Waist Circumference, BMI, and Activity's Role in Glucose Intolerance in Tangerang Adults

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Abstract. Impaired glucose tolerance is a condition that is not included in the category of diabetes, but in this condition is higher blood sugar levels. This is cused by a waist circumference that is more than the reference standard, namely > 80 cm for female and > 90 cm for male, nutritional status based on body mass index 25 kg/m^2. Less activity also become a factor that makes impaired glucose tolerance. The study aimed to identify and analysis the wait circumference, body mass index, physical activity and the impaired glucose tolerance of Indonesian adults in Tangerang City. The research method was quantitative with a cross-sectional design and the sampling technique is propotional random sampling. The number of respondents in this research were 135 adults by age 30 -50 years. The data obtained based on the measurment fasting blood sugar, impaired glucose tolerance, waist circumference, body mass index, and physical activity qustionnaire. The results showed that as much 53,3% respondenths have impaired glucose tolerance, there was a significat relation exists on the waist circumference (p=0,001), BMI (p=0,002), and physical activity (p=0,000) as the impaired glucose tolerance. The conclusion is thar there is a relationship between waist circumference, body mass index and physical activity with incidence of impaired glucose tolerance in adults in Karawaci District, Tangerang City.

Keywords: adult, body mass index, impaired glucose tolerance, physical activity, waist circmuference.

1 Introduction

Metabolic diseases such as diabetes mellitus are characterized by hyperglycemia caused by disturbances in insulin production, insulin action or both.[1] Based on the IDF, the Southeast Asia region ranks 3rd with the number of cases, namely 90.2 million experiencing diabetes mellitus. Indonesia ranks 5th with 19.5 million experiencing diabetes mellitus and is expected to increase in 2045 to 28.6 million people affected by diabetes mellitus.[2] Based on the age category 30-50 years, the prevalence of diabetes in Indonesia is 10.9% .[3] IGT is a condition that is not yet included in the diabetes category, but there has been an increase in blood sugar in the body.[4] IGT is a risk factor that can have an impact on DM, hypertension, and coronary heart disease.[4]

Globally, the occurrence of IGT continues to increase from year to year. Based on the IDF, in 2021 the population of Southeast Asia will be 5.4% and 46.7 million people will experience IGT. Thus, the IDF estimates that in 2045 there will be an increase in the incidence of IGT to 5.8% and 76.6 million people. Meanwhile, the incidence of IGT in developing countries is 12.7% and 33 million people experience impaired glucose tolerance.[2] Based on the 2018 Riskesdas data, the prevalence of IGT in Indonesia is 30.8% and urban areas is 28.8%.[3] Meanwhile, in the provinces Banten by 8.7%. [5]

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IGT is influenced by one of them by nutritional status. Nutritional status in adults can be determined based on BMI and waist circumference measurements. The proportion of IGT is more dominant in individuals who have obese nutritional status (≥25 kg/m2) with a prevalence of 23.4%.[6] Obesity can have an impact on the incidence of insulin resistance which can be characterized by high blood sugar levels. As many as 16% of IGT occur in individuals who have excess BMI (obesity).[7] Nutritional status ≥ 25 kg/m2 has a 1.24 times risk of experiencing impaired glucose tolerance.[8]

Apart from the incidence of obesity in adults which can affect the incidence of IGT, it turns out that excess waist circumference can also have a significant effect on the incidence of IGT. Central obesity rate in Indonesia is 31%, Banten is 30.6% and especially in Tangerang City is 32.21%.[3] Research on measuring waist circumference that exceeds the standard average can affect the occurrence of IGT. The higher the waist circumference, the more likely it is to experience glucose tolerance with a significant value, namely r = 0.259.8 Central obesity is 4 (OR = 4.58) times more at risk of experiencing IGT.[9]

The other factors that can affect the occurrence of glucose tolerance, namely physical activity. A low level of activity can result in a continuous rise in insulin so that blood sugar levels decrease.[10] the proportion of physical activity levels that are lacking, based on Riskesdas data in 2018, is 33.5%, which can lead to obesity and excess abdominal circumference as a result of lazy activity. Physical Meanwhile, the prevalence of low physical activity in adults is 23.2%.[3] In Anisah's study (2021), 76% of individuals who have a low level of physical activity experience IGT.[11] A low level of physical activity can increase the risk of developing IGT by 23%.[12]

Communities who live in Karawaci District, Tangerang City have fairly easy access to various facilities. This is the cause of obesity, especially central obesity and low physical activity so that it can have an impact on the incidence of IGT or increased glucose levels. Based on a preliminary study conducted on adults aged 30-50 years in Karawaci District, the prevalence of waist circumference was ≥80 cm (69.2%), fasting blood sugar was in the category of pre-diabetes (38.5%) and diabetes (7.7%).), and IGT prevalence (7.7%). Based on the description of the problems that have been described, this study seeks to reveal the relationship between waist circumference, BMI, and physical activity with the incidence of IGT in adults in Karawaci District, Tangerang City. The difference between this research and previous research is based on the place, characteristics of respondents, and the population of the region.

