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Correlation of lipid profile, glucose, and body composition on insulin resistance in overweight and obese subjects

Korelasi profil lipid, glukosa, dan komposisi tubuh, terhadap resistensi insulin subjek kelebihan berat badan dan obesitas

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Abstract

Indonesia has the highest prevalence of obesity in the Asia-Pacific region. Insulin resistance is a form of obesity that causes damage to the liver, heart, and pancreatic tissue as we age. This study aimed to determine the correlation among lipid profiles, glucose levels, body composition, and insulin resistance. Methods: This study used a pre-experimental design and was conducted at the Gorontalo Ministry of Health Polytechnic in February 2023 on 31 obese people whose venous blood was collected for examination of insulin resistance variables. Data were collected by purposive sampling with data analysis using Pearson Correlation and Spearman Rank statistical tests at a 95% confidence interval (CI). Results: Insulin resistance status based on sex, using the TyG index, was dominated by women (55%) among the 20 people who experienced insulin resistance. Men are more likely to be aged <30 years than women, according to the HOMA-IR index. The Pearson triglyceride test value (p= 0,000, r= 0,974) shows that the relationship between triglycerides and the TyG index was very strong, whereas when the HOMA-IR index was used, fasting insulin (p= 0,000, r= 0,985) had a very strong relationship. In conclusion, lipid profile (triglycerides, total cholesterol, LDL), fasting glucose, fasting insulin, and visceral fat percentage correlated with insulin resistance.

Keywords: Fasting insulin, fasting glucose, HOMA-IR, TyG Index

Abstrak

Resistensi insulin merupakan salah satu bentuk obesitas yang menyebabkan kerusakan pada jaringan hati, jantung, dan pankreas seiring bertambahnya usia. Penelitian bertujuan untuk mengetahui hubungan profil lipid, glukosa, dan komposisi tubuh dengan resistensi insulin. Metode penelitian menggunakan desain pra-eksperimental dan dilakukan di Politeknik Kesehatan Kementerian Kesehatan Gorontalo pada bulan Februari 2023 terhadap 31 orang penderita obesitas yang diambil darah venanya untuk pemeriksaan variabel resistensi insulin. Pengumpulan data dilakukan secara purposive sampling dengan analisis data menggunakan uji statistik Korelasi Pearson dan Rank Spearman pada CI 95%. Hasil, status resistensi insulin berdasarkan jenis kelamin dengan menggunakan indeks TyG didominasi oleh perempuan (55%). Laki-laki lebih mungkin terjadi resistensi insulin pada usia <30 tahun dibandingkan perempuan, menurut indeks HOMA-IR. Nilai uji trigliserida Pearson (p=0,000, r=0,974) menunjukkan bahwa korelasi antara trigliserida dengan indeks TyG sangat kuat, sedangkan jika digunakan indeks HOMA-IR maka insulin puasa (p=0,000, r=0,985) memiliki korelasi yang sangat kuat. Kesimpulan, profil lipid (trigliserida, kolesterol total, LDL), glukosa puasa, insulin puasa, dan persentase lemak visceral berkorelasi dengan resistensi insulin.

Kata Kunci: HOMA-IR, TyG Index, insulin puasa, glukosa puasa

Introduction

Obesity is a serious problem in Indonesia and worldwide and is worsening every year. Among 20-49 year olds, overweight accounts for 33% and obese for 19% (Anyanwu et al., 2022). In accordance with the Body Mass Index (BMI) of the Asia-Pacific obesity category of 25 kg/m^2, the prevalence of obesity has increased over the past 30 years by 27,5% in adults and 47,1% in children (Ramdas et al., 2018; Apovian, 2016). Energy inflow and output are unbalanced, which leads to obesity (Téllez-Rojo et al., 2019), and environmental factors, epigenetics, and changes in bacteria in the human intestine account for recent advancements in the primary causes of obesity (Singh et al., 2017; Abenavoli et al., 2019).

