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ORIGINAL ARTICLE

Socio-demographic Characteristics and Nutritional Status of Adults at Risk of Type 2 Diabetes Mellitus in Kuala Nerus, Terengganu

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ABSTRACT

Introduction: In Malaysia, the undiagnosed diabetes prevalence has increased. Socio-demographic characteristics and nutritional status play a crucial role in prediabetes development. Hence, this cross-sectional study aimed to identify the socio-demographic characteristics and nutritional status of adults at risk of T2DM in Kuala Nerus, Terengganu. **Methods:** A total of 30 participants at risk of T2DM aged 18 to 59 years old were recruited from Kuala Nerus using a convenience sampling method. Information on socio-demographic, anthropometric, fasting plasma glucose (FPG) level, clinical profile, Finnish Type 2 Diabetes Risk Assessment Tool (FINDRISC) score, dietary intake, and physical activity level were obtained. **Results:** The participants (mean age: 36.1 ± 8.7 years) were mostly female (76.7%), Malay (96.7%), married (43.3%), had a tertiary degree (60.0%), and were working (83.3%) with a monthly salary of less than RM 1000. Half of the participants were from the obese class I category. Their FPG level was 5.6 ± 0.5 mmol/L and half of them were classified as having optimal blood pressure. Also, they had a mean FINDRISC score of 6.3 ± 1.8. The participants consumed 2073 ± 247 kcal/day, which was comprised of 50.8% carbohydrate, 16.1% protein, and 33.1% fat. Most of them (63.3%) were minimally active. **Conclusion:** The participants had moderate T2DM risk with normal FPG level, blood pressure, and heart rate. They had excessive energy and fat intake with insufficient dietary fibre intake. It is vital to examine the socio-demographic characteristics and nutritional status, which can provide important information for planning future cost-effective T2DM preventive strategies.
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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a complicated chronic metabolic disease distinguished by impaired regulation of macronutrient metabolism such as carbohydrate, protein and fat which was caused by insulin resistance or insulin liberation dysfunction (1). According to the World Health Organization (WHO), there were 108 million diabetes diagnoses among adults in 1980, which had elevated to 422 million in 2014 (2). Besides, there were 463 million individuals suffering from diabetes in 2019 and the figure is predicted to increase to over 783 million by 2045 all over the world (3,4). In Malaysia, one in every five persons or around 3.9 million people aged beyond 18 years old, live with diabetes. The diabetes prevalence had risen from 11.2% in 2011 to 18.3% in 2019 (5). Shockingly, 541 million people around the world have impaired glucose tolerance (4). Prediabetes has been linked with an elevated risk of composite cardiovascular disease, coronary heart disease, stroke and all-cause fatality (6) as well as an increased risk of T2DM than normal glycaemia (4,7). Both diabetes and prediabetes are serious public health problems globally (8) as a result of its rising morbidity and mortality (9). Since a higher rate of T2DM development from prediabetes diagnosis, it is vital to target disease detection, risk and strategies to improve illness prevention and severity (10).

Age, race, family history, poor socioeconomic status (SES), obesity, metabolic syndrome, and a number of unhealthy lifestyle habits are among the risk variables implied in T2DM pathogenesis (11–14). Evidence also demonstrated that both diet and physical activity are critical determinants in glycaemic control (15). The precise relationship between these T2DM risk variables is a complicated pathophysiological process involving deep underlying gene-environment associations that seem to change among societies (11,13,14). Therefore, research interests have centred on determining the pathogenetic significance of different T2DM risk factors and recognizing populations at risk of T2DM that may subsequently be addressed in clinical practice, preventative approaches, and public health programmes (11,13,14,16). However, there was scarce information on the socio-demographic profile and nutritional status of adults at risk of T2DM, particularly in Terengganu. Hence, this study was necessary in order to fill the gaps addressed. It is hoped that this study can provide novelty by targeting adults at risk of T2DM. Therefore, this study aimed to identify the socio-demographic characteristics and nutritional status of adults at risk of T2DM in Kuala Nerus, Terengganu.

MATERIALS AND METHODS

Study settings

A cross-sectional study with convenience sampling method was conducted from August to November 2021 among 30 adults at risk of T2DM recruited from Kuala Nerus, Terengganu. Ethical approval was granted from Human Research Ethics Committee. All participants gave their informed consent before the study commencement. The sample size for this study is based on a power calculation for maximum concentration (CMax) of blood glucose. A sample size of 23 participants was determined to detect approximately a 0.62 mmol/L difference in CMax (17) with 80% power and at a 5% significance level. A total of 30 participants were recruited to allow for a 20% dropout. The sample size was calculated according to the intervention outcome as the present study findings were part of the intervention study, which is not included here (18).

