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ORIGINAL RESEARCH

Predictors of Prediabetes Among Young Adults in East Java of Indonesia: A Cross-sectional Study

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Abstract

Background: Prediabetes is a condition that can be controlled and managed to prevent the occurrence of type 2 diabetes mellitus (T2DM). This condition can occur at all ages, especially in young adults. However, little is known about what factors increase the risk of prediabetes in young adults in East Java, Indonesia.
Purpose: This study aimed to estimate the prevalence and the influential risk factors of prediabetes among young adults in East Java, Indonesia.
Methods: This study used a cross-sectional design. The purposive sampling technique was used to recruit young adults in East Java Province, Indonesia. International physical activity questionnaire short-form version questionnaire (IPAQ-SF) and physical indicators for anthropometry were used to obtain data on sociodemographic characteristics, prediabetes knowledge, and physical activity. In addition, blood pressure, impaired fasting glucose (IFG), and body mass index (BMI) were measured. Multivariable logistic regression was employed in the analysis to determine risk factors associated with prediabetes.
Results: There were 126 participants recruited, with 69 (54.8%) having prediabetes based on IFG levels. Age (p=0.035), regular exercise (p=0.015), activity level (p=0.026), body weight (p=<0.001), waist circumference (p=0.002), BMI (p=<0.001) and obesity (p=<0.001) were significant factors associated with prediabetes.
Conclusion: The high prevalence of prediabetes in young adults is associated with age, routine exercise, activity level, body weight, waist circumference, BMI and obesity. It is crucial to implement strategies, such as regular IFG testing, to identify young adults with these risk factors for prediabetes screening.

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1. Introduction

Prediabetes is a condition in which blood glucose levels in the body are higher than normal but not high enough to be categorized as diabetes mellitus. This condition has the highest potential to develop into type 2 diabetes mellitus (T2DM) (American Diabetes Association, 2018). In 2014, there were 314 million people with prediabetes, and by 2025, it is predicted to grow to 418 million. Prediabetes is more prevalent in developing countries at about 69.2% (Andes et al., 2020). More than one-third of people with prediabetes will develop diabetes (Fujiati et al., 2017). Prediabetes prevalence is high in young adults worldwide (Ureña-Bogarín et al., 2015). The prevalence of prediabetes in the United States was 18.0% among adolescents aged 12–18 years based on HbA1c values. This increase was sharper in men (15.8% to 36.4%) compared to women (7.1% to 19.6%) (Andes et al., 2020; Perng et al., 2023). Prediabetes prevalence in Indonesia reaches 26.3% of the adult population (Ministry of Health, Republic of Indonesia, 2018). As an example, based on research results, the prevalence of prediabetes is very high in Pontianak, Indonesia, where two-thirds of subjects have a fasting blood glucose of more than 100 mg/dL (Budiastutik et al., 2022). However, there was limited information available at a younger age (Andes et al., 2020; Noventi et al., 2019). In addition, Surabaya is ranked first with T2DM patients in the province of East Java (Surabaya City Health Office, 2022)

Prediabetes is often unrecognized or cannot be addressed promptly (Eikenberg & Davy, 2013), with the consequences of missing opportunities for diabetes prevention. Based on a previous study, 70% of people with prediabetes turn into diabetes mellitus (Kim & Shim, 2019; Zhao et al., 2016; Zhu et al., 2019). Factors contributing to prediabetes include obesity, increased triglycerides, decreased HDL, and hypertension. Prediabetes can also be caused by reduced physical activity, excessive calorie intake, smoking, imbalance in energy consumption, and weight gain (Altamash et al., 2013; Kim & Shim, 2019). Most of the previous studies did not specifically examine prediabetes in young adults aged 19-25. However, various studies have shown that prediabetes at a young age is linked to an increased risk of cardiovascular disease and mortality from all causes (Joel et al., 2019; Subramaniam et al., 2021; Van Wissen & Blanchard, 2021).

It is essential to be aware of the increased risk of complications from diabetes in young adults. Research conducted in Mexico has shown that the majority of patients with end-stage kidney disease are diabetic and are much younger than those in other countries (Ureña-Bogarín et al., 2015). It has been proven that there are differences in the incidence of prediabetes and diabetes between urban and rural areas. These differences need to be taken into consideration when developing strategies to control the development of diabetes mellitus that are specific to each area category. For example, a study found that women in rural areas are more active, while central obesity is more common in women in urban areas (Nurwanti et al., 2019). Therefore, strategies to increase activity need to be developed for women in urban areas (Dany et al., 2020; Dugani et al., 2021; Kalra et al., 2024). Understanding the risk factors for developing prediabetes can help in planning successful health behavior interventions to delay and prevent diabetes (Okosun & Lyn, 2015). Previous studies in Indonesia found that the prevalence of prediabetes in young adults was very high in tropical urban areas of Pontianak (Budiastutik et al., 2022). A history of urban residence in childhood and higher education can increase the risk of diabetes in adults, while most diabetes is undiagnosed (Tanoey & Becher, 2021). Given that undiagnosed diabetes often stems from prolonged periods of undiagnosed prediabetes, understanding the prevalence of prediabetes in this population is crucial for early intervention and prevention strategies. Therefore, this study aimed to determine the prevalence of prediabetes among young adults in East Java, Indonesia, and find out the most dominant predictor factors for the occurrence of prediabetes in young adults (19-25 years).

2. Methods

2.1. Research design

A descriptive correlation design with a cross-sectional approach was used. This design was used to determine the prevalence and risk factors of prediabetes. Cross-sectional studies are observational studies that analyze data from a population at a single point in time. They are often used to measure the prevalence of health outcomes, understand determinants of health, and describe features of a population. Cross-sectional studies do not follow individuals up over time. They are usually inexpensive and easy to conduct (Wang & Cheng, 2020).

2.2. Setting and samples

In this research, a total of 126 young adults recruited were students in universities from East Java Province, Indonesia, in August-October 2020. Using purposive sampling, participants who met the following inclusion criteria were taken, such as students aged 19-25 who lived in East Java Province for more than six months. The exclusion criteria were having diabetes and being pregnant. Excluding pregnant participants with diabetes helped avoid potential risks to both the mother and fetus and ensured that the study results were not skewed by these unique physiological factors (physiological changes and hormonal fluctuations). Research in Indonesia in 2017 (Fujiati et al., 2017) showed that prediabetes had a 26.6% prevalence in the adult population. When calculating the sample size, the formula for proportions from Lemeshow et al. (1997) was used: n=desired sample size, d=estimated 10% margin of error, P=Proportion of priority population estimated to have prediabetes, and Z=critical value of the normal distribution at 95%, which corresponds to 1.96. There was a mismatch between the errors for obtaining and missing samples, so the sample size was adjusted by 10% to approximately 76 and rounded to 84. The minimum total number of participants in this study was 84. However, 126 students were involved in the study, which met the minimum sample limit.

