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Processed meat consumption increases risk of type 2 diabetes mellitus in adults aged 40 years and older

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ABSTRACT

BACKGROUND
Type 2 diabetes mellitus (T2DM) remains a public health problem in the world, including Indonesia. The high mortality of T2DM is triggered by an unhealthy eating pattern and sedentary lifestyle. We aimed to investigate the relationship of food intake pattern and its related factors with T2DM in adults 40 years and older.

METHODS
This was a cross-sectional study conducted on 11,022 men and women with T2DM aged 40 years and older. Major dietary patterns were collected and multiple logistic regression analysis was used to determine the effect of covariates. Statistical significance was set at a p-value of <0.05.

RESULTS
Males and individuals aged >40 years comprised 50.17% and 26.19%, respectively, of the 11,022 respondents. Individuals aged over 50 years had a higher risk of developing diabetes than those aged less than 50 years (AOR =5.67, 95% CI=1.37-21.94, p<0.05). Dietary processed meat was associated with a higher risk of T2DM (AOR = 4.9; 95% CI=1.08-22.20, p<0.05). Carbohydrate and fruit intakes were negatively associated with and protective factors for DM (AOR= 0.01; 95% CI=0.01-0.06, p<0.01; AOR = 0.35; 95% CI=0.15-0.83, p<0.01). However, physical activity was not a risk factor for T2DM.

CONCLUSIONS
Processed meat consumption, age over 50 years, and carbohydrate intake may increase the risk of T2DM in adults. Conversely, fruit intake may decrease the risk of T2DM in adults. There is a need to control the diet and lifestyle for the early prevention of DM.

Keywords: Diabetes mellitus, dietary processed meat, carbohydrate intake, fruit intake, physical activity, adults

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) as a degenerative disease is still a serious public health problem in the world. Globally, DM ranks seventh as the leading cause of death. [1] Data from the International Diabetes Federation (IDF) in 2021 showed that in South East Asia the number of adults with diabetes is predicted to rise to 152 million by 2045, an increase of 68%.[2] Indonesia, as one of the low-middle income countries, ranks seventh among countries with the highest prevalence of DM in the world (3.4%) after China (37.4%), India (24.8%), the United States (9.8%), Pakistan (6.2%), Brazil (5.4%), and Mexico (4.1%).[3] Furthermore, this fact is made obvious with the increase in DM prevalence in Indonesia from 6.9% in 2013 to 8.5% in 2018 based on data from the Indonesian Basic Health Research (IBHR).[4]

The increased incidence of DM is triggered by changes in lifestyle that include the lack of awareness of healthy eating patterns,[5,6] increased number of obesity cases,[7] lack of physical activity [8] and prevalence of habitual smoking.[9,10] Also, the high prevalence of T2DM in Indonesia is due to the fact that nearly all patients with this disease had difficulties in accessing adequate health care services. In addition, the limited ability of health professionals in DM management that encompasses promotive, preventive, curative, and rehabilitative efforts and the unavailability of drugs may raise the incidence rate of T2DM.[11]

The high prevalence of DM is also triggered by the food consumption pattern that is high in carbohydrate and saturated fat,[12-15] but low in vitamins and fiber.[16,17] Previous studies states that food intake is associated with increased blood sugar level after consuming high-glycemic-index carbohydrates (glucose and sucrose).[18,19] A systematic review of previous studies reported that various fast foods, foods that are high in carbohydrate and calories, or in processed meats, sweetened beverages, and saturated fats, contribute to raising the prevalence of type 2 diabetes.[12] Patients with DM are advised not to consume carbohydrates in amounts of more than 45%-65% of the daily total energy need.[20,21] In addition, the amount of protein recommended for these patients is 10-15% of the total daily calorie need. For saturated fatty food, the recommendation is that it should not exceed 10-20 % of the total daily calorie need.[22] If the diet continuously exceeds the recommended amount, the blood glucose level will be beyond control, and the person in question will experience type 2 DM.