Selection criteria

Malaysian adults were considered eligible if they were at risk of T2DM according to the modified Finnish Type 2 Diabetes Risk Assessment Tool (FINDRISC), with score ≥ 4 and capillary fasting plasma glucose (FPG) < 7.0 mmol/L. Conversely, the participants who: i) were diagnosed with diabetes, ii) had difficulties in providing correct data due to substantial cognitive or sensory disabilities, and iii) had severe comorbidities that potentially bias the study's findings were excluded.

Participants' recruitment

The participants were approached using a flyer distributed through email, social media platforms including Facebook and WhatsApp, and a direct approach. A two-stage screening procedure was used to determine respondent eligibility. In the first stage, the participants at risk of T2DM were examined using a modified FINDRISC (19) and a collection of preliminary inquiries (inclusion and exclusion requirement) which were circulated through Google Form. The risk score is based on a set of variables not requiring laboratory examinations that are used as an instrument to forecast risks of T2DM or determine undiagnosed T2DM. Those who acquired ≥ 4 and fulfilled the inclusion requirement were invited to the second stage screening examination which consisted of a finger pricking capillary FPG measurement. They were required to fast for 10 hr to 12 hr preceding their testing time and hence they were instructed to eat their dinner no later than 10 pm. Participants having FPG < 7.0 mmol/L were asked to participate at this point.

Data collection

The participants attended the Food Preparation and Therapeutic Diet Lab at 8 am with light clothing. The questionnaire was then distributed to them to be completed on the same day, which comprised both open-ended and closed-ended questions. The questionnaire consisted of five main parts namely Part A (socio-demographic data), Part B (anthropometric measurement) Part C (blood pressure measurement), Part D (Food Frequency Questionnaire (FFQ)) and Part E (International Physical Activity Questionnaire-Short Form (IPAQ-SF)).

The anthropometric measurements included height, weight, body mass index (BMI), waist circumference (WC), % body fat and visceral fat. A portable Tanita BC541 Body Composition Monitor (Tanita, Japan) was used to measure the body weight twice and recorded to the nearest 0.1 kg. The same equipment was used throughout the data collection to ensure consistency. The equipment was placed on a flat and hard surface that ensure stabilization without rocking or tipping. The participants were instructed to remove their footwear and socks, empty their pockets before stepping onto the scale. The participants should stand still, face forward in the Frankfurt horizontal plane, put their arm on the side and wait until asked to step off. Reading for % body fat and visceral fat were recorded in the Tanita BC541 Body Composition Monitor (Tanita, Japan). The cut-off point of % body fat > 31% for women and > 25% for men were considered as at risk (20).

A portable Stadiometer Seca 217 (Seca, Germany) was used to measure their height twice and recorded to the nearest 0.1 cm. The same stadiometer was used throughout the data collection to ensure consistency. The participants were asked to remove their footwear and head-gear before measuring. They should stand erected facing the researchers, with heels, buttocks, head and shoulder blades in vertical line against the stadiometer with their head in the Frankfurt horizontal plane. The measuring arm was then gently lowered onto their head with sufficient pressure applied to the hair. The researcher read the height with her eye parallel to the read-off point and recorded it. BMI status was then determined using the following method: weight (kg)/height2 (m2) It was categorised according to the International Obesity Task Force cut-off values for Asian adults (21).

WC was measured using SECA measuring tape to the nearest 0.1 cm. Before starting the measurement, the participants were asked to stand erectly and to breathe normally. The highest point of the hip bone and the bottom of the ribs was located using fingertips. The measuring tape was placed between the two points and was snug against the waist. WC was recorded at the end of the normal expiration. The measurements were repeated twice and the average value was calculated and recorded to the nearest 0.1 cm. The cut-off value of WC (as a marker of abdominal adiposity) is ≥ 90 cm for men and ≥ 80 cm for women (22,23).

Next, blood pressure was measured twice using an Omron automatic digital blood pressure monitor (Omron HEM-7221) in a seated position at all visits after 5 min of sitting. The arm was in a relaxed position with the antecubital fossa facing the researcher and the participant's arm resting on a table. It was categorised according to the CPG Management of Hypertension (2018).

The participants were instructed to complete a semi-quantitative FFQ which was derived from the Malaysian Adult Nutrition Survey (MANS) (25). The FFQ consists of 165 items categorised under 14 groups which are cereals and cereal products, fast food, meat and meat products, fish and seafood, eggs, legumes and legume products, milk and milk products, fruits, vegetables, beverages, alcoholic beverages, confectioneries, bread spreads and flavorings. The frequency of intake is categorised into four options namely daily, weekly, monthly and no intake. These choices will indicate the frequency of intake as number of times per day, number of times per week, number of times per month or not consumed by the participants. Serving size (in local household units) usually consumed at each occurrence was also recorded. The example of household measurements such as bowls, spoons and cups were also displayed to assist the participants on the correct portion size of food consumed. The quantity of food consumption was determined using the following equation (26).