2.3. Measurement and data collection

Data were collected during the pandemic by following the standard COVID-19 prevention protocol provided by the Indonesian Ministry of Health. After obtaining the research permits from two universities, one in the rural area and the other in the urban area of East Java, general students as participants were verbally informed about the research procedures and then asked for their informed consent. Researchers coordinated with research institutions in both universities for the participant recruitment process. Participants willing to be involved in this research and meeting the criteria selected a suitable time for the data collection. The data collection procedure consisted of filling in the questionnaire and carrying out a physical examination, which started with checking fasting blood sugar, anthropometric measurements, and blood pressure according to standard protocols performed by health professionals. Participants were asked to fast for at least 8 hours before the blood sugar examination. At the time of data collection, researchers were assisted by research assistants who had a background in the health sector and were experienced in conducting survey research.

The participants filled in demographic data (age, location of residence, gender, exercise habits, and family health history) and the questionnaire about prediabetes and activity level. Next, the parameters of physical condition were measured, namely measurement of height, weight, fasting capillary blood glucose (FCG), waist circumference, waist-to-hip ratio, body mass index, and blood pressure measurements. Capillary blood sampling for fasting blood glucose (FBG) was measured using Easy Touch GCU 3 in 1 Electrode-based Biosensoch to determine the presence of diabetes or prediabetes in study participants. Recently, mass screening to detect diabetes and prediabetes has been carried out with the FCG Test (Zhao et al., 2013).

The criteria of the American Diabetes Association were used as the reference value for diagnosing prediabetes (American Diabetes Association, 2018). In this study, prediabetes conditions were defined if there was impaired fasting glucose (IFG) which decreased between 100-125 mg/dl or 5.6-6.9 mmol/l, while if the IFG level was 126 mg/dl or 7.0 mmol/l, it was included in the diabetes category or self-reported by the participants. When participants had not previously been diagnosed with type 1 or 2 diabetes mellitus, they were referred to check with a doctor at a national or provincial hospital in the province/city. The microtoise instrument, with an accuracy of 0.1 centimeters (cm), was used to measure waist circumference, waist-to-hip ratio, and height (Irenewati et al., 2020). Scales for body weight used Onemed digital scale with units of kilograms (kg), which then the results were converted into body mass index (BMI), and if the BMI was 25, then it was included obesity (Division of Nutrition, Physical Activity, and Obesity, 2021). Yazumi sphygmomanometer was used to measure systolic and diastolic blood pressure. The results of the mercury sphygmomanometer measurement were entered into the Mean Arterial Pressure (MAP) formula, calculated as MAP= (Systolic+2Diastolic)/3 (DeMers & Wachs, 2021). The instruments used in this study underwent a calibration procedure carried out routinely per standards (Medina, 2019).

In this study, participants were given a demographic data questionnaire, a short-form version of the international physical activity questionnaire (IPAQ-SF), and a knowledge questionnaire about prediabetes. There were three specific types of activity during the past seven days, including walking, moderate activity, and vigorous activity, assessed by the IPAQ-SF questionnaire. The instrument used in this study was the Indonesian version of IPAQ-SF. The IPAQ questionnaire has been validated in 14 centers in 12 countries that have been internationally standardized with a validity level of r=0.40 and a fairly large reliability of 0.70-0.87 (Craig et al., 2003; Lee et al., 2011). Indicators of sustained physical activity (PA) are expressed in metabolic equivalents of duty (MET) every minute/week. MET calculates energy demand by multiplying MET according to the activity type with the implementation minutes in a day or week. To calculate the total PA in MET minutes per week using the Ainsworth formula, the MET values for different activity levels are multiplied by the duration and frequency of each activity. The MET values are as follows: light activity=3.3 MET, moderate activity=4 MET, and strenuous activity=8 MET. Finally, the final PA score is obtained by summing all results (Compeán et al., 2018).

According to IPAQ, the categories of physical activity include: 1) Low activity for not doing moderate-high physical activity <10 minutes/day or <600 METs-minutes / week; 2) The medium activity consists of 3 categories (a. ≥3 days of high physical activity >20 minutes/day; b. greater equal to 5 days of moderate-level activity/ walking physical activity >30 minutes/day; c. greater equal to 5 days combination of walking activities with moderate-level activity to high-intensity activities with minimum total METs of >600 METs-minutes by week); 3) The high activity consists of 2 categories (a. high-intensity activity >3 days with a total METs of at least 1500 METs-minutes by week, b. greater equal to 7 days of combined walking with moderate to high-intensity activity for a total METs of >3000 METs-minutes by week) (Compeán et al., 2018).

The knowledge questionnaire about prediabetes assessed participants' understanding of risk factors for prediabetes, which consisted of 11 true or false dichotomous statements. This questionnaire was developed by Poltavskiy et al. (2016) by referring to the American Diabetes Association (ADA) scoring for prediabetes. This questionnaire was first translated into the Indonesian language by an official translation body and then tested for validity and reliability by the researcher. The test results for the level of validity and reliability were quite large, namely r=0.60 and 0.70-0.75, respectively. According to the results of the score calculation from the answer, prediabetes knowledge was categorized as follows: 1) high if the score T≥mean, 2) low if the score T<mean (Azwar, 2010).

2.4. Data analysis

Descriptive statistics was utilized to describe or provide an overview of the object under study through sample or population data. SPSS version 21.0 for Windows was used in statistical analysis. Participants' characteristics associated with prediabetes were compared between groups using the Chi-square test, independent sample test, or the Mann-Whitney test using 95% confidence intervals. The identification of predictors for prediabetes was done using the recommended procedure through multivariable logistic regression analysis (Hosmer & Lemeshow, 2013).