Lack of physical activity also contributes significantly to the high number of type 2 DM cases.[23,24] In contrast, a randomized controlled trial to compare the effects of 3 different modalities of exercise on metabolic control and insulin resistance among patients with type 2 diabetes mellitus, showed that after 12 weeks of training there was no difference across the groups in blood pressure, fasting plasma glucose, postprandial plasma glucose, lipid profile, and high-sensitivity C-reactive protein (hs-CRP).[25] In addition, the precise mechanism of how physical activity acts to reduce the risk of type 2 diabetes mellitus, such as through altered insulin sensitivity or altered insulin production, is still unknown.[26] If the amount of energy consumed exceeds the amount of energy expended, this gives rise to a positive balance of power in adipose tissue [27] which then triggers insulin resistance that will lead to type 2 DM.[28,29] Previous studies have reported that unhealthy eating patterns and low physical activity have been recognized as the risk factors for the high incidence of DM; [30] therefore, it is necessary to encourage and promote the shift to a healthy lifestyle in the community. A study in Saudi Arabia showed that most of the respondents aged at least 40 years old had diabetes mellitus (44.6%).[31] A systematic review and meta-analysis showed that after adjusting for the potential factor of gender, total carbohydrate was no longer significantly associated with type 2 diabetes risk (RR=1.11, 95% CI: 0.97 to 1.26, p=0.12). Fructose, glucose, lactose, maltose, and sucrose were not significantly associated with type 2 diabetes risk.[32] In their systematic review, Hemmingsen

et al.[33] concluded that there was no effect of diet or physical activity alone on the risk of type 2 DM in people at high risk of developing T2DM. In Indonesia as one of the Asian countries that have a high rate of urbanization and modernization triggered by rapid development, the changes into an unhealthy lifestyle marked by the consumption of unhealthy food and adoption of the sedentary lifestyle [34, 35] may impact on non-communicable diseases such as T2DM. The results of previous studies show that the relationship between carbohydrate diet and physical activity with T2DM is inconsistent and that further studies are needed to confirm this relationship. The aim of the present study was to determine the relationship of food intake pattern and its related factors with T2DM in adults aged 40 years and older.

METHODS

Research design

A cross-sectional study was conducted in 13 provinces in Indonesia, namely North Sumatra, South Sumatra, West Sumatra, Lampung, Jakarta, West Java, Central Java, Yogyakarta, East Java, Bali, West Nusa Tenggara, South Kalimantan, and South Sulawesi. We used secondary data from the fifth wave of the Indonesia Family Life Survey (IFLS-5). Our secondary data collection was performed from October 2014 to August 2015.

Research subjects

A total of 11,022 respondents aged ≥40 years consisting of males (5,530; 50.17%) and females (5,492; 49.83%) from the fifth wave of the Indonesia Family Life Survey (IFLS-5). The latter is a longitudinal survey that collects panel data on socioeconomics and health at the individual, household and community levels in the abovenamed 13 provinces. The inclusion criteria applied to the sample in this study were individuals aged 40 years, having completed the questionnaire, and having been diagnosed with T2DM. Respondents who relocated to another village or passed away during data collection and those who did not complete the questionnaire were excluded.

Measurements

A questionnaire was used comprising closed questions on the variables of age, gender, occupation, educational level, and smoking habit (Yes/No). Psychosocial stress was measured using the Centres for Epidemiologic Studies Depression Scale (CES-D) instrument to assess the symptoms of stress.[36] Based on the symptoms, stress was classified into "Stress" and "No stress". Physical activity variables were assessed using the International Physical Activity Questionnaire (IPAQ) [37] and were categorized into 3 categories, namely "high," "moderate," and "low" activity. A respondent was stated to have a "high" physical activity when he or she met one of the following criteria: 1) physical activity of high intensity for at least 3 days and reaching a total physical activity of at least 1500 MET-minutes/week; or 2) combination of walking activity for at least 7 days with moderate to high intensity physical activity and reaching a total activity of at least 3000 MET-minutes/week. Meanwhile, a respondent that met the following 3 criteria was considered to have a "moderate" physical activity: 1) high-intensity physical activity for at least 3 days with at least 20 minutes per day, 2) moderate-intensity physical activity for at least 5 days and/or at least 30 minutes of walking activity per day, 3) combination of moderate-high intensity walking activities and reaching a total of 600 MET-minutes/week of physical activity. In addition, respondents were categorized as having a "low" physical activity if they did physical activities that were not included in the "high" and "moderate" categories.