Amount of food (g) per day = frequency of intake (conversion factor) x total number of servings x weight of food in one serving

Under and over-reporting of dietary intakes were identified by dividing the recorded total caloric intake by the basal metabolic rate (EI:BMR), according to the Goldberg cut-off points of 1.2 to 1.8 (27). The participants' BMR was estimated using a BMR prediction formula designed for Malaysian adults (28).

The physical activity of the participants was measured using the short version of IPAQ-SF in the Malay language that had been pilot tested and pre-verified in the National Health and Morbidity Survey (NHMS) 2011 (29). The IPAQ-SF consisted of seven questions that would recall the participants' physical activity for the past seven days. The physical activity score was expressed as MET (metabolic equivalents) min per week. MET min indicates the amount of energy expended in carrying out the physical activity. The MET value given (walking = 3.3, moderate activity = 4, vigorous activity = 8) was multiplied with the duration of the activity (min) and again by the frequency of activity was undertaken (days) to obtain the total physical activity scores. The physical activity level can be categorised into three levels: health-enhancing physical activity (HEPA) active, minimally active and inactive. The HEPA active involved engagement in the vigorous intensity exercise on at least three days with a minimum total weekly physical activity of at least 1500 MET min. Alternatively, seven days or more of any combination of walking, moderate intensity or vigorous intensity exercises, totalling at least 3000 MET min/week. For the minimally active category, the participants participated in three days or more of vigorous intensity exercise lasting at least 20 min/day. Also, five days or more of moderate intensity exercise and/or walking of at least 30 min/day, five days or more of any combination of walking, moderate intensity or vigorous intensity exercises totalling at least 600 MET min/week. Lastly, for the inactive category, the participants were not meeting any of the requirement for either minimally active or HEPA active category (5).

Statistical analysis

The IBM SPSS system version 21.0 and Nutritionist ProTM software (Version 7.0.0, Axxya Systems) were used to analyse the data. Data were checked after they were entered into the SPSS. Before the descriptive statistical analysis was performed, the Shapiro-Wilk test was used to assess normality, with $p > 0.05$ indicating that the data was normal.

A descriptive statistic was used to present all outcomes on socio-demographic information, anthropometric measurement, fasting plasma glucose levels, blood pressure measurement, dietary intake, and physical activity. The continuous data were described as mean ± standard deviation if normally distributed or median (interquartile range) if not normally distributed whereas for categorical variables, the data were reported as the number of frequency and percentage.

RESULTS

Participants' characteristics

The characteristics of the enrolled participants are depicted in Table I. On average, the participants aged 36.1 ± 8.7 years. They were mostly female (76.7%), Malay (96.7%), married (43.3%) and had a tertiary degree (60.0%). More than half of the participants were working (83.3%) and earned less than RM 1000/month.

Table I: Socio-demographic and biochemical information of respondents (n = 30)

Parameters	Mean ± SD	n (%)
Age (years)	36.1 ± 8.7	
Gender		
Male		7 (23.3)
Female		23 (76.7)
Ethnicity		
Malay		29 (96.7)
Non-Malay		1 (3.3)
Marital Status		
Single		9 (30.0)
Married		13 (43.3)
Widowed/Divorced		8 (26.7)
Educational level		
No formal education		0 (0.0)
Primary level		1 (3.3)
Secondary level		11 (36.7)
Tertiary level		18 (60.0)
Employment status		
Employed		25 (83.3)
Unemployed		5 (16.7)
Monthly household income (RM)		
≤ RM1000		15 (50.0)
RM1000-RM2300		11 (36.7)
RM2301-RM5599		3 (10.0)
≥RM5600		1 (3.3)
Capillary FPG (mmol/L)	5.6 ± 0.5	
FINDRISC score	6.3 ± 1.8	
Moderate risk (4-6 points)		17 (56.7)
High risk (≥ 7 points)		13 (43.3)

FPG: Fasting Plasma Glucose; FINDRISC: Finnish Type 2 Diabetes Risk Assessment Tool

The average capillary FPG was 5.6 ± 0.5 mmol/L, suggesting that these participants had normal glucose homeostasis. With a mean FINDRISC score of 6.3 ± 1.8, they were at risk of T2DM in which males had 6.9 ± 1.9 score and females had 6.1 ± 1.7 score. In short, 56.7% of participants had a moderate risk of developing T2DM, whereas 43.3% had a high risk of developing T2DM.

Anthropometric and clinical profile information

Table II shows the anthropometric and clinical profile information of the participants. Their height, body weight, % body fat, and visceral fat were 158.6 ± 6.4 cm, 75.1 ± 15.0 kg, 39.0 ± 8.3%, and 10.3 ± 3.7 respectively. They were mostly in the pre-obese category or above, with an average BMI of 29.8 ± 5.1 kg/m2, falling into the obese class I range (27.5-34.9 kg/m2). Next, they had an average WC of 91.0 ± 11.3 cm, normal blood pressure, and heart rate.