2.5. Ethical considerations

Ethical approval from the Ethics Commission of the Faculty of Nursing, Universitas Airlangga, with ethics number 2060/KEPK, had been obtained prior to data collection. The study was conducted following the approved protocol. Informed consent was obtained from all participants before participating in this study. Research data were stored for a minimum of 5-10 years to ensure compliance with ethical and regulatory standards. Data storage was carried out on institutional servers with regular backups or in academic data repositories that were guaranteed to be secure. Access to the data was restricted and protected by an adequate security system.

3. Results

3.1. Participants' characteristics and clinical parameters

In this study, 126 participants who were in the early adulthood group with a range of 19-25 years old and an average of 21.8 years old carried out fasting blood sugar checks with a mean fasting blood glucose of 99.35 (SD=17.94) mg/dL, and there were 54.8% participants indicated to have prediabetes (Table 1). In addition, some participants had a family history of suffering from diabetes mellitus (DM) (38.1%) and hypertension (56.3%). Moreover, the average body weights and heights were 60.21 kg and 160.15 cm, respectively, and 37.3% of participants were obese. The average Mean Arterial Pressure (MAP) was 166.70, and the average MET was 343.83. The average respondent had low knowledge of prediabetes (55.6%).

3.2. Comparisons between participants' characteristics and prediabetes categories

Table 2 compares the sociodemographic and clinical characteristics between prediabetic and normoglycemic participants. Age (p=0.035), regular exercise (p=0.015), level of activity (p=0.026), location of residence (p=0.005), and level of understanding of prediabetes (p=0.041) were variables that differed significantly between the two groups. The average age of the prediabetes participants (21.64 years) was one year younger on average than normoglycemic participants (22.16 years). Meanwhile, from the results of the physical examination of participants, it was found that body weight (p=<0.001), waist circumference (p=0.002), body mass index (p=<0.001), and the ratio of waist and hip circumference (p=<0.001)mwere significantly different between those with prediabetes and normal group. There were 40 (85.1%) participants with prediabetic obesity based on BMI, and it was a significantly larger proportion in the prediabetes group (p=<0.001).

Table 1. Sociodemographic characteristics and clinical parameters (n=126)

Characteristics/ Parameters	f (%)	Mean(SD)	Min-Max
Age		21.87(1.345)	19-25
Gender			
Male	29 (23)		
Female	97 (77)		
Exercise			
Regular	58 (46)		
Irregular	68 (54)		
Location of residence			
Urban area (city)	57 (45.2)		
Rural area (village)	69 (54.8)		
Family history of diabetes mellitus			
Yes	48 (38.1)		
No	78 (61.9)		
Family history of hypertension			
Yes	71 (56.3)		
No	55 (43.7)		
Family history of high cholesterol			
Yes	48 (38.1)		
No	78 (61.9)		
Height (cm)		160.15(7.13)	150-182
Weight (kg)		60.21(13.53)	38-95
Body mass index (kg/m2)		23.47(4.94)	15-34
Waist circumference (cm)		75.99(17.29)	27-135
Waist to hip ratio (cm)		0.8341(0. 23)	0.5-2
Obesity			
BMI<25 (normal)	79 (62.7)		
BMI ≥25	47 (37.3)		
Systolic blood pressure (mmHg)		110.29(13.41)	80-180
Diastolic blood pressure (mmHg)		84.65(17.09)	60-140
Mean arterial pressure (MAP)		166.70(20.13)	127- 233
Fasting capillary blood glucose (FCG)		99.35(17.94)	50-125
Prediabetes categories			
Prediabetes (IFG 100-125 mg/dL)	69 (54.8)		
Normal glycemia	57 (45.2)		
Activity level			
Low	54 (42.9)		
Moderate	30 (23.8)		
High	42 (33.3)		
MET		343.83(286.44)	61- 1499
Knowledge of prediabetes			
High	56 (44.4)		
Low	70 (55.6)		

Notes. IFG=impaired fasting glucose

3.3. Predictors of prediabetes among young adults

A multivariate binary logistic analysis (Table 3) determined that age (p=0.000), waist-to-hip ratio (p=0.000), and location of residence (p=0.000) were the significant variables associated with prediabetes. This study revealed that increasing age was correlated with a 2.1 times higher risk of having prediabetes. Living in rural areas reduced the risk of prediabetes by 0.11 times (p<0.001), and increasing waist to hip ratio increased the hazard of having prediabetes by 0.003 times (p<0.001).

Table 2. Comparison of sociodemographic characteristics and clinical variables between prediabetic and normoglycemic participants (n=126)

Characteristics	Prediabetes		Normal glycemia		*p*
	Mean(SD)	f(%)	Mean(SD)	f(%)	
Age	21.64(1.27)		22.16(1.39)		0.035**
Height (cm)	160.06(7.39)		160.26(6.88)		0.660**
Weight (kg)	64.62(14.47)		54.86(10.06)		<0.001*
Body mass index (kg/m2)	25.19(5.15)		21.39(3.78)		<0.001**
Waist circumference (cm)	80.16(15.55)		70.95(18.06)		0.002**
Waist to hip ratio (cm)	0.9138(0.25)		0.7377(0.16)		<0.001**
Systolic BP(mmHg)	111.70(10.44)		108.58(16.23)		0.071 **
Diastolic BP(mmHg)	85.33(18.23)		83.82(15.73)		0.976**
MAP	168.55(18.58)		164.46(21.81)		0.107**
MET	308.86(242.39)		386.16(329.36)		0.102**
Gender					
Male		17 (58.6)		12 (41.4)	0.634
Female		52 (53.6)		45 (46.4)	
Exercise					
Regular		25 (43.1)		33 (56.9)	0.015
Irregular		44 (64.7)		24 (35.3)	
Location of residence					
Urban area (city)		39 (68.4)		18 (31.6)	0.005
Rural area (village)		30 (43.5)		39 (56.5)	
Family history of diabetes mellitus					
Yes		26 (54.2)		22 (45.8)	0.916
No		43 (55.1)		35 (44.9)	
Family history of hypertension					
Yes		40 (56.3)		31 (43.7)	0.686
No		29 (52.7)		26 (47.3)	
Family history of high cholesterol					
Yes		30 (62.5)		18 (37.5)	0.171
No		39 (50.0)		39 (50.0)	
Obesity					
BMI<25 (normal)		29 (36.7)		50 (63.3)	<0.001
BMI≥25		40 (85.1)		7 (14.9)	
Activity level					
Low		37 (68.5)		17 (31.5)	0.026
Moderate		14 (46.7)		16 (53.3)	
High		18 (42.9)		24 (57.1)	
Prediabetes knowledge					
High		44 (62.9)		26 (37.1)	0.041
Low		27 (45.8)		32 (54.12)	

