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Physiological Factors and Physical Activity Contribute to the Incidence of Type 2 Diabetes Mellitus in Indonesia

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Abstract

Type 2 diabetes mellitus (T2DM) is the sixth highest cause of death in Indonesia, thus it must be prevented and overcome with appropriate management. This study aimed to determine the contribution of physiological factors and physical activities to the incidence of T2DM. The study used a cohort retrospective design using secondary data from the Indonesian Family Life Survey from 2007 to 2014, which included a sample of 14,517 people involved for more than 20 years. Data analysis was performed using multiple logistic regressions. The results revealed a 3.8% incidence of T2DM in Indonesia. Record of hypertension risk increased the likelihood of T2DM by 1.7 times compared to without hypertension. A normal body mass index (BMI) increased the risk by 2.2 times, a higher BMI at 5.5 times, and BMI whose risk obesity was seven times had greater likelihood of having T2DM compared with respondents with a thin BMI. After controlling for sex, age, marital status, record of parents' DM, residence, employment, and education, results also indicated that people with less active physical activity were likely to have T2DM compared to those who were very active. Controlling blood pressure, maintaining a normal BMI, and increasing physical activity since adolescence can prevent T2DM.

Keywords: body mass index, diabetes mellitus, physical activity, record of hypertension

Introduction

Non-communicable diseases (NCDs) are a public health problem in Indonesia with huge social and economic impacts. The number of reported cases has increased over the years, and the diseases have become increasingly widespread in many areas.[1] Various NCDs, such as stroke, hypertension, diabetes mellitus (DM), tumors, and heart diseases are the main causes of death in Indonesia. Type 2 DM (T2DM) is the sixth highest cause of death in Indonesia. It is estimated that about 90% of cases of DM in the world are classified as T2DM. The number of T2DM is increasing in the adult age group, especially those aged more than 30 years, and in all levels of socioeconomic status.[2] The National Basic Health Study Report revealed that, based on interviews, the prevalence of T2DM in Indonesia has increased from 1.1% (2007) to 2.4% (2013). Six provinces that did not change were West Nusa Tenggara, West Sumatra, Bengkulu, West Kalimantan, Aceh, and Jakarta.[3] The improper management of DM is a known risk factor for cardiovascular diseases, kidney and blindness,[4] atherosclerosis,[5] disability leading to death,[6] and reduced life expectancy for 5–10 years. Diabetics have a 3.2 times greater risk of having coronary artery disease, and the risk is 1.9 times greater for those suffering from heart disease. Complications due to DM cause considerable health expenditures, especially in people with DM who experience complications.[7]

The occurrence of NCDs, including T2DM, is caused by lifestyle and eating patterns that should be modified and risk factors that cannot change, such as sex, age, and genetic factors.[1] T2DM is closely related to lifestyle factors and diet patterns, such as smoking, unhealthy diet, lack of physical activity, and consumption of alcoholic beverages. This condition causes physiological changes in the body, such as increased blood pressure, blood sugar, blood cholesterol, and body mass index (BMI, overweight and obesity), from which NCDs may arise after a relatively long time.[8] According to a study in West Jakarta, the risk factors for T2DM are age, family record, physical activity, blood pressure, and stress and cholesterol levels.[9] Other studies have found that the risk factors associated with the incidence of T2DM are age, sex, status marriage, education level, area status, employment status, smoking habits, alcohol consumption, obesity,

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hypertension, and dyslipidemia.[10,11] In order to prevent and control T2DM, it is necessary to modify the physiological and behavioral factors, namely, controlling blood pressure, BMI, and having sufficient physical activity, but the results of studies using national funds are limited in terms of explaining the influence of physiological factors and physical activity on the risk of T2DM in Indonesia.

Several studies have found that the high prevalence of T2DM due to changes in lifestyle, the availability of high-calorie foods, and less physical activity causes obesity.[11] The T2DM is associated with poor glucose control, which can be managed through proper diet, a healthy lifestyle, physical exercise, or medication (insulin). The factors affecting low blood sugar control among T2DM patients who use insulin are lifestyle, emotional and psychosocial factors, and factors related to medication and lack of knowledge.[12] Numerous studies on risk factors for T2DM have been done, but very limited study with cohort approaches, including those in Indonesia, have been carried out to prove the relationship between the risk of T2DM and psychological factors and physical activity. Thus, the purpose of the current study was to analyze the relationship between the incidence of T2DM and physiological factors (BMI and record of hypertension) and physical activity.