Laboratory analysis

Glycosylated hemoglobin (HbA1c) levels of the respondents were collected by the IFLS in collaboration with the laboratory of the Clinical Pathology Department, Gadjah Mada University. The measurement of HbA1c was performed by a physician or paramedic (Yes = HbA1c ≥ 6.5% and No = HbA1c <6.5%).[38]

Assessment of dietary intake

Eating patterns were obtained from the participants' answers to the question about their average frequency of daily intake per week.[39] Those patterns were measured by counting the frequency of consumption of carbohydrate-containing foods (sweet potatoes/rice); fruits; green leafy vegetables; dairy products; fish; processed meats (fresh processed beef/chicken/pork/eggs, etc.) and instant noodles, which was divided into 3 categories ≤once/week, 1-3 times/week, and >3 times/week).[39]

Ethical clearance

Written ethical approval for the study was obtained from the Research Ethics Committee of Universitas Ahmad Dahlan, Yogyakarta, Indonesia (No: 011905053). Written informed consent was obtained from all patients before being included in the study.

Statistical analysis

Participant characteristics were analyzed descriptively and presented as mean and standard deviation for continuous variables and as frequency and percentage for categorical variables. The demographic characteristics analyzed in this study included age, level of education (elementary school/junior high school/senior high school/higher education/did not attend formal school), and occupational status (unemployed/working).

A logistic regression model was constructed to obtain adjusted bivariate and adjusted multivariate effects for outcomes as well as estimated adjustment of association between age, gender, education level, occupational status, smoking habit, physical activity, stress, diet, and DM. Statistical significance was set at a p-value of <0.05, and all data analyses were performed using STATA 15.0 software.

RESULTS

Males and individuals aged >40 years comprised 50.17% and 26.19%, respectively, of the 11,022 respondents. More than half of the respondents did not smoke (58.15%) and were not under stress (84.83%). Meanwhile, a higher percentage of the respondents had a low educational level (elementary school) (51.38%), were working (74.46%), and were less active (55.03%). Further details on the participants' characteristics in this study are presented in Table 1. In summarizing the frequency of food consumption among participants (Table 2), the most common foods consumed (>3 times/week) were carbohydrates (99.58%) and processed meats (60.99%).

Table 3 provides the results of multivariable binary logistic regression analyses, which revealed that carbohydrate intake of more than 3 times per week was significantly and negatively associated with 1% and a protective factor for T2DM (AOR=0.01; 95% CI=0.01-0.06; p<0.001). Subjects who consumed fruit >3 times/week were shown to be significantly associated with T2DM, with the odds of the prevalence of T2DM decreasing by 65% (AOR =0.35, 95% CI=0.15 to 0.83, p<0.01). Meanwhile, the odds of subjects with processed meat intake (>3 times per week) was 4.90 times higher for the prevalence of T2DM (AOR=4.90, 95% CI=1.08 to 22.20, p<0.05). Regarding the patients' age, our study showed that in the age groups of 50-55 years, 55-59 years, and ≥60 years, respectively, age was significantly associated with T2DM, (AOR=5.67, 95% CI=1.37-21.94, p<0.05; AOR=5.46, 95% CI = 1.16-24.00, p<0.05; AOR = 6.15, 95% CI = 6.15, 95% CI=1.32-22.56, p<0.05). In addition, there were no significant associations of T2DM with physical activity and consumption of green leafy vegetables, dairy products, and instant noodles.