Notes. Chi-square test, *Independent sample t-test, **Mann-Whitney test, BP=blood pressure, MAP=mean arterial pressure

4. Discussion

This study aims to determine the prevalence of prediabetes among young adults in East Java, Indonesia, and the significant predictor for the occurrence of prediabetes in young adults (19-25 years). This study found that the high prevalence of prediabetes accounted for 54.8% in young adults was associated with age, regular exercise, activity level, body weight, waist circumference, BMI and obesity. A limited previous study explicitly reviews the prevalence in young adults in Indonesia. In the East Java Province of Indonesia, previous research on 90 participants (40-65 years old) showed that the number of incidents of prediabetes in mountainous areas was 83.3%, in coastal areas was 43.4%, and in urban areas was 73.4% (Noventi et al., 2019). The average age was 38 years old, and the prevalence of prediabetes was 17.14% in a study conducted in the province of Central Java, Indonesia (Kusumaningrum et al., 2020). The prevalence of young adults with prediabetes in both developed and developing countries is significantly high but often remains undiagnosed, as indicated by epidemiological findings (Andes et al., 2020; Eikenberg & Davy, 2013; Ureña-Bogarín et al., 2015). This study's findings were in line with the findings in other developing countries that the prevalence of prediabetes was high among young adults. This could be affected by some of the factors that were known to be the predictors of the occurrence of prediabetes, such as age, waist and hip circumference ratio, activity level, body weight, and BMI.

Table 3. Multivariate binary logistic analysis results on the incidence of prediabetes (n=126)

	Variables	Coefficient (B)	*p*	OR/HR(95%CI)
Step 1	Sex	0.749	0.332	0.47 (0.104-2.149)
	Age	0.743	0.000	2.1 (1.384-3.136)
	Location of residence	-2.120	0.000	0.11 (0.034-0.356)
	Exercise	-0.420	0.405	0.66 (0.244-1.766)
	Waist size	-0.003	0.840	0.997 (0.964-1.030)
	Waist-to-hip ratio	-5.854	0.000	0.003 (0.000-0.074)
	Family History of DM	-0.218	0.698	1.24 (0.414-3.731)
	Family History of Hypertension	-0.208	0.707	1.23 (0.416-3.642)
	Family History of Hypercholesterolemia	-0.303	0.575	0.74 (0.256-2.133)
	Weight (kg)	-0.187	0.443	0.83 (0.515-1.336)
	Height (cm)	0.175	0.340	1.19 (0.832-1.704)
	Body mass index (kg/m2)	0.367	0.547	1.44 (0.437-4.763)
	Systolic blood pressure	-0.016	0.986	0.99 (0.164-5.888)
	Diastolic blood pressure	-0.011	0.985	0.99 (0.300-3.256)
	Mean arterial pressure	-0.021	0.982	1.02 (0.170-6.142)
	Knowledge	-0.005	0.769	1.01 (0.974-1.036)
	Constant	-36.679	0.216	0.000

Notes. OR=Odds ratio, HR=Hazard ratio

In this study, more than 50% of young adults were prediabetes. The finding was consistent with previous studies in the United States and the United Kingdom, which found that prediabetes was more than 30% of the population. However, it differed from the findings of other studies in Mexico (Okosun & Lyn, 2015), where the prevalence of prediabetes was 20%, and several other international studies (Rodriguez-Segade et al., 2019). A possible explanation for this was that most of the participants with prediabetes in this study lived in urban areas. It has been a longstanding practice to investigate the prevalence of non-communicable diseases in urban and rural areas through multiple research studies (Chiwanga et al., 2016; Quang Binh et al., 2012). However, data on national representation still needs to be improved for several developing countries with diverse characteristics in Asia, including Indonesia (Dany et al., 2020). The critical finding in this study was that age was the main factor influencing the emergence of prediabetes, where increasing age was 2.1 times more likely to be at risk of developing prediabetes. A previous study found that the overall cases of prediabetes in adolescents aged 12-18 years were 20%, and the prevalence increased in young adults aged 19-34 years to 25% (Andes et al., 2020). The fact that the high prevalence of prediabetes is directly proportional to age has been reported repeatedly in other studies (Andes et al., 2020; Budiastutik et al., 2022; Kalra et al., 2024; Ureña-Bogarín et al., 2015). Age is not a modifiable risk factor in this case. The causal relationship between age and prediabetes was not investigated in this study, but it may be related to the body's inability to adapt to maintaining blood glucose levels. Further studies are important to monitor the prevalence of the body's inability to adapt to maintain blood glucose levels in the broader area. This finding will support prevention efforts and focus on targeting groups at higher risk of developing diabetes.

Another finding of this study was that the prediabetes participants were one year younger on average than normoglycemic participants. This finding contrasted with the research in Mexico, which produced opposite results with a two-year difference (Ureña-Bogarín et al., 2015). However, it is a short period to express a rapid decrease in glucose tolerance on progression to prediabetes or diabetes. Insulin resistance impairs glucose metabolic activities, and it occurs quickly in a short time (Fajriyah et al., 2020). The relevance of causality in our findings is difficult to explain due to the weaknesses in our correlational design. However, age is directly proportional to a higher risk of prediabetes in multivariate trials. This finding significantly supports previous studies (American Diabetes Association, 2018; Andes et al., 2020; Kalra et al., 2024; Mainous et al., 2014; Shiyanbola et al., 2018; Zhao et al., 2013).

The number of cases of overweight and obesity was measured by looking at the BMI value and the occurrence of obesity in the abdomen because the waist circumference value was above normal in prediabetic young adults. The result was in line with a study conducted in Mexico in 2012 by the National Health and Nutrition Survey, which showed that 70% of adults over 20 years were obese when measuring BMI or waist circumference (Ureña-Bogarín et al., 2015). Obesity is a well-known risk factor for developing high blood pressure (hypertension) and can lead to increased MAP (El Meouchy et al., 2022). The findings of this study confirmed this, showing that the MAP average was quite high for young adults. Obesity can be associated with a secondary impact on metabolic and cardiovascular conditions for central deposition of adipose tissue, and this is more often found in people with insulin resistance and those who are prone to prediabetes or diabetes (Jiang et al., 2020). The existence of primary prevention interventions in adult patients has a significant impact on changing healthier behavior in individuals who are at high risk of developing diabetes or prediabetes (An et al., 2015). The existence of intervention efforts that focus on individuals can improve diabetes management for the better (Pratiwi et al., 2018). This study emphasized that it was essential to implement health behavior changes in young adults with prediabetes and diabetes to improve their physical health, including their BMI and body circumference. Regular monitoring is also necessary for young adults with prediabetes to assess their current health behaviors.