Method

This study used a longitudinal approach cohort retrospective by utilizing secondary data from the Indonesian Survey Meter, Yogyakarta, namely, the Indonesian Family Life Survey (IFLS) from 2007 to IFLS 2014. The IFLS data were published by the RAND Corporation. IFLS data are public domain data that can be accessed free of charge. This study was reviewed by and received ethical approval from the Health Study Ethics Commission at the Bengkulu Health Polytechnic of Health Ministry No. DM.01.04/095/V/2018.

The conceptual framework outlines the relationship between physiological factors (BMI and record of hypertension) and physical activity with the incidence of T2DM by controlling the potential confounding variables (sex, age, employment status, education, ethnicity, record of father's DM, record of mother's DM, region, and marital status. All the independent variables (physiological factors and physical activity data) and possible confounding variables were obtained from the 2007 IFLS data. The independent variables were physiological factors (BMI and record of hypertension) and physical activities. The dependent variable was T2DM obtained from IFLS 2014 data.

The respondents in this study were more than 20 years of age. They came from 13 provinces in the study area at the time of the 2007 IFLS. The sample consisted of respondents who were randomly netted in the IFLS 2007. A total of 14,517 people in the IFLS 2007 dataset met the inclusion criteria: over 20 years of age, had complete data for factors that could and could not be modified, had complete data on measurements of blood sugar levels, respondents must still be alive until the age of IFLS 2014, and had not suffered from DM in 2007. The exclusion criteria were the missing data and outlier data.

The IFLS data were obtained by filling out the questionnaire by the interviewer. The questionnaire was available in the question books (Book US1, Book 3A, Book 3B, Book K). Data on the respondents' characteristics, health information, information on education and employment were presented through the 2007 IFLS data. The information needed in this study was obtained from the US1 book for data on age, sex, an BMI from height and weight data. Individuals with a BMI under 18.5 were classified as underweight, whereas those with a BMI over 25 were considered overweight. Those with BMI values of over 30, over 35, and over 40 were classified as having class 1, class 2, and class 3 obesity, respectively.[13]

For the sake of analysis, the BMI variables were grouped into four categories: underweight, normal, overweight, and obesity. Book 3A was for education, ethnicity, and employment; book 3B for chronic diseases (DM and hypertension), frequency of eating sweet potatoes, protein, fat and fiber as well as physical activity and psychological conditions; and book K for information on household members (serial number of biological father and mother). In this survey, anthropometric measurements were also carried out for all family members (Book US1).

Data processing began with checking the completeness of the raw data. From the list of available questions, an examination of the variables to be analyzed was carried out. Next, data exploration was carried out by looking at the data distribution in order to determine the type of data distribution available. In addition, data cleaning was not carried out in accordance with the interests of analysis and missing data, so that they were excluded in the next analysis. Then, the data merger was performed. Merging was done by combining 2007 IFLS data with IFLS 2014 using a specific binding ID. The next step was to transform the data by compiling or recoding the variables as detailed below:

1. BMI was obtained through weight calculation (kg) divided by height (m^2) and classified into four categories: obesity, overweight, normal, and thin.
2. Physical activity was obtained through multiplication between types of activity. The following scores were given: 0 = does not do activities, 1 = sitting, 2 = walking, 3 = moderate activity, 4 = heavy activity. The scores for the time needed to do the activities were as follows: 1 for < 30 minutes, 2 for ≥ 30 minutes, 3 for < 4 hours, and 4 for ≥ 4 hours. The frequency of activities was measured for at least 10 minutes in a row during