Obesity is one of the main components of metabolic syndrome. Individuals with obesity and healthy metabolic disorders do not show increased mortality, heart disease, or diabetes mellitus. In contrast, metabolic disorders associated with obesity cause the liver, heart, and pancreatic tissues to worsen with age (Molli et al., 2017). Research has shown that a high-carbohydrate, high-fat diet for 8-16 weeks causes localized inflammation and metabolic disturbances that should be avoided (Sun et al., 2017).

Reduced sensitivity to insulin action as well as lower absorption and utilization of glucose in the liver, which is exacerbated by obesity and dietary fat intake, is known as insulin resistance (Liu et al., 2021; Labatjo et al., 2023). A hyperinsulinemic euglycemic clamp to evaluate insulin-mediated glucose signaling (Mishra et al., 2022), "homeostasis model assessment of insulin resistance (HOMA-IR) index using fasting glucose and fasting insulin levels (de Cassia da Silva et al., 2019), and triglyceride/glucose (TyG) as a good marker for predicting glucose conversion (Liberty et al., 2021) are a few techniques for examining insulin sensitivity to assess insulin resistance. Adipose tissue cytokine (M1) normalizes insulin sensitivity in obesity, thereby preventing pancreatic cell death (Chen et al., 2021).

A cross-sectional survey of 2497 Qatari individuals between the ages of 18 and 64 years revealed that, whereas physical activity, central obesity, and hypertension were strongly related to DM, an unhealthy diet was significantly associated with pre-DM diabetes mellitus (Al-Thani et al., 2021). Another study showed that foods high in carbohydrates, such as white rice and sugar, and foods high in glycemic load lead to obesity in Asia, whereas foods high in fat, such as nuts and milk, are not associated with weight gain (Ludwig & Ebbeling, 2018). Type 2 diabetes mellitus can be caused by central obesity, increased body fat, and insulin resistance. According to the IDF, there will be 578 million adults with diabetes worldwide by 2030, and 700 million by 2045(Atlas, 2019).

This study was first conducted in the Gorontalo Province. The prevalence of obesity in Gorontalo is higher than the national obesity rate of 31% (Kemenkes, 2018). To date, there has been no research on insulin resistance. The purpose of this study was to determine the status of insulin resistance in overweight or obese subjects using two assessment methods: the TyG index and the HOMA-IR index. In addition, this study aimed to determine the correlation between lipid profile, glucose, body composition, and insulin resistance.

Methods

A pre-experimental design was used in this study. The research was carried out at the Gorontalo Ministry of Health Polytechnic for one month and was approved by the Ethics Commission of the Faculty of Medicine, Diponegoro University, based on Ethical Clearance No. 12/EC/KEPK/FK-UNDIP/1/2023, and in collaboration with the Gorontalo Prodia Laboratory. This study was conducted in February, 2023. Thirty-one obese people were recruited, and 163 had previously undergone BMI screening to meet the inclusion and exclusion criteria (Figure 1).

The inclusion criteria were as follows: willingness to be a research subject and sign informed consent, aged 18–45 years, obese nutritional status (indicated by a BMI ≥ 25 kg/m^2), not pregnant, no history of DM, and not smoking. Meanwhile, the exclusion criteria were not following the research procedures, withdrawal at the beginning and/or middle of the study, not taking medication, fasting for more than 14 h, and heavy physical activity 12 h before blood collection. Obese subjects who met the exclusion criteria were excluded from the study.

Venous blood collection was performed by two analysts at Prodia Gorontalo Laboratory.

Before blood collection, obese subjects fasted at night for 10–12 h. Obese subjects had 5 ml of blood drawn from the vein and placed into ethylenediaminetetraacetic acid (EDTA) tubes with green caps to obtain a good lipid profile, including total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides, and fasting glucose. Red-cap tubes were used to analyze fasting insulin levels. levels. It was then analyzed in the laboratory using the ultracentrifugation method, and the results were obtained after four days of blood collection.