Table II: Anthropometric and clinical profile information of respondents (n = 30)

Parameters	Mean ± SD	n (%)
Height (cm)	158.6 ± 6.4	
Weight (kg)	75.1 ± 15.0	
% Body Fat (%)	39.0 ± 8.3	
Acceptable: 18-25% (men), 25-31% (women)		1 (3.3)
At risk: >25% (men), >31% (women)		29 (96.7)
Body Mass Index (kg/m^2)	29.8 ± 5.1	
Body Mass Index classes		
Normal (18.5-22.9)		2 (6.7)
Pre-obese (23.0-27.4)		9 (30.0)
Obese class I (27.5-34.9)		15 (50.0)
Obese class II (35.0-39.9)		3 (10.0)
Obese class III (≥ 40.0)		1 (3.3)
Waist Circumference (cm)	91.0 ± 11.3	
Category 0: <90 (men), <80 (women)		5 (16.7)
Category 1: 90–99 cm (men), 80–89 cm (women)		14 (46.7)
Category 2: 100 cm (men), ≥90 cm (women)		11 (36.7)
Visceral Fat	10.3 ± 3.7	
Systolic Blood Pressure (mmHg)	122 ± 15	
Diastolic Blood Pressure (mmHg)	75 ± 9	
Classification		
Optimal (<120/80)		15 (50.0)
Normal (120-129/80-84)		5 (16.7)
At risk (130-139/85-89)		3 (16.7)
Hypertension Stage 1 (140-159/90-99)		7 (23.3)
Heart Rate (bpm)	74 ± 9	

Dietary intake and physical activity

In this study, the participants did not underreport or overreport their food consumption because the EI: BMR proportion ranging from 1.20 to 1.43 which is within the normal range. Generally, mean intakes were 2073 ± 247 kcal, 263.5 ± 35.4 g of carbohydrate, 83.5 ± 12.4 g of protein, 76.0 ± 8.7 g of fat and 6.6 ± 1.6 g of dietary fibre (Table III).

Certain dietary intake did not meet the recommendation: above recommended intake for energy, fat, vitamin C and selenium whereas below recommended intake for dietary fibre, vitamin A, E, K, calcium and magnesium.

The physical activity level of the participants were depicted in Table IV. More than half of the participants (63.3%) were considered as minimally active, followed by 20.0% physically inactive and only 16.7% reporting HEPA active.

DISCUSSION

This study describes the socio-demographic characteristics and nutritional status of adults at risk of T2DM. Commonly, individuals with increased age will have an increased risk of T2DM in which T2DM is more likely to develop in the age between 40 to 60 years old and more than 60 years old in developing and developed countries respectively (30). Aging is closely associated with lipid metabolism disorder which will result in body

Table III: Comparison of total daily calories, macronutrients and micronutrients intake with RNI (n = 30)

Dietary Variables	Mean ± SD	RNI	% RNI	Indications
Energy (kcal)	2073 ± 247	1610 - 1960	105.8	Slightly above the recommendation
Energy Intake: Basal Metabolic Rate ratio	1.42 ± 0.17			
Macronutrients				
Carbohydrate intake				
Total (g)	263.5 ± 35.4	50-65%	78.2	Within the recommendation
% from energy intake	50.8			
Protein intake				
Total (g)	83.5 ± 12.4	10-20%	80.5	Within the recommendation
% from energy intake	16.1			
Fat intake				
Total (g)	76.0 ± 8.7	25-30%	110.3	Slightly above the recommendation
% from energy intake	33.1			
Micronutrients				
Dietary fibre (g)	6.6 ± 1.6	20-30	33.0	Below the recommendation
Vitamin A (µg)	28.1 ± 22.7	600	4.7	Below the recommendation
Vitamin E (mg)	5.3 ± 1.3	7.5-10	70.7	Below the recommendation
Vitamin K (µg)	8.2 ± 5.7	55-65	14.9	Below the recommendation
Vitamin C (mg)	86.2 ± 52.2	70	123.1	Slightly above the recommendation
Calcium (mg)	629.9 ± 229.3	1000-1200	63.0	Below the recommendation
Magnesium (mg)	130.2 ± 34.8	320-420	40.7	Below the recommendation
Iron (mg)	20.4 ± 4.1	11-29	70.3	Within the recommendation
Zinc (mg)	5.6 ± 1.9	4.6-6.5	86.2	Within the recommendation
Selenium (mg)	44.9 ± 20.8	24-32	140.3	Slightly above the recommendation

RNI: Recommended Nutrient Intake

Table IV: Physical activity level of respondents (n = 30)

Parameters	Median (interquartile range)	n (%)
Physical activity score (MET min per week)		
Total	1668.0 (1822)	
Walking (3.3 MET)	643.5 (952.9)	
Moderate intensity (4.0 MET)	540.0 (1275.0)	
Vigorous intensity (8.0 MET)	0 (960.0)	
Physical activity category		
HEPA active		5 (16.7)
Minimally active		19 (63.3)
Inactive		6 (20.0)

MET: metabolic equivalents, HEPA: health-enhancing physical activity

fat accumulation and free fatty acids concentration in the blood raised with subsequent insulin resistance (31). In contrast, another study demonstrated that young individuals are becoming more likely to have diabetes, particularly in Asian nations where T2DM manifests at an earlier age than in Caucasian populations attributed to the main risk factors such as obesity, family history and sedentary lifestyle (32,33). Hence, the current study focus on adults with mean age of 36.1 ± 8.7 years old instead of ageing populations.