the week (scores of 1–7). Scores were then grouped into five groups: very active, active, moderately active, less active, and very less active.
3. Record of hypertension was based on blood pressure measurement results, which were grouped into hypertension and no hypertension.
4. Age was grouped into five categories, namely, 20–29 years, 30–39 years, 40–49 years, 50–59 years, and ≥ 60 years.
5. Education referred to the formal education of respondents who were grouped into four categories: no schooling, low (elementary/junior high/equivalent), secondary (high school/equivalent), and high (diploma and undergraduate education).
6. Work was based on activities that generate money to meet daily needs. Work was classified as either working or not working.
7. Record of DM in the elderly was obtained through a merger between chronic disease data (variables taken regarding the record of DM) with household member data (taking the serial numbers of the natural sequences of the father and mother), and sex data. From here, authors obtained the record of the parents' DM. Parental data were divided into two: father's data and mother's data (based on sex). Each data set was then merged with the child's data using the household serial number variable (household ID), each respondent's serial number (person ID), and the serial number of the biological father or mother.
8. The tribes were grouped into four categories: Javanese and Madurese: Sumatra; Bali, Nusa Tenggara, and Ambon; Kalimantan; Sulawesi; and others. The categories were based on geographical areas, because the ethnic groups in the same geographical area tend to have similar culture and customs (in this case, the basic ingredients used in similar traditional foods).

Univariate analysis was performed to describe the frequency distribution of each variable. Then, bivariate analysis was conducted to identify the relationship of each independent variable with the dependent variable using simple logistic regression. Multivariate analysis was performed using multiple logistic regression by controlling the confounding variables. The multivariate analysis stage begins by integrating the main independent variables and all potential confounding variables with p-value < 0.25 in the bivariate analysis into the multivariate model along with the possible interacting variables. Next, the backward elimination test was carried out. This involved the selection of all candidate variables into the model in full, and then eliminating these interaction variables one by one, starting from the interaction variable with the highest p-value until the variable interacts with the p-value below 0.05. If the final model does not obtain an interaction variable with a p value below 0.05, it means that the model is without interaction. If there exist interacting variables, then in determining the final model, the interaction variable must be entered and this must become a confounding variable. A test was then performed to determine whether or not a variable is a confounding variable based on changes in the beta coefficient or odd ratio (OR) value of more than 10%. The final stage performs the final model diagnostics based on the goodness of fit. This is done by identifying the correctly classified model, looking at the distribution of changes in the chi square, and the leverage and Pearson residual tests.

Results

The univariate analysis was performed to describe the incidence of T2DM based on the characteristics of the respondents. The obtained results are shown in Table 1 below.

Table 1 shows the 3.8% incidence of T2DM in Indonesia. The figures are based on the characteristics of the respondents, the proportion of homogeneous DM occurrences according to sex, the age group of 45–59 years, has parents with a record of DM, living in urban areas, married, unemployed, and completed secondary and high education.

Table 2 shows that the proportion of the incidence of T2DM is highest among respondents who have a record of hypertension, a higher BMI, and low frequency of physical activity. Meanwhile, Table 3 shows that there is a significant relationship between physiological factors (BMI and record of hypertension) and physical activity with the incidence of T2DM after controlling for other factors. Table 3 shows that there are differences in the risk of developing DM among respondents who have or do not have a record of hypertension. Based on the group BMI, results indicate that a higher BMI leads to a greater risk of developing T2DM. Based on physical activity, there is a risk difference in DM between those who are less active and those who are very active.

Other variables related to the incidence of T2DM are sex, marital status, record of parental DM, residence, employment status, and education. Table 3 shows that adolescents who are at risk of developing T2DM as adults are adolescent girls, those who do not have a job, are highly educated, married, living in urban areas, and have families with a record of T2DM. As the person grows older, the risk of having T2DM also increases.

Discussion

The findings of this study indicate a 3.8% incidence of T2DM in Indonesia in 2014. This figure illustrates a higher prevalence compared to the results of the *Riset Kesehatan Dasar (Riskesdas),* or National Basic Health Research, 2007(1.1%) and *Riskesdas 2013*,[3] (2.1%).