The results of the triglyceride/glucose (TyG) and fasting insulin tests were used to calculate the insulin resistance status based on the following formula: TyG index= Ln (fasting triglycerides mg/dL × fasting glucose mg/dL) /2 (≤4,51: not resistant, >4,52: insulin resistance), HOMA-IR= (fasting glucose × fasting insulin)/22,5, (≤ 2,5: not resistant, >2,5: insulin resistance) (Er et al., 2016; Wang et al., 2020).

Body composition was measured using a Tanita brand inner scan body composition monitor. The measured parameters were percent body fat, percent body water content, percent visceral fat, bone mass, and Basal Metabolic Rate (BMR), which were measured before blood collection, along with blood pressure. Physical activity is calculated based on the Physical Activity Level (PAL) calculation by asking for the physical activity ratio (PAR) for 1 day, which is categorized into 1,40–1,69 kcal/hour for light, 1,70–1,99 kcal/hour for moderate, and 2,00–2,40 kcal/hour for heavy (Abdurrosidi et al., 2021).

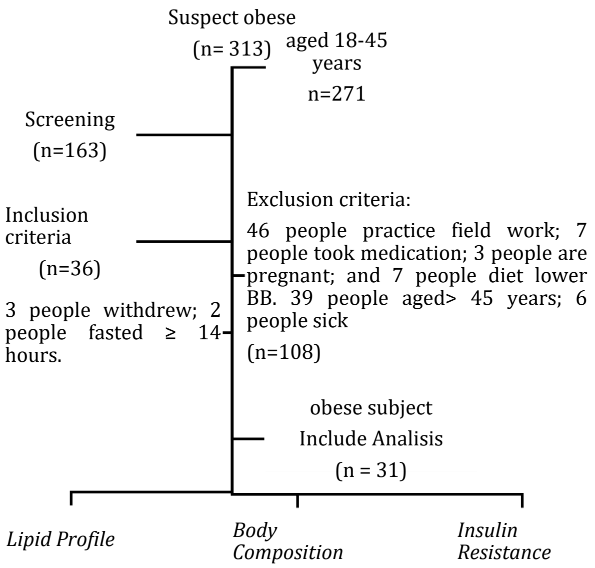

Figure 1. Consort flow diagram

The results of the data analysis are presented as standard deviation (SD), percentages, tables, and graphs used to describe data other than mean, median, minimum, and maximum values. Data normality was tested using the Shapiro-Wilk test if the data distribution was normal using the Pearson correlation test, and otherwise using the Spearman rank test. Pearson correlation and Spearman rank tests were used to determine the relationships between several variables, such as lipid profile, glucose level, and body composition. The interpretation of the correlation test results (r) uses the coefficient interval relationship level, namely (0,00-0,199) very low, (0,20-0,399) low, (0,40-0,599) quite strong, (0,60-0,799) strong, and (0,80-1,000) very strong (Sopiyudin, 2016).

Result and Discussion

Overall, 31 participants were obese (BMI>25,1 kg/m^2) (Table 1).

Table 1. Characteristics subject

Characteristics Subject	Mean ± SD
Subject n (%)	31 (100)
Age (years)	29,2 ± 8,7
Weight (kg)	72,2 ± 11,1
Height (cm)	157,1 ± 7,2
BMI (kg/m^2)	29,2 ± 3,6
Blood pressure (mmHg)	
Systolic	121,6 ± 15,5
Diastolic	83,4 ± 11,9
Sex n (%)	
Woman	20 (64,5)
Men	11 (35,5)
Employment n (%)	
Lecturer	9 (29,0)
Student	12 (38,7)
Security Guards	1 (3,3)
Educational staff	9 (29,0)
Physical activity	1,7 ± 0,3

BMI= body mass index, kg= kilogram, cm= centimeter, m= meters, %= persentage, mmHg= milimeter hydrargyrum.