Next, a higher FINDRISC score was observed in men compared with his counterpart, which is in line with a study which claimed that males tend to develop T2DM as compared to females (33). Several components of glucose metabolism and energy balance are controlled differently in males and females, which affect their risk of developing T2DM. Also, females are more sensitive to insulin and have greater capacity for insulin secretion and incretin responses than males (34). Besides, Chow et al. (2012) reported that ethnicities such as Indians, Asians, Africans, Latinos, Hispanics and Native Americans have an elevated risk for T2DM development. This finding is in accord with a study by the NHMS in Malaysia which stated that Indians had the highest prevalence followed by Malays and Chinese (5). However, the present study recruited mostly Malays (96.7%), which made the comparisons among ethnicities less suitable.

Surprisingly, despite of the greater proportion of participants with tertiary education, the monthly income was below RM1000. This could be attributed to the background of the participants, which was derived from the students. Low SES, which is primarily determined by salary, employment, and educational level, is an independent risk factor for T2DM (14,36). The specific processes connecting poor SES to elevated T2DM risk are currently being researched, with 33 to 50% of the connection attributed to the important modifiable T2DM risk factors (such as obesity, nutrition, physical activity, and alcohol use) (36). The rest can be ascribed to a variety of additional variables such as psychosocial problem, despair, poverty, limited autonomy, and inadequate exposure to nutritious food, sport equipment, and health services (37).

In this study, the normal FPG value of the participants is comparable with the previous studies performed (10,38) which reported FPG of 5.5 mmol/L, and 5.1 mmol/L respectively. Moreover, the body weight and BMI values were comparable with the data obtained from previous studies: 77.4 ± 7.26 kg and 27.7 ± 1.79 kg/m2 (39); 71.3 ± 12.0 kg and 24.7 ± 3.3 kg/m2 (17) as well as 84.9 kg and 27.7 ± 0.3 kg/m2 (38). A similar BMI of 29.5 ± 3.4 kg/m2 was also reported (10). Excessive fat indicated by a high BMI is the single most powerful risk factor for T2DM and is related to various metabolic disorders that lead to insulin resistance. This could be attributed to the inflammation that occurred which disrupted the function of beta-cells with subsequently reduced insulin sensitivity (40),. Besides, the current study found that WC, % body fat, and visceral fat were positively correlated with T2DM risk score. It is evidenced that abdominal obesity indicated by WC or waist-hip ratio as well as visceral adiposity predicted T2DM risk independent of BMI (11).

The findings on the clinical profile matched those observed in a study that reported systolic blood pressure of 123.9 ± 2.3 mmHg, diastolic blood pressure of 76.0 ± 1.3 mmHg and heart rate of 71.1 ± 2.3 bpm (38). Another study also reported an indistinguishable heart rate of 74.5 ± 5.6 bpm (10). Study reported that elevated T2DM risk was observed in higher systolic blood pressure (41). This could be attributed to the reduced glucose uptake by the human body due to increased sympathetic nervous system activity which resulted in insulin resistance (40). Apart from that, the NHMS (2019) stated that 25.1% of Malaysian adults were physically inactive which was slightly higher than the current study finding. On the contrary, a higher percentage (80.0%) of the study participants were physically active than 74.9% as reported by NHMS (2019) (5). Physical inactivity lowers insulin sensitivity with gradual loss of beta-cells. As a result, this caused impaired glucose tolerance and T2DM development (40).

The mean energy intake of this study was in accord with MANS 2003 (2097 kcal) and MANS 2014 (2123 kcal) after excluding under-reporters (42). However, the macronutrients distribution particularly carbohydrate and fat was slightly different to those reported in MANS 2014 with 55% carbohydrate, 16% protein and 29% fat (25). The current study reported a slightly lower carbohydrate (50.1%) and greater fat (33.1%) distribution than MANS 2014 . A more recent survey demonstrated that carbohydrate, protein and fat accounted for 54%, 14% and 32% of total daily energy intake, respectively (43). Both national and personal surveys included in a review and meta-analysis demonstrated that Malaysian adults typically ingested sufficient or greater protein (80% of RNI) and fat (≥ 30% of total caloric intake) throughout various participants' categories, regardless of the dietary assessment tools used (44).