DISCUSSION

The results of this study indicated that frequent excessive consumption of processed meat increased the risk for DM among respondents. This is in line with other studies which state that consuming red meat and

Table 1. Characteristics of participants with and without T2DM (n=11,022)

Characteristics	Diabetic (%)	Non-diabetic (%)	Total participants (%)	Prevalence 95% CI
Overall	28 (0.25)	10,994 (99.75)	11,022 (100.00)	0.001 – 0.003
Gender				
Male	19 (67.86)	5,511(50.13)	5,530 (50.17)	0.002 - 0.005
Female	9 (32.14)	5,483 (49.87)	5.492 (49.83)	0.001 – 0.003
Age (years)				
40-44	3 (10.71)	2,884 (26.23)	2,887 (26.19)	0.001 – 0.002
45-49	6 (21.43)	2,368 (21.47)	2,366 (21.47)	0.001 – 0.005
50-54	7 (25.00)	1,918 (17.45)	1,925 (17.47)	0.001 – 0.006
55-59	5 (17.86)	1,475 (13.42)	1,480 (13.43)	0.004 – 0.006
≥60	7 (25.00)	2.357 (21.44)	2,364 (21.45)	0.007 – 0.005
Education level				
Elementary school	11 (39.29)	5,678 (51.65)	5,689 (51.61)	0.001 – 0.003
Junior high school	3 (10.71)	1,702 (15.48)	1,705 (15.47)	0.001 – 0.004
Senior high school	11 (39.29)	2,428 (22.08)	2.439 (22.13)	0.002 – 0.007
Higher Education	3 (10.71)	1,186 (10.79	1,189 (10.79)	0.001 - 0.005
Smoking habit				
No	14 (50.00)	6,395 (58.17)	6,409 (58.15)	0.001 – 0.003
Yes	14 (50.00)	4,599 (41.83)	4,613 (41.85)	0.002 – 0.005
Stress condition				
No stress	22 (78.57)	9,328 (84.85)	9,350 (84.83)	0.001 – 0.003
Stress	6 (21.43)	1,666 (15.15)	1,672 (15.17)	0.001 – 0.006
Occupational status				
Unemployed	7 (25.00)	2,808 (25.54)	2,815 (25.54)	0.001 – 0.004
Working	21 (75.00)	8,186 (74.46)	8,207 (74.46)	0.001 – 0.003
Physical activity				
High	12 (42.86)	4,506 (40.99)	4,518 (40.99)	0.001 – 0.004
Moderate	1 (3.57)	438 (3,98)	439 (3.98)	0.002 – 0.007
Low	15 (53.57)	6,050 (55.03)	6,065 (55.03)	0.001 – 0.004

Note: T2DM: Type 2 Diabetes Mellitus

processed meat increases the risk of insulin resistance and type 2 DM.[40, 41] Meanwhile, the results of this study are inversely proportional to those of a study in Korea which stated that consuming processed red meat was not associated with the incidence of T2DM.[42] In addition, saturated fat can cause obesity and result in glucose intolerance, insulin resistance and diabetes.[43] Furthermore, the results of our study showed that frequent consumption of carbohydrates is a protective factor against developing T2DM. This research is in line with a study in Korea which showed that very high carbohydrate intake was associated with an increased risk of T2DM in men and women.[44] However, these results are in contrast to a study in Europe which stated that consuming easily digested carbohydrates was not associated with the incidence of diabetes.[45] Controlling carbohydrate consumption is the primary key to controlling DM by lowering the glycemic index (GI) through regulating dietary patterns,[46] such as through consumption of brown rice, beans, bananas, corn, breadfruit, and various types of tubers.[47]

DM is known as one of the silent killers because patients often do not realize that they have DM due to nonspecific symptoms of this disease. This is aggravated by the fact that most DM patients suffer from complications, especially those who live in low-middle income countries such as Indonesia. Some of the complications of this disease are cardiovascular disease (CVD), blindness, heart failure, and even amputation of the lower limbs. In pregnancy, uncontrolled diabetes increases the risk of

Table 2. The frequency of food consumption among participants with and without T2DM