In this study, prediabetes participants tend to have low activity levels. This finding was consistent with a study that found two out of three participants (64.2%) had low and moderate activity levels (Compeán et al., 2018). Diabetes and prediabetes groups were predominant compared to those without diabetes at low levels of physical activity (Hidayati et al., 2021; Rahim et al., 2020). Physical activity levels have various health benefits, such as regulating blood sugar and preventing diabetes (Centers for Disease Control and Prevention, 2019; Faizah et al., 2020; Pratiwi et al., 2024). Physical activity was effective in individuals with prediabetes in reducing the predictor of changing diabetes (Díaz-Redondo et al., 2015; Indarwati et al., 2019; Sinawang et al., 2020; Thojampa et al., 2020). We highlight the concern that knowledge may not always be translated into practice, but individuals with prediabetes should gradually strive to increase their physical activity.

It was also reported in this study that low knowledge about prediabetes was associated with the prevalence of prediabetes. Previous research has shown that the management and care of DM were associated with adequate knowledge, and there was a correlation between knowledge of DM and hemoglobin A1c levels (Al-Maskari et al., 2013; Gillani et al., 2018). In addition, poor knowledge of prediabetes was related to a high incidence of prediabetes in both developed and developing countries (AlSaleh et al., 2021; Hyder et al., 2021; Pakpour et al., 2024). Many factors affect knowledge, such as education level, sources and access to information, and environmental changes (Indarwati et al., 2019; Pratiwi et al., 2019). Improving knowledge about prediabetes conditions will further help prevent its development into diabetes.

This study also found that living in rural areas reduced the risk of prediabetes. In urban areas, a fast-paced lifestyle, high-stress levels, and unhealthy eating habits (e.g., consuming fast food and sweet drinks) increase the risk of prediabetes (Budiastutik et al., 2022; Dany et al., 2020; Kyrou et al., 2020). In addition, in big cities, low physical activity patterns due to the lack of open spaces and increased use of private vehicles also contribute to a sedentary lifestyle, which risks triggering insulin resistance (Zhu et al., 2023). Although rural lifestyles may be more active, a lack of knowledge about healthy eating patterns and regular health checks may increase the risk of prediabetes in adults (Dany et al., 2020; Kyrou et al., 2020). Further studies on the relationship between residential location and prediabetes risk are important to identify more targeted interventions.

5. Implications and limitations

In line with the key findings of our study, it is important to implement strategies to identify young adults with these risk factors for prediabetes, with the aim of slowing disease progression to diabetes through adequate preventive interventions. Many risk factors are modifiable and have the potential to be changed. Several factors known to be predictors of prediabetes in this study include age, location of residence, and waist-to-hip circumference ratio. By integrating prediabetes screening into routine assessments and providing tailored preventive interventions, nurses can help mitigate its progression to diabetes through lifestyle modification, education on healthy habits, and regular follow-up. This proactive approach not only supports the health and well-being of young adults but also reduces the long-term burden on the healthcare system by preventing the onset of diabetes and its associated complications.

The limitations of this study was that the number of sample size was relatively small concerning the situation of COVID-19 restrictive protocol when the study was conducted. Additionally, the study's cross-sectional nature did not account for temporal changes in risk factors or the progression of prediabetes over time. Furthermore, potential biases such as recall bias or unmeasured confounding factors could influence the results, limiting the generalizability of the findings to other populations or regions outside East Java, Indonesia.

6. Conclusion

Most of the young adult participants in our study had prediabetes. Many risk factors were modifiable and had the potential to change. Some of the factors that were known to be predictors of the occurrence of prediabetics in this study included age, location of residence, and waist and hip circumference ratio. An increase in a good understanding of prediabetes risk factors in young adults is essential. Therefore, it is necessary to implement strategies in community settings to identify young adults who are at high risk for prediabetes so that strategic efforts in implementing preventive interventions against diabetes can be developed timely. A cohort study will also likely be conducted with a broader population size for adequate early detection of prediabetes. This study has yet to investigate the model in depth so that some findings can be followed up through a more comprehensive population sample.

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Author contribution

INP conceived and designed the study, conducted research, provided research materials and the final draft of the article, and provided logistic support. AQ and INP collected, organized data, and wrote the initial manuscript. ZP analyzed and interpreted data. BOL, NN, and IYW reviewed and edited the final draft of the article. All authors had critically reviewed and approved the final draft and were responsible for the content and similarity index of the manuscript.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Al-Maskari, F., El-Sadig, M., Al-Kaabi, J. M., Afandi, B., Nagelkerke, N., & Yeatts, K. B. (2013). Knowledge, attitude and practices of diabetic patients in the United Arab Emirates. *PLoS ONE*, *8*(1), e52857. https://doi.org/10.1371/journal.pone.0052857

AlSaleh, E., Alnaser, M., Alsalman, A., ALRamdhan, A., Alsalman, H., Alhamrani, O., Alhamrani, A., AlSaleh, M., AlEithan, T., AlArfaj, K., Al Sunayhir, H., & AlSaleh, M. (2021). A community-based prediabetes knowledge assessment among Saudi adults in Al-Ahsa region, 2018. J*ournal of Public Health Research, 10*(1), 2032. https://doi.org/10.4081/jphr.2021.2032

Altamash, M., Arledal, S., Klinge, B., & Engström, P. E. (2013). Prediabetes and diabetes: Medical risk factors and periodontal conditions. *Acta Odontologica Scandinavica*, *71*(6), 1625–1631. https://doi.org/10.3109/00016357.2013.788207

American Diabetes Association (2018). 5. Prevention or delay of type 2 diabetes: Standards of medical care in Diabetes-2018. *Diabetes Care, 41*(Suppl 1), S51–S54. https://doi.org/10.2337/dc18-S005

An, Y., Zhang, P., Wang, J., Gong, Q., Gregg, E. W., Yang, W., Li, H., Zhang, B., Shuai, Y., Chen, Y., Engelgau, M. M., Cheng, Y., Hu, Y., Bennett, P. H., & Li, G. (2015). Cardiovascular and all-cause mortality over a 23-year period among Chinese with newly diagnosed diabetes in the Da Qing IGT and diabetes study. *Diabetes Care*, *38*(7), 1365–1371. https://doi.org/10.2337/dc14-2498

Andes, L. J., Cheng, Y. J., Rolka, D. B., Gregg, E. W., & Imperatore, G. (2020). Prevalence of prediabetes among adolescents and young adults in the United States, 2005-2016. *JAMA Pediatrics, 174*(2), e194498. https://doi.org/10.1001/jamapediatrics.2019.4498

Azwar, S. (2010). *Sikap manusia: Teori dan pengukurannya* [Human attitude: Theory and measurement]. Pustaka Pelajar.