Their average blood pressure was below the normal limits, and the sex ratio between men and women was 1:2. According to the physical activity ratio (PAR) calculation, the average physical activity of obese subjects was 1,7, with a standard deviation of 0,3 for the moderate activity category.

The research subjects were 38,7 percent students, 29,0 percent lecturers, and 3,3 percent security guards. Most of the subjects engaged in light physical activity, namely sitting in class, studying, teaching, sweeping the floor, washing dishes and only to 1-2 people engaged in sports. The food consumed every day was ordered at a stall near the research location (eat in the morning and afternoon) and then dinner at home at night.

Research conducted by Liang et al. (2018) stated that body composition and BMI were related to obesity (Liang et al., 2018). Based on the results of the research on 31 obese subjects (Table 2), the average body fat was 36,2%, the minimum was 21,1%, and the maximum was 52,9%. The majority of obese subjects had above-normal body fat (25,8% in men and 37,1% in women), making it a 2-4 fold cardiovascular risk factor (Krol et al., 2020). High body fat and low muscle mass cause insulin resistance and increase the risk of developing type 2 DM. Body water content was 46,9%, minimum 134%, and maximum 58%, mean visceral fat 9,3%, minimum 6,0%, and maximum 16% high visceral fat related to dyslipidemia (Table 2), This is in line with research conducted that the obese group has high triglycerides and total cholesterol, LDL and HOMA-IR (Liu et al., 2021).

Insulin resistance status based on sex using the TyG index was dominated by women (55%) of the 20 people who were insulin resistant, while men (45,5%) of the 11 people who were insulin resistant were identified more frequently at age <30 years (56,2). In contrast to the HOMA-IR index, insulin resistance was more common in men (54,5%) out of 11 people and women (20%) out of 20 people, similar to the TyG index, which was more common in patients aged <30 years (Table 3). This is due to the differences in the index parameters, namely triglycerides and fasting insulin. Most women have higher triglyceride levels than men, whereas men have higher fasting insulin levels than women.

The Pearson correlation values for insulin resistance using the TyG index were % visceral fat (p= 0,002, r = 0,528), total cholesterol (p= 0,002, r= 0,560), and LDL (p= 0,008, r= 0,466) (Table 4). This shows that the relationship between visceral fat, total cholesterol, LDL, and the TyG index is quite strong. Triglycerides were (p= 0,000, r= 0,974), indicating that the relationship between triglycerides and the TyG index was very strong. Meanwhile, using the HOMA-IR index, fasting glucose (p= 0,049, r= 0,356) had a strong relationship, and fasting insulin (p= 0,000, r= 0,985) had a very strong relationship. The distribution of lipid and glucose levels and body composition profile data for all subjects are shown in figure 2. Body composition was not correlated with insulin resistance using the HOMA-IR index, in line with a previous study (Lisnawati et al., 2023). The difference in the index parameters used was also a cause. The TyG index used triglyceride and fasting glucose parameters, whereas the HOMA-Ir index used fasting insulin and fasting glucose.

The relationship between BMI and several diseases includes the risk of developing tuberculosis in subjects with a BMI above 30 kg/m2, which is approximately 2,5 times lower than that in subjects with a normal BMI; therefore, it is a protective factor against obesity (Kim et al., 2018; Rahmad, 2020). Maintaining a normal BMI can prevent a person from developing various diseases, such as diabetes mellitus or other diseases such as tuberculosis. Compared with anthropometric measurements, visceral fat has the potential to be a good indicator for measuring preDM and DM with obesity. The risks of preDM and DM are higher with increased visceral fat (Jung et al., 2016).. Due to reduced muscle mass and high body fat, obese sarcopenia increases the risk of insulin resistance compared to that in older people with obesity alone (Han et al., 2022). Body fat percentage varies from person to person depending on genetic factors, diet, regular exercise, and other lifestyle habits (Liang et al., 2018)