The higher fat intake in the diets seems to have replaced the participants' carbohydrate intake as supported by another study (45). With a booming economy and an upper-middle income, Malaysia is a country currently going through the 'substitution phase' of the nutrition transition (46,47). This phase is characterised by a change in the types of food ingested without a significant change in the total amount of energy supplied (48). Typically, the changes in food groups are characterised by an increase in the intake of refined carbohydrates, added sweeteners, edible oils, and foods derived from animals, along with a decrease in the consumption of legumes, other vegetables, and fruits (49). Malaysians prefer chicken which contain more than twice as much fat as it did in 1940, a third more calories, and a third less protein. They also give more energy from fat than from protein. The way that meat is prepared (deep frying) also significantly affects how nutritious it is (47).

Last but not least, the dietary fibre intake of the current study was two times greater than that of another study, which reported 3.0 ± 2.6 g/day (45) but still below the recommendation. The result is not surprising because the most recent NHMS 2019 stated that 94.9% of the Malaysians did not consume sufficient fruits and/or vegetables as recommended by the WHO or Malaysian Dietary Guidelines (5) which contributed to the low dietary fibre intake. It is evidenced that a low total dietary fibre consumption was related with elevated T2DM risk (50).

The present study has several significances. Firstly, it adds to the body of literature by documenting the preliminary findings on the nutritional profiles involving community-living adults at risk of T2DM in Kuala Nerus, Terengganu. Next, a validated T2DM screening tool among Malaysians was used, which provided accuracy in participants' recruitment. However, several limitations of this study are acknowledged. Its cross-sectional design precluded drawing a direct connection between socio-demographic characteristics and T2DM risk as well as between nutritional status and T2DM risk. The sample was only drawn from adults at risk of T2DM in Kuala Nerus, Terengganu with predominantly homogeneous Malays population. This does not reflect the ethnic diversity of Malaysian. Therefore, the findings could not be generalized to other Malaysian population of adults at risk of T2DM from other races such as Chinese and Indians in which their dietary intake are likely to be different.

CONCLUSION

The participants had moderate T2DM risk with normal FPG level, blood pressure, and heart rate. They had excessive energy and fat intake with insufficient dietary fibre intake. It is vital to examine the socio-demographic characteristics and nutritional status, which can provide important information for planning future cost-effective T2DM preventive strategies. This is because a strategic method of primary prevention for T2DM is by managing risk factors through lifestyle modification. As a result, it can improve quality of life and minimise stress

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REFERENCES

1. DeFronzo RA, Ferrannini E, Groop L, Henry RR, Herman WH, Holst JJ, et al. Type 2 diabetes mellitus. Nat Rev Dis Prim. 2015;1. doi: 10.1007/978-3-319-45015-5_5.
2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. Lancet.