Budiastutik, I., Kartasurya, M. I., Subagio, H. W., & Widjanarko, B. (2022). High prevalence of prediabetes and associated risk factors in urban areas of Pontianak, Indonesia: A cross-sectional study. *Journal of Obesity, 2022*, 4851044. https://doi.org/10.1155/2022/4851044

Centers for Disease Control and Prevention. (2019). *Prediabetes. National diabetes prevention program*. CDC. https://www.cdc.gov/Diabetes/Prevention/about-Prediabetes.Html.

Chiwanga, F. S., Njelekela, M. A., Diamond, M. B., Bajunirwe, F., Guwatudde, D., Nankya-Mutyoba, J., Kalyesubula, R., Adebamowo, C., Ajayi, I. O., Reid, T. G., Volmink, J., Laurence, C., Adami, H. O., Holmes, M. D., & Dalal, S. (2016). Urban and rural prevalence of diabetes and prediabetes and risk factors associated with diabetes in Tanzania and Uganda. *Global Health Action*, *9,* 31440. https://doi.org/10.3402/gha.v9.31440

Compeán, O. L. G., Trujilla, O. L. E., Valles, M. A. M., Reséndiz, G. E., García, S. B., & Pérez, B. D. A. (2018). Obesity, physical activity and prediabetes in adult children of people with diabetes. *Revista Latino-Americana de Enfermagem*, *25*, e2981. https://doi.org/10.1590/1518-8345.2102.2981

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise, 35*(8), 1381–1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB

Dany, F., Dewi, R. M., Tjandrarini, D. H., Pradono, J., Delima, D., Sariadji, K., Handayani, S., & Kusumawardani, N. (2020). Urban-rural distinction of potential determinants for prediabetes in Indonesian population aged ≥15 years: A cross-sectional analysis of Indonesian Basic Health Research 2018 among normoglycemic and prediabetic individuals. *BMC Public Health*, *20*, 1509. https://doi.org/10.1186/s12889-020-09592-7

DeMers, D., & Wachs, D. (2021). *Physiology, mean arterial pressure* [Updated 2021, 21 April. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/Books/NBK538226/

Díaz-Redondo, A., Giráldez-García, C., Carrillo, L., Serrano, R., García-Soidán, F. J., Artola, S., Franch, J., Díez, J., Ezkurra, P., Millaruelo, J. M., Seguí, M., Sangrós, J., Martínez-Candela, J., Muñoz, P., Goday, A., Regidor, E., Alonso, M., Álvarez, B., Álvarez, F., ... Villaró, M. (2015). Modifiable risk factors associated with prediabetes in men and women: A cross-sectional analysis of the cohort study in primary health care on the evolution of patients with prediabetes. *BMC Family Practice*, *16*, 5. https://doi.org/10.1186/s12875-014-0216-3

Division of Nutrition, Physical Activity, and Obesity. (2021). *Obesity and weight status*. CDC. https://www.cdc.gov/nccdphp/dnpao/data-trends-maps/help/npao_dtm/definitions.html

Dugani, S. B., Mielke, M. M., & Vella, A. (2021). Burden and management of type 2 diabetes in rural United States. *Diabetes/Metabolism Research and Reviews*, *37*(5), e341. https://doi.org/10.1002/dmrr.3410

Eikenberg, J. D., & Davy, B. M. (2013). Prediabetes: A prevalent and treatable, but often unrecognized, clinical condition. *Journal of the Academy of Nutrition and Dietetics*, *113*(2), 213–218. https://doi.org/10.1016/j.jand.2012.10.018

El Meouchy, P., Wahoud, M., Allam, S., Chedid, R., Karam, W., & Karam, S. (2022). Hypertension related to obesity: Pathogenesis, characteristics and factors for control. *International Journal of Molecular Sciences, 23*(20), 1230. https://doi.org/10.3390/ijms232012305

Faizah, R., Efendi, F., & Suprajitno, S. (2020). A Systematic review of foot exercises with group support to improve the foot health of diabetes mellitus patients. *Jurnal Ners*, *15*(1Sp), 129–134. https://doi.org/10.20473/jn.v15i1sp.18996

Fajriyah, N., Sudiana, I. K., & Wahyuni, E. D. (2020). The effects from physical exercise on the blood glucose levels, HbA1c and quality of life of type 2 diabetes mellitus patients: A systematic review. *Jurnal Ners*, *15*(1Sp), 486–496. https://doi.org/10.20473/jn.v15i1sp.20517

Fujiati, I. I., Damanik, H. A., Bachtiar, A., Nurdin, A. A., & Ward, P. (2017). Development and validation of prediabetes risk score for predicting prediabetes among Indonesian adults in primary care: Cross-sectional diagnostic study. *Interventional Medicine and Applied Science*, *9*(2), 76–85. https://doi.org/10.1556/1646.9.2017.18

Gillani, A. H., Islam, F. M. A., Hayat, K., Atif, N., Yang, C., Chang, J., Qu, Z., & Fang, Y. (2018). Knowledge, attitudes and practices regarding diabetes in the general population: A cross-sectional study from Pakistan. *International Journal of Environmental Research and Public Health, 15*(9), 1906. https://doi.org/10.3390/ijerph15091906

Hidayati, L., Pratiwi, I. N., Pawanis, Z., McKenna, L., & Widyawati, I. Y. (2021). Buerger exercise reduces the risk of neuropathy in people with diabetes mellitus. *Open Access Macedonian Journal of Medical Sciences*, *9*(G), 94–99 . https://doi.org/10.3889/oamjms.2021.6743