Hypertrophic adipocytes cause local hypoxia in the endoplasmic reticulum, adipocyte death, and macrophage infiltration. c-Jun N-terminal kinase (JNK) and IkB kinase (IKK) increase the inhibitory serine phosphorylation of Insulin Receptor Substrate-1 (IRS-1), thereby causing insulin resistance. Nitrite Oxide (NO) and peroxynitrite derivative (ONOO) inhibit insulin signaling by nitration of IRS-1, phosphatidylinositol 3-kinase, and Akt, which are key to the translocation of glucose transporter 4 (GLUT4) to the cell surface and activation of glucose transport in myocytes (Paleva et al., 2019).

Physical activity refers to any movement of the body caused by skeletal muscle contractions involving energy expenditure.

Teenagers should engage in physical activity for 30 minutes per day, five days per week (Aydo & Kutlutu, 2023). No significant correlation was observed between physical activity and muscle function. The levels of physical activity and muscle strength decline with age (Perkin et al., 2018). Only 6,5 percent of the participants in this study exercised for more than 30 minutes each day, none of them walked home from the Gorontalo Ministry of Health Polytechnic; they all gained weight from lack of sleep, and they consumed fewer fruits and vegetables. This is consistent with research conducted by Dornelles (2019). Physical activity can reduce pancreatic cells to produce insulin as it breaks down glycogen into glucose.

Table 2. Data on lipid profile, blood glucose and body composition of obese subjects (n= 31)

	Mean	SD	Median	Min	Max
Body Composition					
% Body fat	36,2	7,9	36,9	21,1	52,9
% Body water content	46,9	5,8	46,2	34	58
% Visceral fat	9,3	3,0	8,0	6,0	16
Bone mass (kg)	2,6	0,4	2,5	2,1	3,3
BMR (kcal)	1415,4	223,3	1361	1143	1860
Venous Blood Test					
Fasting Glucose (mmol/l)	4,7	0,3	4,7	3,8	5,6
Fasting Insulin (µIU/ml)	10,1	3,8	9,7	3,1	21,9
Total cholesterol (mg/dL)	174,2	24,9	167	145	250
LDL (mg/dL)	111,7	22,7	110	73	174
HDL (mg/dL)	45,9	7,0	45	32	65
Triglycerides (mg/dL)	101,7	37,3	94	48	196
Index Value					
TyG	4,5	0,2	4,5	4,2	4,9
HOMA-IR	2,1	0,8	1,9	0,7	4,7
Physical activity	1,7	0,3	1,7	1,4	2,2

Table 3. Insulin resistance status TyG index and HOMA-IR based on sex and age

Characteristics Subject	Insulin Resistance Status							
	TyG Index				HOMA-IR Index			
	Insulin Resistance		Not Resistance		Insulin Resistance		Not Resistance	
	n	%	n	%	n	%	n	%
Sex								
Men	5	45,5	6	54,5	6	54,5	5	45,5
Women	11	55	9	55	4	20	16	80
Age (years)								
< 30	9	56,2	7	43,8	6	37,5	10	62,5
≥ 30	7	46,7	8	53,3	4	26,7	11	73,3

Insulin regulates blood sugar levels in the human body. High blood sugar levels are an effect of uncontrolled diabetes mellitus. Therefore, in the long term, it can damage several organs of the human body, including the heart, blood vessels, eyes, kidneys, and nerves (Chan 2016). In overweight and obese individuals, fat deposits due to an imbalance in intake and need cause pancreatic cells to be unable to produce insulin to compensate for excessive calories in the body, resulting in increased blood sugar and insulin resistance, which later causes diabetes mellitus (Tjandrawinata, 2016; Anggraeny et al., 2018). Blood sugar imbalance and lipid metabolism disorders, especially increased total cholesterol, triglycerides, LDL, and decreased HDL, cause atherosclerosis, stroke, and heart disease owing to damage to large and small blood vessels, increasing blood viscosity and pressure (Michille et al., 2022). In this study, the maximum values of the TyG index and