Table 1. Incident of Type 2 Diabetes Mellitus Based on the Respondents' Characteristics

Risk Factor	Category	Diabetes Mellitus		No Diabetes Mellitus		p-value
		n	%	n	%	
Sex	Male	293	3.7	7,637	96.3	0.623
	Female	257	3.9	6,332	96.1	
Age (years)	21–44 years	180	2.0	8,833	98.0	< 0.001*
	45–59 years	283	7.8	3,343	92.2	
	60–74 years	82	5.1	1,519	94.9	
	75–90 years	4	1.5	271	98.5	
	> 90 years	0	0	2	100	
Ethnicity	Java-Bali	418	4.1	9,766	95.9	0.001*
	Sumatra	67	3.0	2,179	97.0	
	Kalimantan	29	4.6	605	95.4	
	Sulawesi, Nusa Tenggara, and Papua	25	2.0	1,249	98.0	
	Others	59	4.8	1,170	95.2	
Record of DM-father	DM	3	11.5	23	88.5	< 0.001*
	No DM	16	1.4	1,092	98.6	
	Do not know	535	4.0	12,848	96.0	
Record of DM-mother	DM	4	4.4	87	95.6	0.001*
	No DM	30	2.0	1,459	98.0	
	Do not know	517	4.0	12,420	96.0	
Marital status	Single	92	2.9	3,082	97.1	0.003*
	Married	454	4.0	10,889	96.0	
Employment	Employed	366	3.1	11,440	96.9	< 0.001*
	Unemployed	2,627	96.9	84	3.1	
Education	Low	399	3.2	12,066	96.8	< 0.001*
	Intermediate	100	6.5	1,437	93.5	
	High	45	8.7	470	91.3	
Regional	Urban	368	5.6	6,198	94.4	< 0.001*
	Rural	183	2.3	7,768	97.7	
The incidence of T2DM			3.8		96.2	

Notes: *simple logistic regression, DM: Diabetes Mellitus, T2DM: Type 2 Diabetes Mellitus

Table 2. Incident of Type 2 Diabetes Mellitus Based on Physiological Factors and Physical Activities

Risk Factor	Category	Diabetes Mellitus		No Diabetes Mellitus		p-value
		n	%	n	%	
Body mass index	Obesity	81	9.8	747	90.2	< 0.001*
	Overweight	219	7.5	2,707	92.5	
	Normal	229	2.6	8,576	97.4	
	Underweight	20	1.1	1,807	98.9	
Record of hypertension	Hypertension	263	7.2	3,390	92.8	< 0.001*
	No hypertension	282	2.6	10,581	97.4	
Physical activity	Very active activity	28	3.1	888	96.9	0.001*
	Active	314	3.0	10,139	97.0	
	Enough active	154	8.1	1,745	91.9	
	Inactive	30	4.3	663	95.7	
	Very inactive	26	4.7	530	95.3	

Note: *simple logistic regression

This finding is in accordance with the report published by the *Atlas of the International Diabetes Federation 2013*, in which the total number of DM patients in Indonesia among adults aged 20–79 years reached 8,554 million cases with a prevalence of around 5.84%.[14] The number of people who suffer from this disease continues to increase every year, making it a major public health problem because of its complications in the short and long term.[11] Various epidemiological studies have shown that there is a trend toward an increase in the incidence and prevalence of T2DM. The World Health Organization estimated an increase in DM patients in Indonesia from 8.4 million in 2000 to 13.7 million in 2003 and predicted a further increase to around 21.3 million in 2030. The high number of people with DM in Indonesia has resulted in Indonesia ranking fourth in the number of people with DM after the United States, China, and India.[2]

T2DM is the result of progressive damage to insulin secretion along with insulin resistance, and is usually as-

Table 3. Relationship between the Incidences of Type 2 Diabetes Mellitus and Physiological Factors and Physical Activity