Food consumption	Diabetic (%)	Non-diabetic (%)	Total participants (%)
Carbohydrate (sweet potatoes and rice)			
≤ once/week	2 (7.14)	24 (0.22)	26 (0.24)
1-3 times/week	2 (7.14)	18 (0.16)	20 (0.18)
> 3 times/week	24 (85.71)	10,952 (99.62)	10,976 (99.58)
Fruits			
≤ once/week	14 (50.00)	3,938 (35.82)	3,952 (35.86)
1-3 times/week	4 (14.29)	1,623 (14.76)	1,627 (35.86)
> 3 times/week	10 (35.71)	5,433 (49.42)	5,443 (49.38)
Green leafy vegetables (include carrot)			
≤ once/week	2 (7.14)	1,819 (16.55)	1,821 (16.52)
1-3 times/week	3 (10.71)	1,468 (13.35)	1,471 (13.35)
> 3 times/week	23 (82.14)	7,707 (70.10)	7,730 (70.13)
Dairy products (milk, yogurt, cheese, etc.)			
≤ once/week	22 (78.57)	8,475 (77.09)	8,497 (77.09)
1-3 times/week	2 (7.14)	640 (5.82)	642 (5.82)
> 3 times/week	4 (14.29)	1,879 (17.09)	1,883 (17.08)
Fish			
≤ once/week	11 (39.29)	3,800 (34.56)	3,811 (34.58)
1-3 times/week	3 (10.71)	1,953 (17.76)	1,956 (17.75)
> 3 times/week	14 (50.00)	5,241 (47.67)	5,255 (47.68)
Processed meats (fresh beef/chicken/ pork, egg, etc.)			
≤ once/week	2 (7.14)	2,523 (22.95)	2,525 (22.91)
1-3 times/week	4 (14.29)	1,771 (16.11)	1,775 (16.10)
> 3 times/week	22 (78.57)	6,700 (60.94)	6,722 (60.99)
Instant noodle			
≤ once/week	16 (57.14)	7,156 (65.09)	7,172 (65.07)
1-3 times/week	5 (17.86)	1,791 (16.29)	1,796 (16.29)
> 3 times/week	7 (25.00)	2,047 (18.62)	2,054 (18.64)

Note: T2DM : Type 2 Diabetes Mellitus

maternal and fetal complications.[2] Therefore, to reduce mortality due to DM, efforts are needed to improve DM management by, among others, increasing knowledge on self-management among DM patients, increasing physical activities, and implementing nutritional therapy to control blood sugar levels and complications.[48] It is essential to change the patient's lifestyle into a healthier one, mainly by reducing the consumption of food that has high calories as well as food high in unsaturated fat, sugar, salt, or sodium and with minimal fiber content. In addition, shifting the behavior from less active with a minimum amount of exercise into a more active one will have a very significant impact in reducing the incidence of DM.[30,49]

However, the findings in this study indicated that physical activity did not significantly influence T2DM in the adult population. This study contradicts 2 studies which state that adults who have moderate physical activity are associated with the incidence of DM [50] and that decreased physical activity increases the risk of T2DM. [51] This is due to the fact that the intensity and duration of physical activities performed by most participants were still low, despite the fact that high-intensity physical activity provides benefits in reducing the glycemic level in individuals who are at risk of developing DM.[52] Low physical activity affects the suboptimal metabolism of blood and body cells that use glucose as the source of fuel for