Hosmer, D. W., & Lemeshow, S. (2013). *Applied logistic regression (Second edition)*. John Wiley & Son. https://doi.org/10.1002/0471722146

Hyder, K. M., Mohan, J., Varma, V., Ponnusankar, S., & Raja, D. (2021). Impact of prediabetes education program on knowledge, attitude and practice among prediabetic population of south India. *Preventive Medicine Reports, 23*, 10139. https://doi.org/10.1016/j.pmedr.2021.101395

Indarwati, R., Pratiwi, I. N., & Yuniarsih, N. (2019). Playing cards using the "tepuk nyamuk" method improves cognitive function and social interaction in the elderly. *Indian Journal of Public Health Research and Development*, *10*(8), 2575-257. https://doi.org/10.5958/0976-5506.2019.02255.1

Irenewati, S., Arkhaesi, N., & Wistiani. (2020). Association of BMI measurements to waist circumference and waist-to-height ratio in overweight and obese children. *Paediatrica Indonesiana*, *6*(1), 131–136. https://doi.org/10.14238/pi60.3.2020.131-6

Jiang, J., Cai, X., Pan, Y., Du, X., Zhu, H., Yang, X., Zheng, D., Gaisano, H., Wei, T., & He, Y. (2020). Relationship of obesity to adipose tissue insulin resistance. *BMJ Open Diabetes Research and Care, 8,* e000741. https://doi.org/10.1136/bmjdrc-2019-000741

Joel, S. E., Galantino, M. L., Hutchinson, J., & Jeffrey, M. G. (2019). Health coaching for healthcare employees with chronic disease: A pilot study. *Work*, *63*(1), 49–56. https://doi.org/10.3233/WOR-192907

Kalra, S., Anjana, R. M., Verma, M., Pradeepa, R., Sharma, N., Deepa, M., Singh, O., Venkatesan, U., Elangovan, N., Aggarwal, S., Kakkar, R., & Mohan, V. (2024). Urban–rural differences in the prevalence of diabetes among adults in Haryana, India: The ICMR-INDIAB Study (ICMR-INDIAB-18. *Diabetes Therapy*, *15*(7), 1597–161. https://doi.org/10.1007/s13300-024-01602-w

Kim, K. A., & Shim, J. L. (2019). Factors influencing prediabetes in middle-aged women based on the KNHANE. *Korean Journal of Adult Nursing*, *31*(6), 62. https://doi.org/10.7475/kjan.2019.31.6.628

Kusumaningrum, N. S. D., Hidayati, W., & Muin, M. (2020). Prediabetes and the contributing factors: A study in Semarang, Central Java. *Jurnal Keperawatan Soedirman*, *15*(2), 39–48. http://doi.org/10.20884/1.jks.2020.15.2.846

Kyrou, I., Tsigos, C., Mavrogianni, C., Cardon, G., Van Stappen, V., Latomme, J., Kivelä, J., Wikström, K., Tsochev, K., Nanasi, A., Semanova, C., Mateo-Gallego, R., Lamiquiz-Moneo, I., Dafoulas, G., Timpel, P., Schwarz, P. E. H., Iotova, V., Tankova, T., Makrilakis, K., & Manios, Y. (2020). Sociodemographic and lifestyle-related risk factors for identifying vulnerable groups for type 2 diabetes: A narrative review with emphasis on data from Europe. *BMC Endocrine Disorders, 20*, 134. https://doi.org/10.1186/s12902-019-0463-3

Lee, P. H., Macfarlane, D. J., Lam, T. H., & Stewart, S. M. (2011). Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity, 8*, 115. https://doi.org/10.1186/1479-5868-8-115

Lemeshow S., Lwanga S. K., & Organization, W. H. (1997). *Sample size determination in health studies: A practical manual / S. K. Lwanga and S. Lemeshow*. World Health Organization. https://iris.who.int/handle/10665/40062

Mainous, A. G., Tanner, R. J., Baker, R., Zayas, C. E., & Harle, C. A. (2014). Prevalence of prediabetes in England from 2003 to 2011: Population-based, cross-sectional study. *BMJ Open*, *4*(6), 4–11. https://doi.org/10.1136/bmjopen-2014-005002

Medina, N. (2019). *News on the calibration of non-automatic weighing instruments*. The 19th International Congress of Metrology. https://doi.org/10.1051/metrology/201927002

Ministry of Health Republic of Indonesia. (2018). *Riset kesehatan dasar 2018* [2018 Basic health research]. Ministry of Health Republic of Indonesia.

Noventi, I., Rusdianingseh, R., & Khafid, M. (2019). Prevalensi, karakteristik dan faktor resiko prediabetes di wilayah pesisir, pegunungan dan perkotaan [Prevalence, characteristics and risk factors for prediabetes in coastal, mountainous and urban areas]. *Jurnal Ners dan Kebidanan*, *6*(3), 371–381. https://doi.org/10.26699/jnk.v6i3.art.p371-381

Nurwanti, E., Hadi, H., Chang, J. S., Chao, J. C., Paramashanti, B. A., Gittelsohn, J., & Bai, C. H. (2019). Rural-urban differences in dietary behavior and obesity: Results of the Riskesdas study in 10-18-year-old Indonesian children and adolescents. *Nutrients, 11*(11), 281. https://doi.org/10.3390/nu11112813

Okosun, I. S., & Lyn, R. (2015). Prediabetes awareness, healthcare provider's advice, and lifestyle changes in American adults. *International Journal of Diabetes Mellitus*, *3*(1), 11–18. https://doi.org/10.1016/j.ijdm.2010.12.001

Pakpour, V., Molayi, F., & Nemati, H. (2024). Knowledge, attitude, and practice of prediabetic older people regarding prediabetes. *BMC Geriatrics, 24*, 264. https://doi.org/10.1186/s12877-024-04864-y

Perng, W., Conway, R., Mayer-Davis, E., & Dabelea, D. (2023). Youth-onset type 2 diabetes: The epidemiology of an awakening epidemic. *Diabetes Care*, *46*(3), 490–499. https://doi.org/10.2337/dci22-0046

Poltavskiy, E., Kim, D. J., & Bang, H. (2016). Comparison of screening scores for diabetes and prediabetes. *Diabetes Research and Clinical Practice, 118,* 146–153. https://doi.org/10.1016/j.diabres.2016.06.022