Risk Factor	Category	β	p-value	OR (95% CI)
Body mass index	Underweight			1
	Normal	0.807	0.001	2.241 (1.408–3.567)
	Overweight	1.714	0.000	5.549 (3.457–8.906)
	Obesity	1.948	0.000	7.011 (4.184–11.749)
Record of hypertension	No hypertension			1
	Hypertension	0.515	0.000	1.673 (1.377–2.033)
Physical activity	Very active			1
	Active	0.027	0.917	1.028 (0.617–1.711)
	Self-active	–0.065	0.734	0.937 (0.645–1.363)
	Less active	0.68	0.000	1.973 (1.401–2.779)
Sex	Male			1
	Female	–0.488	0.000	2.63 (1.31–2.024)
Marital status	Single			1
	Married	–0.903	0.002	2.469 (1.404–4.329)
Age (years)	21–44 years			1
	45–59 years	1.063	0.000	2.896 (2.344–3.578)
	60–74 years	0.592	0.000	1.808 (1.326–2.464)
	≥75 years	–0.426	0.417	0.653(0.234–1.825)
Record of DM-mother	No DM			1
	Do not know	–0.274	0.167	0.76 (0.515–1.122)
	DM	0.566	0.293	1.762 (0.614–5.057)
Record of DM-father	No DM			1
	Do not know	–0.42	0.128	0.657 (0.383–1.128)
	DM	1.432	0.045	4.186 (1.03–17.009)
Regional	Rural			1
	Urban	0.587	0.000	1.799 (1.484–2.182)
Employment	Employed			1
	Unemployed	0.42	0.01	1.522 (1.107–2.093)
Education	Low			1
	Medium	0.328	0.073	1.388 (0.969–1.987)
	High	0.474	0.000	1.606 (1.251–2.062)
Constant		–5.274		

Notes: OR: Odd Ratio, CI: Confidence Interval

sociated with obesity, aging, and genetics.[15] The high prevalence of DM is due to lifestyle changes, the availability of foods high in calories, and physical inactivity leading to obesity.[11] If not managed properly, T2DM will result in various chronic complications, such as cerebrovascular disease, coronary heart disease, limb blood vessel disease, and eye, kidney, and nerve disorders.[2] T2DM is associated with poor glucose control and can be managed through a healthy diet/lifestyle, physical exercise, and medication/insulin. Meanwhile, the factors affecting low blood sugar control in T2DM using insulin are psychosocial lifestyle, emotional factors, and lack of knowledge.[12] The increasing incidence and prevalence of DM makes this disease an important target of various prevention and management efforts.

The findings of this study indicate that there are differences in the risk of developing DM among respondents who have and have not reported a record of hypertension (p-value = 0.000). In other words, someone who has a record of hypertension is 1.7 times more likely to have DM than those who do not have a record of hypertension. Based on the results of the *Riskesdas* 2013,[3] the prevalence of interrupted glucose tolerance (IGT) and DM tended to be higher in the group suffering from hypertension compared with those without hypertension. In the hypertension group, the percentages of IGT and DM are 15.1% and 9%, respectively. In comparison, lower numbers are found in the non-hypertension group, with the percentages of IGT and DM being 8.4% and 3.4%, respectively. The Korean genome and epidemiology study also found that hypertension is an independent risk factor for T2DM. Subjects with baseline prehypertension (hazard ratio (HR): 1.27; 95% CI: 1.09–1.48) and hypertension (HR: 1.51; 95% CI: 1.29–1.76) have been found to be at higher risk of diabetes.[16]

Hypertension usually occurs when blood pressure reaches more than 140 mmHg (systolic) and 85–90 mmHg (diastolic). The effect of hypertension on the incidence of DM is due to the thickening of the arteries, which causes the narrowing of the blood vessel diameter. This disrupts the process of transporting glucose from the blood.[17] The higher prevalence of hypertension in diabetics makes the need for special treatment for diabetics who also have hypertension. Handling is in the form of

controlling blood pressure to remain at the normal limit (less than 120/80 mmHg) by implementing a healthy lifestyle.

