare professionals to monitor and promote physical activity among Malaysia vegetarians.

CONCLUSION

Taken into current the aforementioned limitations, the current study depicts the current situation of insufficient physical activity among Malaysian vegetarian population, whereby 46.2% of them were not meeting the WHO recommendations. Being female, older age, Chinese, married individuals, and those with high total household income were associated with a higher prevalence of insufficient physical activity. Identification of these factors is an essential approach to develop an effective intervention for promoting regular physical activity among Malaysian vegetarians. Since insufficient physical activity was well-known as one of the significant contributors to non-communicable diseases, therefore,

it is important to educate those vegetarians who at the high prevalence of insufficient physical activity on the current recommendation of physical activity as prevention for non-communicable chronic diseases.

ACKNOWLEDGEMENT

The authors would like to express their sincere thanks to all respondents for their time and generosity. The authors also would like to thank the staffs and students for their assistance during the data collection. The study obtained grant support from Universiti Putra Malaysia, under the Putra Graduate Initiative (IPS) with grant number of GP-IPS/2017/9533200. Mahenderan Appukutty is currently on sabbatical leave at Jeffrey Cheah School of Medicine and Health Sciences, Monash University Malaysia.

REFERENCES

- Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness : definitions and distinctions for health-related research. *Public Health Rep.* 1985;100(2):126–31.
- Barnes J, Behrens, Timothy K, Benden, Mark E, Biddle S, Bond D, Brassard P, et al. Letter to the editor: standardized use of the terms “sedentary” and “sedentary behaviours.” *Appl Physiol Nutr Metab Appl Nutr Metab.* 2012;542(January):540–2.
- World Health Organization WHO. Global recommendations on physical activity for health. Switzerland; 2010.
- World Health Organization WHO. Non-communicable diseases country profiles 2018. Geneva; 2018.
- World Health Organization WHO. Physical inactivity: a global public health problem. 2008.
- Institute for Public Health. National health and morbidity survey 2015 (NHMS 2015). vol. II: non-communicable diseases, risk factors & other health problems. Vol. II, Ministry of Health Malaysia. 2015.
- Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980 – 2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet.* 2014;384:766–80.
- World Health Organization WHO. Global status report on noncommunicable diseases 2010. 2010.
- Harvey SB, Overland S, Hatch SL, Wessely S, Mykletun A, Hotopf M. Exercise and the prevention of depression: Results of the HUNT cohort study. *Am J Psychiatry.* 2018 Jan 1;175(1):28–36.
- Chekroud SR, Gueorguieva R, Zheutlin AB, Paulus M, Krumholz HM, Krystal JH, et al. Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *The Lancet Psychiatry.* 2018 Sep 1;5(9):739–46.
- Chan YY, Lim KK, Lim KH, Teh CH, Kee CC, Cheong SM, et al. Physical activity and overweight/obesity among Malaysian adults: Findings from the 2015 National Health and morbidity survey (NHMS). Vol. 17, *BMC Public Health.* BioMed Central Ltd.; 2017.
- Chiu YF, Hsu CC, Chiu THT, Lee CY, Liu TT, Tsao CK, et al. Cross-sectional and longitudinal comparisons of metabolic profiles between vegetarian and non-vegetarian subjects: A matched cohort study. *Br J Nutr.* 2015 Aug 19;114(8):1313–20.
- Murtagh EM, Murphy MH, Murphy NM, Woods C, Nevill AM, Lane A. Prevalence and correlates of physical inactivity in community-dwelling older adults in Ireland. *PLoS One.* 2015 Feb 11;10(2).
- Patil C, Dhoble M, Kaware A. A study of physical activity levels and its correlates among adults: a cross-sectional study. *Int J Community Med Public Heal.* 2017 Mar 28;4(4):1154.
- Teh CH, Lim KK, Chan YY, Lim KH, Azahadi O, Hamizatul Akmar AH, et al. The prevalence of physical activity and its associated factors among Malaysian adults: Findings from the National Health and Morbidity Survey 2011. *Public Health.* 2014;128(5):416–23.
- Hoek AC, Luning PA, Stafleu A, De Graaf C. Food-related lifestyle and health attitudes of Dutch vegetarians, non-vegetarian consumers of meat substitutes, and meat consumers. *Appetite.* 2004 Jun;42(3):265–72.
- Аллис В, Baudry J, МйJean C, Touvier M, Рйneau S, Hercberg S, et al. Comparison of sociodemographic and nutritional characteristics between self-reported vegetarians, vegans, and meat-eaters from the nutrinet-santй study. *Nutrients.* 2017 Sep 15;9(9).
- Rizzo NS, Sabatй J, Jaceldo-Siegl K, Fraser GE. Vegetarian dietary patterns are associated with a lower risk of metabolic syndrome: The Adventist Health Study 2. *Diabetes Care.* 2011 May;34(5):1225–7.
- Kim MH, Bae YJ. Postmenopausal vegetarians’ low serum ferritin level may reduce the risk for metabolic syndrome. *Biol Trace Elem Res.* 2012 Oct;149(1):34–41.
- Ching YK, Chin YS, Appukutty M, Gan WY, Ramanchadran V, Chan YM. Prevalence of metabolic syndrome and its associated factors among vegetarians in Malaysia. *Int J Environ Res Public Health.* 2018 Sep 17;15(9).
- Ching YK, Chin YS, Appukutty M, Ramanchadran V, Yu CY, Ang GY, et al. Interaction of dietary linoleic acid and α -linolenic acids with rs174547 in fads1 gene on metabolic syndrome components among vegetarians. *Nutrients.* 2019 Jul 1;11(7).
- World Health Organization. Obesity : preventing and managing the global epidemic : report of a WHO consultation. World Health Organization;