2 Research Methods

This research used a cross-sectional study conducted from October to November 2022 in Karawaci District, Tangerang City, Banten Province, Indonesia. This research has received ethical approval from the Ethics Commission for Medical and Health Research at the University of Muhammadiyah Prof. Dr. Hamka.

The population of this study was adults aged 30-50 years in two sub-districts in the Karawaci District, Tangerang City. The inclusion criteria are: (a) adults aged 30-50 years who live in Bugel and Nambo Jaya sub-districts; (b) Do not suffer or have a history of diabetes mellitus; and (c) People who are willing to be research respondents by filling out *informed consent*. Respondents who were sick, respondents, who were pregnant, did not fast the night before the interview and took kailer blood samples would be excluded from the respondents. This research was conducted in Karawaci District by selecting 2 sub-districts, namely Bugel and Nambo Jaya Sub-

Districts. The sample in this study was 135 respondents. The selection of research locations used the *cluster sampling method* with the sampling method, namely *random sampling*.

Information on the characteristics of the respondents (age, gender, and occupation), family history of DM, and physical activity were obtained by conducting interviews using a questionnaire. Anthropometric measurements are carried out by trained enumerators with pre-calibrated tools. Weight measurements used digital scales, height measurements used a microtoise stature meter and waist measurements used an Onemed measuring tape (waist ruler OD325).

BMI is calculated by dividing the results of measurements of body weight (kg) by height (m2) and waist circumference from the results of waist circumference measurements (cm). Physical activity based on the total from the results of the questionnaire (Mets-minutes/week). BMI is categorized as obese if it is >27 kg/m^2, overweight if it is 25.0 – 27.0 kg/m^2, normal if it is >18.5 – 24.9 kg/m^2, and less if it is <18.5 kg/m^2. For waist circumference, it is categorized as central obesity if it is >80 cm for women or >90 cm for men (Ministry of Health, 2013). For physical activity scores, it is categorized as light physical activity if <600 MET-minutes/week, moderate physical activity ≥600 MET-minutes/week, and active physical activity if 1500 – 3000 or ≥3000 MET-minutes/week.[13]

Impaired glucose tolerance was carried out by OGTT by checking fasting blood glucose levels and given a 75 gram glucose load, then 2 after that it was checked again to check post prandial blood glucose levels using a glucometer. It is said that IGT is with fasting glucose <100 mg/dL and OGTT between 140 – 199 mg/dL and is said to be normal with OGTT results <140 mg/dL).

Descriptive data are presented using the mean, median, min-max, and standard deviation for continuous data, while proportions are for categorical data. Bivariate analysis used the *chi-square* test while calculating the risk factors associated with IGT used a multivariate logistic regression test with a 95% confidence interval. Statistical analysis was calculated using SPSS software version 26.

3 Results and Discussion

3.1 Results

The prevalence of *Impaired Glucose Tolerance* (IGT) in adults in Karawaci District, Tangerang City is 53.3%. Respondent characteristics and observed influence factors included female sex (86.7%), age 36-45 years (54.8), not working (54.1%), central obesity (73.3%), obesity (51 .9%), and low activity (48.2%) (Table1).

Analysis of the relationship between several variables with the incidence of *Impaired Glucose Tolerance* (IGT) can be seen in (Table 2). Based on the results of bivariate analysis, waist circumference (p-value<0.001), body mass index (p-value<0.002), and physical activity (p-value<0.000) showed a significant relationship with the incidence of impaired glucose tolerance.

The results of multivariate logistic regression analysis (Table 3) revealed factors associated with IGT. Nutrtional status based on BMI is times more at risk of IGT (OR =3,721, p-*value* = 0,003). Physical activity has a significant influence on the incidence of IGT, 3 times more at risk of ecperiencing IGT (OR = 3,804, p-*value* = 0,001).