Hypertension, especially systolic hypertension, is a strong risk factor for the occurrence of T2DM. The results of the analysis of the Malaysian diabetes registry 2009 found 57.4% of diabetics had hypertension.[18] found that 57.4% of diabetics had hypertension. The Korean genome and epidemiology study found that the incidence rate of T2DM was 14.7%, consisting of 28.12% prehypertension and 29.74% hypertension, only 42.13% with normal blood pressure.[16] Increased blood pressure or hypertension in subjects is a risk factor for cardiovascular diseases, and there is a significant relationship between such diseases and hypertension and insulin resistance. Various studies in different European countries have reported that about 50% of patients who have essential hypertension also experience insulin resistance and have other metabolic syndrome components, such as high triglyceride levels and low high-density lipoprotein (HDL) cholesterol.[18]

The findings of the current study shows that a greater the BMI increases the risk of developing DM (p-value < 0.001). Having normal, fat, and obesity BMI values correspond to 2.2, 5.5, and 7 times greater risk of having DM compared with a respondent with a thin BMI. These findings are in line with the study among outpatient T2DM subjects at Tugurejo Hospital Semarang, which reported that a higher BMI value means a higher blood sugar level.[19]

Obesity, especially the central type, is one of the factors that influence the onset of T2DM. Excessive fat deposits in the body can lead to insulin resistance which, in turn, affects blood sugar levels in people with diabetes.[20] If someone is overweight, then the leptin levels in the body will increase. Leptin is a hormone that is associated with the obesity gene. Leptin plays a role in the hypothalamus functions of regulating body fat levels, burning fat into energy, and feeling full. Plasma leptin levels increase with increasing body weight. Leptin works in the peripheral and central nervous system, and its role in the occurrence of resistance is carried out by inhibiting the phosphorylation of insulin receptor substrate-1 (IRS) which, consequently, can inhibit glucose uptake and then increase blood sugar levels.[21]

The heavier the degree of obesity, the greater the risk of developing T2DM. This is because, under the condition of having excess body weight and being obese, there will be an increase in fatty acids or free fatty acids (FFA) in the cells, resulting in decreased glucose transporter translocation to the plasma membrane and finally leading to insulin resistance in muscle tissue and adipose. Insulin resistance results in increased glucose levels in the blood.[22-23] The effect of BMI on DM is related to the lack of physical activity and the high consumption of carbohydrates, proteins, and fats, which are risk factors for obesity. From these findings, weight loss and maintaining a BMI under normal conditions can help prevent the risk of diabetes, while also reducing the risk of cardiovascular disease and death from diabetes in people who have diabetes.

The results of the study show a difference in risk of having DM between those who are less active and those who are very active, that is, a person with less physical activity has twice the risk of having DM compared to someone who is very physically active. The results reported by Werdani and Triyanti,[24] from a study of 187 *Badan Pemberdayaan Masyarakat & Keluarga* employees and the Regional Secretariat of Depok City showed significant differences in the average fasting blood sugar levels among respondents who have sufficient physical activity and those with less physical activity (p-value = 0.011). Moreover, the average blood sugar level in the latter group is 98.95 mg/dL, whereas the average blood sugar level in the former group is 92.70 mg/dL. The results of the Valliyot study found an association of physical activity to the incidence of T2DM (p-value < 0.01). Physical activity is a protective factor for T2DM.[25]

The lack of physical activity causes the amount of energy consumed to exceed the amount of energy released, giving rise to a balance of positive energy stored in the adipose tissue. This causes insulin resistance, which eventually develops into T2DM. The lack of physical activity combined with the high consumption of carbohydrates, proteins, and fats which are risk factors for obesity, increase FFA in cells. Such an increase will reduce the translocation of glucose transporters to the plasma membrane and cause insulin resistance in muscle tissue and adipose.[23]

Sufficient physical activity can increase insulin secretion and insulin sensitivity. When doing physical activities, such as exercise, it generated skeletal muscle contractions, increased regulation of insulin and the release of calcium ions from the sarcoplasmic reticulum which, in turn, cause contraction processes resulting in a decrease in blood glucose.[24] BMI is used to diagnose obesity associated with various types of degenerative diseases, especially DM.[26]

Physical activity can help reduce blood sugar levels in diabetics. Physical activity, especially in moderate and high intensity, can help reduce body fat levels and also increase insulin sensitivity. However, the impact of physical activity only lasts for a short period of time, e.g., 3–6 days after the last physical activity is carried out. Therefore, food intake must be regulated appropriately, people should avoid being overweight, and they must engage in regular physical activity to prevent the onset of DM.[27] Therefore, in order to reduce the risk of DM,

strong determination and consistency are needed to change one's lifestyle and become more active and healthy.