HOMA-IR were higher than the normal limits (4,9 and 4,7), indicating that obese patients already have blood sugar and lipid metabolism abnormalities that impact insulin resistance and mild inflammation. TNF-α and leptin levels were higher in overweight and obese subjects. The body mass index (BMI) percentile and fasting insulin were found to have a negative association with adiponectin but positively correlated with lipid profiles, inflammatory markers, and insulin resistance (Chang et al., 2015). Blood serum levels of total cholesterol, triglycerides, and LDL correlate with insulin resistance (Chang et al., 2015).

Table 4. Correlation of lipid profile, glucose, and body composition on insulin resistance in overweight and obese subjects

Characteristics Subject	Correlation Insulin Resistance			
	TyG Index		HOMA-IR Index	
	r	p-value	R	p-value
Body Composition				
% Body fat	-0,075	0,690	0,071	0,706
% Body water content	0,107	0,567	-0,097	0,603
% Visceral fat	0,528	0,002	0,305	0,095
Bone mass (kg)	0,244	0,187	0,297	0,105
BMR (kcal)	0,272	0,139	0.320	0,080
Venous Blood Test				
Fasting Glucose (mmol/l)	0,337	0,064	0,356	0,049
Fasting Insulin (μIU/ml)	0,223	0,228	0,985	0,000
Total cholesterol (mg/dL)	0,560	0,001	0,171	0,356
LDL (mg/dL)	0,466	0,008	0,146	0,433
HDL (mg/dL)	-0,197	0,289	-0,275	0,134
Triglycerides (mg/dL)	0,974	0,000	0,154	0,407

In Thailand, those with a low socioeconomic status who are over 30 years of age are more likely to have prediabetes. Smoking, alcohol consumption, lack of exercise, moderate to high levels of stress, being overweight, and high total cholesterol, triglyceride, and LDL cholesterol levels are risk factors for diabetes in this country (Apidechkul et al., 2022; Al Rahmad, 2021). Participants with high lipid profiles, such as total cholesterol, low-density lipoprotein (LDL), and triglycerides, may experience metabolic problems and intestinal and adipose tissue inflammation via the TLR4 signaling pathway (Kim et al., 2012).

All subjects in this study were obese (mean 29,2 kg/m^2); therefore, several strategies are needed to maintain metabolism, which can cause unwanted diseases, including consumption of foods high in antioxidants, which can help prevent and control obesity. Low fat oxidation and/or increased carbohydrate oxidation can lead to excess adipose tissue and weight gain. Individuals with lower carbohydrate oxidation and less fat oxidation tend to store less glycogen, leading to more hunger (Aghamohammadi et al., 2019). Furthermore, in obese mice, the administration of insoluble fiber with zinc (IDF-Zn) at a zinc content of insoluble fiber with zinc (IDF-Zn) at a zinc content of 31,25 mg/g can lower normal body weight, serum levels of triglycerides, total cholesterol, low-density lipoprotein cholesterol, daily health, and lipid deposits. By raising probiotics (*Lactobacillus, Muribaculaceae, and Bacteroides*), lowering the abundance of bacteria Romboutsia and Clostridia-UCG-014, and reducing the ratio of Firmicutes to Bacteroides (Ge et al. 2023). Suppressing FFA levels through calories can also reduce fat deposition in skeletal muscle, which is associated with mitochondrial dysfunction and insulin resistance, as well as impaired glucose transport after meals due to decreased GLUT-4 translocation.

Conclusion

Assessment of insulin resistance is necessary because most obese and overweight participants in this study had metabolic problems, especially glucose and lipid profiles. To support government programs in reducing obesity and/or non-communicable diseases in Indonesia, functional food interventions based on high fiber and resistant starch are required to reduce triglyceride and glucose levels.

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