2016;387(10027):1513–30. doi: 10.1016/S0140-6736(16)00618-8.
3. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019;157:107843. doi: 10.1016/j.diabres.2019.107843.
4. International Diabetes Federation. IDF Diabetes Atlas, 10th edn. [Internet]; 2021 [cited 2021 Dec 17]. Available from: https://diabetesatlas.org/atlas/tenth-edition/
5. National Institute of Health Malaysia. Non-communicable diseases: Risk factors and other health problems (NHMS 2019) Vol. 1 [Internet]; 2019 [cited 2021 Dec 17]. Available from: http://www.iku.gov.my/nhms-2019
6. Huang Y, Cai X, Mai W, Li M, Hu Y. Association between prediabetes and risk of cardiovascular disease and all cause mortality: Systematic review and meta-analysis. BMJ. 2016;355. doi: 10.1136/bmj.i5953.
7. Gerstein HC, Santaguida P, Raina P, Morrison KM, Balion C, Hunt D, et al. Annual incidence and relative risk of diabetes in people with various categories of dysglycemia: A systematic overview and meta-analysis of prospective studies. Diabetes Res Clin Pract. 2007;78(3):305–12. doi: 10.1016/j.diabres.2007.05.004.
8. Kassaian N, Feizi A, Aminorroaya A, Ebrahimi MT, Norouzi A, Amini M. Effects of probiotics and synbiotic on lipid profiles in adults at risk of type 2 diabetes: A double-blind randomized controlled clinical trial. Funct Foods Heal Dis. 2019;9(7):494–507. doi: 10.31989/ffhd.v9i7.617.
9. Mao T, Huang F, Zhu X, Wei D, Chen L. Effects of dietary fiber on glycemic control and insulin sensitivity in patients with type 2 diabetes: A systematic review and meta-analysis. J Funct Foods. 2021;82:104500. doi: 10.31989/ffhd.v9i7.617.
10. Kay B. The acute effect of soluble dietary fibre-enriched pudding products on glycemic and insulinemic response in adults at risk for type 2 diabetes [Internet]. The University of Guelph; 2016. Available from: https://atrium2.lib.uoguelph.ca/xmlui/handle/10214/9479
11. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nat Rev Endocrinol. 2018;14(2):88–98. doi: 10.1038/nrendo.2017.151.
12. American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of medical care in diabetes. Diabetes Care. 2019;42(Supplement_1):S13–28. doi: 10.2337/dc19-S002.
13. Khetan AK, Rajagopalan S. Prediabetes. Can J Cardiol. 2018;34(5):615–23. doi: 10.1016/j.cjca.2017.12.030.
14. Weisman A, Fazli GS, Johns A, Booth GL. Evolving trends in the epidemiology, risk factors, and prevention of type 2 diabetes: A review. Can J Cardiol. 2018;34(5):552–64. doi: 10.1016/j.cjca.2018.03.002.
15. Camacho-arriola M. Postprandial glycemic response of whole peas and lentils and their flours in adults with type 2 diabetes. [Internet]. Iowa State University; 2020 [cited 2021 Dec 17]. Available from: https://dr.lib.iastate.edu/entities/publication/c300a19a-e2d2-449b-a29f-3130022e5bc2
16. Manios Y, Androutsos O, Lambrinou CP, Cardon G, Lindstrom J, Annemans L, et al. A school- and community-based intervention to promote healthy lifestyle and prevent type 2 diabetes in vulnerable families across Europe: Design and implementation of the Feel4Diabetes-study. Public Health Nutr; 2018; 21:3281–90. doi: 10.1017/S1368980018002136.
17. Stewart ML, Zimmer JP. A high fiber cookie made with resistant starch type 4 reduces post-prandial glucose and insulin responses in healthy adults. Nutrients. 2017;9(3). doi: 10.3390/nu9030237.
18. Ong YQ, Harith S, Shahril MR, Shahidan N, Hapidin H. Acute effect of Melon Manis Terengganu peel powder on glycemic response, perceived satiety, and food intake: a randomized, placebo - controlled crossover trial in adults at risk of type 2 diabetes. BMC Nutr. 2022;8:75. doi:10.1186/s40795-022-00572-1. Preprint at https://www.researchsquare.com/article/rs-1494015/v2 (2022).
19. Oo AM, Al-Abed A abed AA, Lwin OM, Kanneppady SS, Sim TY, Mukti NA, et al. Type 2 diabetes mellitus prediction in Malaysia using modified diabetes risk assessment tool. Malaysian J Public Heal Med. 2020;20(1):15–21. doi: 10.37268/mjphm/vol.20/no.1/art.442
20. Muth ND. What are the guidelines for percentage of body fat loss? [Internet]. The American Council on Exercise (ACE). 2009 [cited 2021 Jun 25]. Available from: https://www.acefitness.org/education-and-resources/lifestyle/blog/112/what-are-the-guidelines-for-percentage-of-body-fat-loss/
21. CPG on Management of Obesity. In Ministry of Health Malaysia; 2004.
22. World Health Organization (WHO). The Asia Pacific perspective: Redefining obesity and its treatment. [Internet]. Sydney: Health Communications Australia; 2000 [cited 2021 Dec 17]. Available from: https://apps.who.int/iris/handle/10665/206936
23. World Health Organization (WHO). Waist circumference and waist–hip ratio: Report of a WHO expert consultation [Internet]. Geneva; 2008 [cited 2021 Jul 6]. Available from: https://www.who.int/publications/i/item/9789241501491
24. CPG Management of Hypertension. In Ministry of Health Malaysia; 2018.
25. Institute for Public Health. National Health and