2000. 253.
23. Bradshaw PT, Monda KL, Stevens J. Metabolic syndrome in healthy obese, overweight, and normal weight individuals: The atherosclerosis risk in communities study. *Obesity*. 2013 Jan;21(1):203–9.
 24. Mikkola I, Keinänen-Kiukkaanniemi S, Laakso M, Jokelainen J, Härkönen P, Meyer-Rochow VB, et al. Metabolic syndrome in connection with BMI in young Finnish male adults. *Diabetes Res Clin Pract*. 2007 Jun;76(3):404–9.
 25. The Economic Planning Unit TEPU. Tenth Malaysia Plan 2011–2015. 2010. 465.
 26. Craig WJ, Mangels AR. Position of the American dietetic Vegetarian: vegetarian diets. *J Am Diet Assoc*. 2009;109(7):1266–82.
 27. World Health Organization WHO. Tobacco questions for surveys. A subset of key questions from the Global Adult Tobacco Survey (GATS). 2nd ed. Atlanta, GA; 2011. 42.
 28. 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. 1–50.
 29. Armstrong T, Bull F. Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). *J Public Health (Bangkok)*. 2006;14(2):66–70.
 30. Soo KL, Wan Abdul Manan WM, Wan Suriati WN. The Bahasa Melayu version of the Global Physical Activity Questionnaire: reliability and validity study in Malaysia. *Asia-Pacific J Public Heal*. 2015;27(2):NP184–93.
 31. World Health Organization WHO. Summary: surveillance of risk factors for noncommunicable diseases: the WHO STEPwise approach (No. WHO/NMH/CCS/01.01). 2001.
 32. George D, Mallerym P. SPSS for Windows step by step: a simple guide and reference, 17.0 update. 10th ed. Boston : Allyn & Bacon; 2010.
 33. Win AM, Yen LW, Tan KH, Lim RBT, Chia KS, Mueller-Riemenschneider F. Patterns of physical activity and sedentary behavior in a representative sample of a multi-ethnic South-East Asian population: A cross-sectional study. *BMC Public Health*. 2015 Apr 1;15(1).
 34. Nebl J, Haufe S, Eigendorf J, Wasserfurth P, Tegtbur U, Hahn A. Exercise capacity of vegan, lacto-ovo-vegetarian and omnivorous recreational runners. *J Int Soc Sports Nutr*. 2019;16(1):23.
 35. Craddock JC, Probst YC, Peoples GE. Vegetarian and omnivorous nutrition-comparing physical performance. *Int J Sport Nutr Exerc Metab*. 2016;26(3):212–20.
 36. Lian TC, Bonn G, Han YS, Choo YC, Piau WC. Physical activity and its correlates among adults in Malaysia: A cross-sectional descriptive study. *PLoS One*. 2016 Jun 1;11(6).
 37. Crombie IK, Irvine L, Williams B, McGinnis AR, Slane PW, Alder EM, et al. Why older people do not participate in leisure time physical activity: A survey of activity levels, beliefs and deterrents. *Age Ageing*. 2004 May;33(3):287–92.
 38. Chmelo E, Nicklas B, Davis C, Miller GD, Legault C, Messier S. Physical activity and physical function in older adults with knee osteoarthritis. *J Phys Act Heal*. 2013;10(6):777–83.
 39. Davis MG, Fox KR, Hillsdon M, Coulson JC, Sharp DJ, Stathi A, et al. Getting out and about in older adults: The nature of daily trips and their association with objectively assessed physical activity. *Int J Behav Nutr Phys Act*. 2011 Oct 21;8.
 40. Cheah YK, Poh BK. The Determinants of Participation in Physical Activity in Malaysia. *Osong Public Heal Res Perspect*. 2014 Feb;5(1):20–7.