In terms of limitations, this survey data collection used a structured interview method with a questionnaire. However, this data collection method enables information bias to occur, especially on questions about the frequency of eating and physical activity, whose answers rely on respondents' memories of eating habits and activities during the past week. Thus, in this study, missing data on consumption variables can cause selection bias. Carbohydrate consumption in this study can only be extracted from sweet potato consumption; thus, it is only able to explain the actual amount of carbohydrate intake, which can lead to the underestimation of one's calorie intake. However the missing data are supposed to be missing because the respondents did not consume the type of food asked in the questionnaire. The IFLS 2014 sample only included 13 of the 26 provinces in Indonesia in 1993, representing only 83% of the country's population. The results of the *Riskesdas* 2013 showed that the national prevalence of diabetes for ages 15 and above was 2.1%. This proportion is similar to the prevalence of DM aged 15 years and over in the provinces of the 2014 IFLS, which is based on the *Riskesdas* 2013. Thus, it can be concluded that the sample in the 2014 IFLS is sufficient to represent the population of Indonesia.

This study using a retrospective cohort design can explain the causal relationship between the aforementioned elements. With almost the same prevalence among different surveys, it shows that the IFLS data can well-represent the study population. Thus, the analysis results have good external variability wherein the results of this study have a good level of validity that can be generalized to the source population (e.g., Indonesia) and is also expected to be generalizable toward developing countries.

Moreover, in this study, in order to obtain historical data on T2DM in parents, authors used a questionnaire that asked about the record of the incidence of DM in parents based on memory. This may lead to selection bias, which can lead to the underestimated or overestimated results. However, because T2DM is chronic, it is most likely to be remembered, because this incident is likely to be an unwanted event for the family. To obtain accurate data, anthropometric measurements were carried out by enumerators who had passed the training stage. Thus, the IFLS data can be considered to have good internal validity.

Conclusion

The physiological factors (record of hypertension and BMI) and physical activity contribute to the incidence of T2DM in Indonesia. Hence, the modifications of the physiological factors (normal control of blood pressure and BMI) and increased physical activity can prevent and overcome the increased incidence of T2DM in Indonesia.

Abbreviations

T2DM: Type 2 Diabetes Mellitus; IFLS: Indonesian Family Life Survey; BMI: Body Mass Index; NCDs: Non-Communicable Diseases; DM: Diabates Mellitus; OR: Odd Ratio; CI: Confidence Interval; *Riskesdas: Riset Kesehatan Dasar* (National Basic Health Research); IGT: Interrupted Glucose Tolerance; HR: Hazard Ratio; IRS: Insulin Receptor Substrate-1; HDL: High-density Lipoprotein; FFA: Free Fatty Acids; BPMK: *Badan Pemberdayaan Masyarakat & Keluarga*.

Ethics Approval and Consent to Participate

Ethics approval and consent to participate in the IFLS were obtained from the personal communication with the IFLS study team. The IFLS survey and its procedures were reviewed and approved by the Institutional Review Boards in the USA (at RAND Corporation, Santa Monica, California) and in Indonesia (Ethics Committees of Universitas Gadjah Mada, Yogyakarta and earlier at Universitas Indonesia, Jakarta). Written informed consent was obtained from all participants. Written consent was also obtained from the next of kin, caretakers, or guardians on behalf of the children enrolled in the survey. Ethical approval for this study was obtained from the Health Study Ethics Commission of the Bengkulu Health Ministry.

Competing Interest

The authors declare that there is no conflict of interest.

Availability of Data and Materials

This study used longitudinal data from the IFLS in 2007 through 2014. IFLS secondary data are public domain data that can be accessed at *rand.org.*.

Authors' Contribution

Demsa Simbolon and Afriyana Siregar conceived and designed the experiments, analyzed the data and contributed the analysis tools. Demsa Simbolon, Afriyana Siregar, Ruzita ABD Talib wrote the paper.

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