Pratiwi, I. N., Nursalam, N., Widyawati, I. Y., & Ramoo, V. (2024). Spousal involvement in collaborative management and glycemic behavior change among patients with diabetes mellitus: A Systematic review. *SAGE Open Nursing*, *10*, 1-16 https://doi.org/10.1177/23779608241245196

Pratiwi, I. N., Pawanis, Z., Hidayati, L., Widyawati, I. Y., Ni'Mah, L., Sukartini, T., Bakar, A., & Mariyanti, H. (2018). The role of a healthy-eating educational module during Ramadan in a community health centre. *Journal of Diabetes Nursing*, *22*(2), JDN013. https://www.diabetesonthenet.com/resources/details/healthy-eating-educational-module-ramadan

Pratiwi, I. N., Purwaningsih, & Ramahwati, S. (2019). The correlation between family support and quality of life in mothers with positive HIV in Surabaya. *Indian Journal of Public Health Research and Development*, *10*(8), 2703-270. https://doi.org/10.5958/0976-5506.2019.02278.2

Quang Binh, T., Tran Phuong, P., Thi Nhung, B., Dinh Thoang, D., Van Thang, P., Khanh Long, T., & Van Thanh, D. (2012). Prevalence and correlates of hyperglycemia in a rural population, Vietnam: Implications from a cross-sectional study. *BMC Public Health*, *12*, 939. https://doi.org/10.1186/1471-2458-12-939

Rahim, F. F., Abdulrahman, S. A., Maideen, S. F. K., & Rashid, A. (2020). Prevalence and factors associated with prediabetes and diabetes in fishing communities in Penang, Malaysia: A cross-sectional study. *PLoS ONE*, *15*(2), e0228570. https://doi.org/10.1371/journal.pone.0228570

Rodriguez-Segade, S., Rodriguez, J., Camiña, F., Sanmartín-Portas, L., Gerpe-Jamardo, J., Pazos-Couselo, M., García-López, J. M., Alonso-Sampedro, M., González-Quintela, A., & Gude, F. (2019). Prediabetes defined by HbA 1c and by fasting glucose: Differences in risk factors and prevalence. *Acta Diabetologica*, *56*(9), 1023–1030. https://doi.org/10.1007/s00592-019-01342-5

Shiyanbola, O. O., Ward, E. C., & Brown, C. M. (2018). Utilizing the common sense model to explore African Americans' perception of type 2 diabetes: A qualitative study. *PLoS ONE, 13*(11), e0207692. https://doi.org/10.1371/journal.pone.0207692

Sinawang, G. W., Kusnanto, K., & Pratiwi, I. N. (2020). Systematic review of family members in improving the quality of life of people with T2DM. *Jurnal Ners*, *15*(2), 107–112. http://doi.org/10.20473/jn.v15i2.18975

Subramaniam, S., Dhillon, J. S., & Wan Ahmad, W. F. (2021). Behavioral theory-based framework for prediabetes self-care system—design perspectives and validation results. *International*

Journal of Environmental Research and Public Health, *18*(17), 916. https://doi.org/10.3390/ijerph18179160

Surabaya City Health Office. (2022). *Profil kesehatan tahun 2021 [Health profile in 2021].* Surabaya City Health Offic https://dinkes.jatimprov.go.id/userfile/dokumen/PROFIL%20KESEHATAN%202021%20 JATIM.pdf

Tanoey, J., & Becher, H. (2021). Diabetes prevalence and risk factors of early-onset adult diabetes: Results from the Indonesian family life survey. *Global Health Action*, *14*(1), 2001144. https://doi.org/10.1080/16549716.2021.2001144

Thojampa, S., Sarnkhaowkhom, C., Klankhajhon, S., Puraya, A., & Sahattecho, W. (2020). Self-efficacy of exercise in older adults with diabetes: A concept analysis. *Jurnal Ners*, *15*(1), 105–112. https://doi.org/10.20473/jn.v15i1.19184

Ureña-Bogarín, E. L., Martínez-Ramírez, H. R., Torres-Sánchez, J. R., Hernández-Herrera, A., Cortés-Sanabria, L., & Cueto-Manzano, A. M. (2015). Prevalence of prediabetes in young Mexican adults in primary health care. *Family Practice*, *32*(2), 159–164. https://doi.org/10.1093/fampra/cmu047

Van Wissen, K., & Blanchard, D. (2021). The 'work' of self-care for people with cardiovascular disease and prediabetes: An interpretive description. *International Journal of Nursing Studies*, *116*, 10354 . https://doi.org/https://doi.org/10.1016/j.ijnurstu.2020.103548

Wang, X., & Cheng, Z. (2020). Cross-sectional studies: Strengths, weaknesses, and recommendation. *Chest, 158*(1S), S65–S71. https://doi.org/10.1016/j.chest.2020.03.012

Zhao, M., Lin, H., Yuan, Y., Wang, F., Xi, Y., & Wen, L. M. (2016). Prevalence of prediabetes and its associated risk factors in rural areas of Ningbo , China. *International Journal of Environmental Research and Public Health 13(8), 808.* https://doi.org/10.3390/ijerph13080808

Zhao, X., Zhao, W., Zhang, H., Li, J., Shu, Y., Li, S., Cai, L., Zhou, J., Li, Y., & Hu, R. (2013). Fasting capillary blood glucose: An appropriate measurement in screening for diabetes and prediabetes in low-resource rural settings. *Journal of Endocrinological Investigation*, *36*(1), 33–37. https://doi.org/10.3275/8304

Zhu, J., Xing, G., Shen, T., Xu, G., Peng, Y., Rao, J., & Shi, R. (2019). Postprandial glucose levels are better associated with the risk factors for diabetes compared to fasting glucose and glycosylated hemoglobin (HbA1c) levels in elderly prediabetics: Beneficial effects of polyherbal supplements-a randomized, double-blind, placebo controlled trial. *Evidence-Based Complementary and Alternative Medicine: eCAM, 2019*, 792373. https://doi.org/10.1155/2019/7923732

Zhu, P., Lao, G., Li, H., Tan, R., Gu, J., & Ran, J. (2023). Replacing of sedentary behavior with physical activity and the risk of mortality in people with prediabetes and diabetes: a prospective cohort study. *The International Journal of Behavioral Nutrition and Physical Activity, 20*, 81. https://doi.org/10.1186/s12966-023-01488-0