Table 3. Multivariable adjusted OR and 95% CI for T2DM

Items	Unadjusted OR (95%CI)	p-value	Adjusted OR (95%CI)	p-value
Age (ref: 40-44)				
45-49	2.44 (0.61 - 9.78)	0.207	2.71 (0.66 - 11.09)	0.165
50-54	3.51 (0.91 - 13.58)	0.069	5.67 (1.37 - 21.94)	0.014
55-59	3.26 (0.78 - 13.65)	0.106	5.46 (1.16 - 24.00)	0.029
≥60	2.86 (0.74 - 11.05)	0.129	6.15 (1.32 - 22.56)	0.015
Education level (Ref: Elementary school)				
Junior high school	0.91 (0.25 - 3.26)	0.885	1.05 (0.28 - 3.89)	0.955
Senior high school	2.33 (1.01 - 5.40)	0.047	3.32 (1.32 - 8.32)	0.014
Higher Education	1.30 (0.36 - 4.68)	0.683	1.57 (0.41 - 6.02)	0.517
Smoking habit (Ref: no smoking)				
Yes	1.39 (0.66 - 2.92)	0.384	1.18 (0.52 – 2.64)	0.683
Stress condition (Ref: no stress)				
Stress	1.52 (0.62 - 3.77)	0.359	1.64 (0.65 – 4.17)	0.293
Occupational status (Ref: unemployed)				
Working	1.02 (0.44 - 2.42)	0.948	1.23 (0.47 – 3.22)	0.672
Physical activity (ref: high)				
Moderate	0.86 (0.11 - 6.61)	0.883	0.63 (0.08 – 5.07)	0.663
Low	0.93 (0.43 – 1.99)	0.854	0.78 (0.35 – 1.72)	0.542
Carbohydrate (sweet potatoes and rice) (Ref: ≤ once/week)				
1-3 times/week	1.33 (0.17 - 10.38)	0.784	0.81 (0.08 – 7.60)	0.763
> 3 times/week	0.03 (0.01 – 0.11)	0.001	0.01 (0.01– 0.06)	**0.002**
Fruits (Ref: ≤ once/week)				
1-3 times/week	0.69 (0.22 - 2.10)	0.519	0.55 (0.17 – 1.74)	0.339
> 3 times/week	0.51 (0.22 – 1.17)	0.112	0.35 (0.15 – 0.83)	**0.024**
Green leafy vegetables (Ref: ≤ once/week)				
1-3 times/week	1.85 (0.31 - 11.13)	0.497	1.98 (0.32 - 12.40)	0.443
> 3 times/week	2.71 (0.64 - 11.52)	0.176	2.96 (0.66 - 13.22)	0.137
Dairy products (milk, yogurt, cheese, etc.) (Ref: ≤ once/week)				
1-3 times/week	1.20 (0.28 – 5.13)	0.802	1.25 (0.29 – 5.48)	0.797
> 3 times/week	0.82 (0.28 – 2.38)	0.715	0.58 (0.19 – 1.76)	0.331
Fish (Ref: ≤ once/week)				
1-3 times/week	0.53 (0.14 – 1.90)	0.331	0.56 (0.15 – 2.06)	0.377
> 3 times/week	0.92 (0.42 – 2.03)	0.842	0.87 (0.38 – 2.00)	0.750
Processed meats (beef/chicken/pork, egg, etc.) (Ref: ≤ once/week)				
1-3 times/week	2.84 (0.52 – 15.57)	0.227	2.81 (0.49 - 15.88)	0.237
> 3 times/week	4.14 (0.97 – 17.62)	0.054	4.90 (1.08 – 22.20)	**0.035**
Instant noodle (Ref: ≤ once/week)				
1-3 times/week	1.24 (0.45 – 3.41)	0.665	1.06 (0.37 – 3.05)	0.993
> 3 times/week	1.52 (0.62 – 3.72)	0.349	1.73 (0.68 – 4.41)	0.283

Note: Ref: reference; OR: Odds ratio; 95%CI: 95% confidence interval; T2DM: Type 2 diabetes mellitus, CI: confidence interval

the body so that it will not significantly affect the blood glucose level.[53] Routine and regular physical activities are strongly recommended for diabetic patients to improve insulin sensitivity, control the GI, and control the metabolic profile, which was also true for individuals who were at risk of developing diabetes.[54] Mild physical activity with high

intensity and a minimum duration of 30 minutes was sufficient for preventing T2DM.[55] However, this study also had several limitations. First, it used secondary data from data collected using a structured questionnaire that allowed for biased information, especially for details regarding eating frequency and physical activity frequency that entirely relied on the respondents' memory about their eating habits and activities in the past week. Also, missing data was found in this study that requires the researchers to only analyze data from respondents that met the established research inclusion criteria to prevent selection bias. The cross-sectional design of this study also makes causal inferences between exposure and disease impossible, because it cannot determine whether the exposure preceded the disease or vice versa. There is a need for further well-designed prospective cohort studies to examine the potential association between macronutrient intake and T2DM. Our findings provided valuable information for the primary prevention of T2DM through dietary modifications in a middle-aged Indonesian population.

CONCLUSION

Dietary processed meat increased the risk of T2DM in adults. While physical activity did not affect the prevalence of T2DM, nevertheless, all parties need to continue to exercise and to exert control over dietary intake through early preventive measures as a way to minimize the development of T2DM.

CONFLICT OF INTEREST

None.

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CONTRIBUTORS

SS was involved in the conception, design, analysis, and drafting of this manuscript. AL performed the data collection. Both authors have read and approved the final manuscript.

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