Morbidity Survey 2014: Malaysian Adult Nutrition Survey (MANS). Volume I: Methodology and general findings. Kuala Lumpur; 2014.
26. Norimah AK, Safiah M, Jamal K, Siti H, Zuhaida H, Rohida S, et al. Food consumption patterns: findings from the Malaysian Adult Nutrition Survey (MANS). Malays J Nutr. 2008;14(1):25–39. https://pubmed.ncbi.nlm.nih.gov/22691762/
27. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, et al. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. Eur J Clin Nutr. 1991;45(12):569–81. https://pubmed.ncbi.nlm.nih.gov/1810719/
28. Ismail MN, Ng KK, Chee SS, Roslee R, Zawiah H. Predictive equations for the estimation of basal metabolic rate in Malaysian adults. Malays J Nutr. 1998;4(1–2):81–90. https://www.researchgate.net/publication/225300932_Predictive_equations_for_the_estimation_of_basal_metabolic_rate_in_Malaysian_adults
29. 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. doi: 10.1016/j.puhe.2013.10.008.
30. Nolan CJ, Damm P, Prentki M. Type 2 diabetes across generations: From pathophysiology to prevention and management. The Lancet. 2011:169–81. doi: 10.1016/S0140-6736(11)60614-4.
31. Suastika K, Dwipayana P, Siswadi M, Tuty RA. Age is an important risk factor for type 2 diabetes mellitus and cardiovascular diseases. In: Glucose Tolerance [Internet]. IntechOpen; 2012 [cited 2021 Aug 1]. Available from: https://www.intechopen.com/chapters/41385
32. Lascar N, Brown J, Pattison H, Barnett AH, Bailey CJ, Bellary S. Type 2 diabetes in adolescents and young adults. Lancet Diabetes Endocrinol. 2018;6(1):69-80. doi: 10.1016/S2213-8587(17)30186-9.
33. Chen L, Magliano DJ, Zimmet PZ. The worldwide epidemiology of type 2 diabetes mellitus - Present and future perspectives. Nat Rev Endocrinol. 2012;8(4):228–36. doi: 10.1038/nrendo.2011.183.
34. Tramunt B, Smati S, Grandgeorge N, Lenfant F, Arnal JF, Montagner A, et al. Sex differences in metabolic regulation and diabetes susceptibility. Diabetologia. 2020;63(3):453-461. doi: 10.1007/s00125-019-05040-3.
35. Chow EA, Foster H, Gonzalez V, McIver LS. The disparate impact of diabetes on racial/ethnic minority populations. Clin Diabetes. 2012;30(3):130–3. doi: 10.2337/diaclin.30.3.130.
36. Bonilla GS, Rodriguez-Gutierrez R, Montori VM. What we don't talk about when we talk about preventing type 2 diabetes - Addressing socioeconomic disadvantage. JAMA Intern Med. 2016;176:1053–4. doi: 10.1001/jamainternmed.2016.2952.
37. Volaco A, Cavalcanti AM, Filho RP, Precoma DB. Socioeconomic status: The missing link between obesity and diabetes mellitus? Curr Diabetes Rev. 2018;14(4):321–6. doi: 10.2174/1573399813666170621123227.
38. Oliver Chen CY, Rasmussen H, Kamil A, Du P, Blumberg JB. Orange pomace improves postprandial glycemic responses: An acute, randomized, placebo-controlled, double-blind, crossover trial in overweight men. Nutrients. 2017;9(2). doi: 10.3390/nu9020130.
39. Bhoite R. Effects of a fiber-rich nutritional supplement on postprandial glycemic response and lipid parameters in overweight adults with and without impaired fasting glucose in India. J Diabetes Metab. 2020;11(2):841. doi: 10.35248/2155-6156.20.11.841.
40. Ismail L, Materwala H, Al Kaabi J. Association of risk factors with type 2 diabetes: A systematic review. Comput Struct Biotechnol J. 2021;19:1759–85. doi: 10.1016/j.csbj.2021.03.003.
41. Emdin CA, Anderson SG, Woodward M, Rahimi K. Usual blood pressure and risk of new-onset diabetes evidence from 4.1 million adults and a meta-analysis of prospective studies. J Am Coll Cardiol. 2015;66(14):1552–62. doi: 10.1016/j.jacc.2015.07.059.
42. Zainuddin AA, Nor NM, Yusof SM, Ibrahim AIN, Aris T, Huat FL. Under-reporting of energy and nutrient intake is a persistent issue in the Malaysian Adult Nutrition Surveys. Malays J Nutr. 2019;25(2):261–71. doi: 10.31246/nutriweb-2018-0022.
43. Karupaiah T, Chuah KA, Chinna K, Pressman P, Clemens RA, Hayes AW, et al. A cross-sectional study on the dietary pattern impact on cardiovascular disease biomarkers in Malaysia. Sci Rep. 2019;9(1). doi: 10.1038/s41598-019-49911-6.
44. Shahar S, Mohamed HJBJ, Reyes F de los, Amarra MS. Adherence of Malaysian adults' energy and macronutrient intakes to national recommendations: A review and meta-analysis. Nutrients. 2018;10(11). doi: 10.3390/nu10111584.
45. Lee YY, Wan Muda WAM. Dietary intakes and obesity of Malaysian adults. Nutr Res Pract. 2019;13(2):159–68. doi: 10.4162/nrp.2019.13.2.159.
46. Lipoeto NI, Geok Lin K, Angeles-Agdeppa I. Food consumption patterns and nutrition transition in South-East Asia. Public Health Nutr. 2013;16(9):1637–43. doi: 10.1017/S1368980012004569.
47. Goh E Von, Azam-Ali S, McCullough F, Roy Mitra S. The nutrition transition in Malaysia; Key drivers and recommendations for improved health outcomes. BMC Nutr. 2020;6(1):1–14. doi:

10.1186/s40795-020-00348-5.
48. Kearney J. Food consumption trends and drivers. Philos Trans R Soc B. 2010;365(1554):2793–2807. doi: 10.1098/rstb.2010.0149.
49. Popkin BM. Nutrition transition and the global diabetes epidemic. Curr Diab Rep. 2015;15(9). doi: 10.1007/s11892-015-0631-4.
50. McRae MP. Dietary fiber intake and type 2 diabetes mellitus: An umbrella review of meta-analyses. J Chiropr Med. 2018;17(1):44–53. doi: 10.1016/j.jcm.2017.11.002.