Table 1. Distribution of participants characteristics, incidence of IGT, FBS, BMI, WC, physical activity

Variable	Category	n	%	Mean (SD)
Age	Early Adulthood (26 – 35 years)	18	13,3	42 (5,891)
	Late Adulthood (36 – 45 years)	74	54,8	
	Early Elderly (46 – 55 years)	43	31,9	
Sex	Male	18	13,3	
	Female	117	86,7	
Profession	Entrepreneur	33	24,4	
	labour	11	8,1	
	Honorer workers	2	1,5	
	Civil servant	1	0,7	
	Private employes	15	11,1	
	Not working/housewife	73	54,1	
FBS	Diabetes	5	3,7	94,90 (15,040)
	Pre-Diabetes	35	25,9	
	Normal	95	70,4	
IGT	IGT	72	53,3	138,42 (29,867)
	Normal	63	46,7	
WC	Central obesity	99	73,3	86,47 (8,661)
	Normal	36	26,7	
BMI	Obesity	70	51,9	27,18 (3,690)
	Overweight	26	19,3	
	Normal	38	28,1	
	Underweight	1	0,7	
Physical Activity	Low Activity	65	48,2	759,40 (321,602)
	Moderate Activity	67	49,6	
	High Activity	3	2,2	

Notes: SD: Standard Deviation, FBS: Fasting Blood Sugar, IGT: Impaired Glucose Tolerance, WC: Waist Circumference, BMI: Body Mass Index

Table 2. The relationship between waist circumference, body mass index, and physical activity with impaired glucose tolerance (n=135)

Variable	Category	IGT		Normal		Total		P-*value*	OR 95% - CI
		n	%	n	%	n	%		
WC	Central Obesity	61	62,2	37	37,8	98	100	0,001	3,897 (1,725 – 8,801)
	Normal	11	29,7	26	70,3	37	100		
BMI	Overweight – Obesity	58	62,4	35	37,6	93	100	0,002	3,314 (1,540 – 7,133)
	Normal – Kurang	14	33,3	28	66,7	42	100		
Physical Activity	Low Activity	45	69,2	20	30,8	65	100	0,000	3,583 (1,756 – 7,134)
	Moderate Activity	27	38,6	43	61,4	70	100		

Notes: SD: Standard Deviation, OR: Odds Ratio, IGT: Impaired Glucose Tolerance, WC: Waist

Circumference, BMI: Body Mass Index

Table 3. Multiple Logistic Regression Results for Factors Associated with IGT Incidence (n = 135)

Independent Variable	Sig (2-tailed)	Coeff B	OR	95% CI OR	
				LL	UL
Age	0,023	-0,695	0,499	0,274	0,907
Body Mass Index	0,003	1,314	3,721	1,587	8,728
Physical Activity	0,001	1,336	3,804	1,737	8,329
Constant	0,405	-0,426			

Notes: Sig = Significant, OR = Odds Ratio, LL = Lower Limit, UL = Upper Limit

3.1 Discussion

3.1.1 Prevalency of IGT

Based on the results of research conducted in Karawaci District, Tangerang City, a total sample of 135 respondents was taken using simple random sampling technique. This research was conducted from September to October 2022. It was found that the prevalence of IGT in adults in the Karawaci District, Tangerang City, was 53.3%, higher than the national data (30.8%) and 28.8% in urban areas.[3] Meanwhile, the prevalence the incidence of IGT in Indonesia is 30.8% and in urban areas 28.8%.[3] This is probably due to the fact that most of the respondents were aged (>40 years), in contrast to Riskesdas, which took the youngest sample at 15 years. In addition, most of the respondents were female and had a nutritional status of obesity, central obesity and low physical activity. This is because the nutritional status of obesity, central obesity and light physical activity can affect the incidence of IGT. The incidence of IGT can have an impact on DM, hypertension and coronary heart disease.[14]

The National Kohort Study from 2007 to 2009 said that as many as 47.8% still had TGT.[4]

In addition, research on young adults in urban Indonesia, found results that the incidence of TGT was more common at the age of ≥30 years with a prevalence of 5.7% and 42% respectively, & experienced TGT. [4][5] This is caused by increasing age and increasing abnormal nutritional status which can affect the performance of pancreatic beta cellsal. [15][16]

3.1.2 Waist circumference

Measuring nutritional status is not only seen from BMI but can also be seen from waist circumference. Waist circumference measurement that can identify with the incidence of central obesity. Central obesity occurs due to the accumulation of excess fat in the abdominal area and increased levels of visceral fat. [8][17] The incidence of central obesity is associated with the risk of cardiovascular disease from metabolic syndrome so that waist circumference measurements can identify the presence of visceral fat deposits. [18]

The results of this study indicate that there is a significant relationship between central obesity and the incidence of IGT. Respondents who are centrally obese with impaired glucose tolerance are 62.2%. The results of these data are higher compared to research conducted in Yogyakarta (35.5%) and DKI Jakarta (47.8%). [4] [9]

This study shows that the risk of experiencing IGT in respondents who are classified as centrally obese is 4 times higher than that of those with a normal waist circumference. When compared to other studies, Astuti's (2012) research found a significant relationship between central obesity and the incidence of IGT (p-value = 0.003), and the odds ratio (OR) results indicated that respondents with central obesity were 5 times more likely to have impaired glucose tolerance.[2] The same results were also found in Ramadhani's research (2017) centrally obese individuals were 2 times more at risk of having pre-diabetes.[18]

Based on the results of the researchers' observations, when measuring waist circumference, it was found that some respondents had excess waist circumference, especially in women. Respondents with central obesity have a GDP level that is close to pre-diabetes. After being given fasting glucose loading, there was a very significant increase in the value of blood glucose levels. Meanwhile, individuals in the normal category had normal GDP levels and after being given a fasting glucose load did not experience an increase, and there were even some respondents who experienced a decrease in blood glucose levels, the initial GDP value was > 90 mg/dL, and after fasting glucose loading, the TGT value was <80 mg/dL.

The incidence of central obesity can affect non-communicable diseases, one of which is diabetes mellitus. Central obesity has an adverse impact on organ function. Central obesity can cause an increase in cytokines, particularly TNF- a and IL-6, which can lead to hyperglycemia and hyperinsulinemia. This is caused by an increase in *lipolysis* in the body and the release of free fatty acids, which will then continue to be stored in the liver, muscles, and pancreatic β cells.[9][19] *Tumor necrosis factor alpha* (TNF-a) and *interleukin*-6 (IL-6) act as inflammatory mediators in this condition, increasing appetite and influencing metabolism.[20] When TNF-a secretion increases, it can interfere with insulin production by inhibiting insulin receptor signaling, or "interfering with receptor kinase activity," so that IRS (IL-6-induced *insulin receptor substrates*) are not phosphorylated. Reduced IRS phosphorylation can indicate that IRS does not react with PI 3-kinase. PI-3 kinase activation decreases, which causes the vesicles in GLUT 4 to not function on the cell surface. The function of the vesicles on the cell surface does not occur, so glucose cannot enter the cell.[21]

3.1.3 Body mass index

The measurement of nutritional status based on body mass index is a very simple measurement in terms of body weight and height to categorize nutritional status as under, normal, or more in adults. Poor nutritional status can put you at risk of infectious diseases, while excess nutritional status can put you at risk of degenerative diseases.[22] Degenerative diseases are caused by decreased organ function in the body.[23] Obesity-related nutritional status can increase the risk of experiencing metabolic syndrome events, such as tolerance events or impaired glucose, which have an impact on type 2 diabetes mellitus, compared to normal nutritional status.[17]

The results of this study indicate that there is a significant relationship between *overweight-obesity* and the incidence of IGT. Respondents who are *overweight* or obese with impaired glucose tolerance are 62.4%. The results of these data are higher compared to research conducted in urban areas of Indonesia, namely 23.4%.[6]

This study shows that the risk of experiencing IGT in *overweight* or obese respondents is three times higher than that in those with normal nutritional status. When compared to other studies, showed that there was a significant difference between the nutritional status of obesity and the incidence of IGT (p-value = 0.000) and stated that the Odss Ratio (OR) results were 1 times more at risk of experiencing impaired glucose tolerance in respondents with overweight-

obesity nutritional status. 6 The same findings were found in study, which discovered that obese people are two times more likely to develop pre-diabetes. [24]

Based on the results of observations, some respondents who had normal nutritional status had a GDP value in the normal category, and after loading fasting glucose there was no significant increase; there were even some respondents who experienced a decrease in blood glucose levels, while individuals with *overweight* or obese nutritional status had a value or level of GDP approaching pre-diabetes. Then, after loading fasting glucose, there is a very significant increase in blood glucose levels. It has been found that the incidence of obesity can affect the increase in blood glucose levels.

Individuals with an obese nutritional status are more likely to have impaired glucose tolerance.[6] some literature says that obesity is closely related to insulin resistance, causing an increase in blood sugar levels.[25] The decrease in pancreatic β-cells is influenced by the incidence of obesity. β-cells have a very important function in regulating insulin release. Obesity-related decreases in -cell function can result in pancreatic inflammation. Thus, inflammation can cause the proliferation of macrophages. Then, macrophages will meet directly with β-cells or interact directly so that they can cause damage to β-cells. The presence of β-cell damage caused by macrophage interactions can result in abnormal fasting glucose tolerance. [26][27]

3.1.4 Physical activity

Nowadays, where transportation is easily accessible and technology is sophisticated enough to make it easier for people to travel to a location that encourages low physical activity, [28]

The results of this study indicate that there is a significant relationship between physical activity and the incidence of IGT. 69.2% of those who participated in light physical activity had impaired glucose tolerance. The results of these data are below the prevalence of research conducted in Java, which is 76%.[11]

According to this study, respondents with a low level of physical activity are four times more likely to experience IGT than those who regularly engage in physical activity. When compared to other studies, showed that there was a significant difference between lack of physical activity and the incidence of IGT (p-value = 0.001) and stated that the results of the Odss Ratio (OR) were 49 times more at risk of experiencing impaired glucose tolerance in respondents who were less active in physical activity.[11] The same results were also found in was a significant relationship between lack of physical activity and the incidence of prediabetes with a p-value of 0.006 (p 0.05). This is because in respondents who do less physical activity, there can be interference with insulin release, which can cause hyperglycemia.[29]

The results of logistic regression analysis show that physical activity affets the incidence of IGT. The low physical activity, than more siginificat the ecperience of IGT (OR= 3,804; 95% CI = 1,737 – 8,329). This is line with showing that light physical activity has a risk having IGT (OR = 49,08) compared to those who regularly do physical activity.[11] This due to the rarity of the community doing physical activity. On average, people do more physical activities such as housework, rarely do sports.

Based on the results of observations, there were 3 respondents who regularly carried out physical activities with the intensity and duration of physical activity, namely 3 to 4 times per week for 30 to 1 hour of exercise. These respondents routinely do *endurance* and *cardiorespiratory* sports. At the time of examination, the results of the respondent's GDP were 84 mg/dL, and after being given a glucose load, there was no increase; the results of examining blood sugar levels remained at 84 mg/dL. Therefore, this is in accordance with the theory that

regular physical activity can prevent and control blood sugar levels. Physical activity can cause blood sugar regulation and control because it causes the use of glucose in the muscles, which is then converted into energy, causing blood sugar levels to fall. Conversely, if there is a lack of physical activity, an increase in blood sugar levels can occur.[30] Exercise is a form of physical activity. Physical activity can be done for at least 30 minutes or more in one week. Physical activity is extremely beneficial to blood sugar management. Physical activity can cause the breakdown of sugar stored in the muscles. This is caused by the contraction of the muscles resulting from the movement of physical activity, which then results from the breakdown of sugar and can be converted into energy. This can cause a decrease in blood sugar levels.[29] Physical activity such as walking or moderate-intensity aerobic exercise for about 30 minutes can reduce blood sugar levels by 25.36–76 mg/dL, 0.3–0.4 mmol/L, and 0.02–0.9%. So it can be concluded that there is a decrease in blood sugar levels after physical activity of both moderate and heavy intensity.

4 Conclusions

The prevalence of impaired glucose tolerance in adults in Karawaci District, Tangerang City, is 53.3%. This study shows that there is a significant relationship between waist circumference, body mass index, and physical activity and the incidence of impaired glucose tolerance in adults in Karawaci District, Tangerang City.

4.1.1 Abbreviations

IGT : Impaired Glucose Tolerance, FBG: Fating Blood Glucose, BMI: Body Mass Index, WC: Waist Circumference, IDF: International Diabetes Ferediton, Riskesdas: Riset Kesehatan Dasar, DM: Diabetes Melitus.

4.1.2 Ethics approval and consent to participate

This research has been reviewed with an ethical test by the Ethics Commission for Medical and Health Research at the University of Muhammadiyah Prof. Dr. Hamka.

4.1.3 Competing interest

The author declares that there are no significant competing financial, professional, or personal interests that might significantly influence the performance or presentation of the work in this manuscript.

4.1.4 Availability of data and materials

The data presented in this article is openly available and can be accessed by following the links attached in the references section.

4.1.5 Authors' contribution

All authors were involved in this research. SFM organizes research topics beginning with concept generation, design, data analysis, and research data interpretation. The DRP and LNN played a role in the intellectual content of the research, providing revisions and final approval for publication of this research.

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