ORIGINAL

METS-IR vs. HOMA-AD and Metabolic Syndrome in Obese Adolescents

Nur Aisiyah Widjaja[1], Roedi Irawan[1], Meta Herdiana Hanindita[1], IDG Ugrasena[1], and Retno Handajani[2]

[1]Department of Child Health, Dr. Soetomo General Academic Hospital, Surabaya, 60286, Indonesial, [2]Institute of Tropical Disease, Universitas Airlangga, Surabaya, Indonesia

Abstract : Purpose : Obesity is associated with chronic low-grade inflammation in which is the key in the pathogenesis Insulin Resistance (IR) and Metabolic Syndrome (MetS). Homeostasis model assessment of insulin resistance (HOMA-IR) has been validated as a surrogate measure of IR. The combination of HOMA and adiponectin, known as HOMA-AD was proposed to measure IR in adults. However, study on these indicators in obese adolescents is still limited. This study aims to analyse METS-IR and HOMA-AD to determine MetS and IR in obese adolescents. Methods : A cross-sectional study was conducted on obese adolescents who looked healthy from secondary schools in Surabaya and Sidoarjo, East Java, aged 12-18 years. Subjects were selected randomly and grouped into 2, namely MetS and non-MetS based on IDF 2000. Anthropometric examination and blood measurements, such as fasting blood glucose levels, lipid profiles, insulin, and adiponectin level were carried out according to standards. HOMA-IR, HOMA-AD, AND METS-IR were calculated using formula. Spearman's Rho correlation were conducted between assessment tools (METS-IR and HOMA-AD) to identify the correlation with MetS component (lipid profile, FBG, and blood pressures). A receiving operation curve (ROC) performed to find area under curve (AUC) and cut-off points based on the biggest Youden index. Result : A total of 250 subjects were enrolled the study, and found 103 subjects had MetS. METS-IR correlates with all lipid profile and blood pressures ($p < 0.05$). While HOMA-AD correlated with TG ($r=0.356$, $p=0.000$), systolic-BP ($r=0.188$, $p=0.003$), and HDL-c levels ($r=-0.249$, $p=0.000$). Cut-off point for METS-IR to determines MetS in obese adolescents was ≥ 46.53 (sensitivity of 64.24% and specificity of 75.76%), while HOMA-AD was ≥ 0.43 (sensitivity of 71.52% and specificity of 59.60%). Cut-off point for METS-IR index to determines IR was ≥ 52.01 (sensitivity of 83.44% and specificity of 44.44%). Cut-off point for HOMA-AD to determine IR was ≥ 0.37 (sensitivity of 74.17% and specificity of 84.85%). Conclusion : METS-IR is better surrogate to determine MetS with cut-off point of ≥ 46.53, while HOMA-AD is better to determine IR with cut-off point ≥ 0.37 in obese adolescents. J. Med. Invest. 70 : 7-16, February, 2023

Keywords **:** *Obese adolescence, Metabolic syndrome, Insulin resistance, METS-IR, HOMA-AD*

INTRODUCTION

Obesity is associated with chronic low-grade inflammation in which is the key in the pathogenesis of insulin resistance. It has been well known that adipose tissue acts as an endocrine organ by secreting numerous hormones and pro-inflammatory cytokine (1). IR happen due to the decrease of insulin sensitivity which leads to hyperinsulinemia and dyslipidemia, and disturbances on glucose homeostasis (2). IR is strongly correlate with metabolic syndrome (MetS) in obesity, is a cluster of cardiometabolic abnormalities (3), with the presence of hypertension, abdominal obesity, hyperglycaemia and dyslipidemia (4).

Adiponectin expressed exclusively on the adipose tissue and released into the circulatory system, acts a hormone and reduce inflammatory response and improve the insulin resistance. Plasma adiponectin is known to be low at obesity or people with IR (5) due to downregulation of adiponectin receptors (6), and the level is higher in women than men. The low level of adiponectin plays a crucial role in the pathogenesis of atherosclerosis and MetS (7). It has been correlated with insulin sensitivity, and known as insulin-sensitizing agent (8) by stimulating the fatty acid oxidation and increase the expression of molecules involved in fatty acid transport (CD36), acetyl coenzyme A oxidase and increase the uncoupling protein (UCP-2) which leads to the reduction of energy and decrease the triglyceride levels (6).

Homeostasis model assessment of insulin resistance (HOMA-IR) has been validated as a surrogate measure of IR and shows a high correlation with clamp measurements and acceptable and useful to assess IR in epidemiological study (9, 10). The combination of HOMA and adiponectin, known as HOMA-AD was proposed as a surrogate measure of insulin resistance in Japanese adults (11). The study in children HOMA-AD correlates with clamp-derived insulin sensitivity index (EHC) (12). The use of this index based on the evidence that serum adiponectin acts as indirect measurement of adiposopathy and provide indirect information of insulin resistance (12) and thought involved in the pathogenesis of syndrome X (13).

Other index has been introduction for identifying IR and predicts the visceral adiposity in type-2 diabetes, named as metabolic score for insulin resistance or METS-IR (14). It correlates with insulin sensitivity (M-value adjusted by fat-free mass or MFFM) obtained by euglycemic–hyperinsulinemic clamp (EHC) (2). This index includes BMI and other non-insulin factor in the formula, and proved to be correlated with hypertension in healthy adult Chinese population (15) and proves to detect arterial stiffness (14).

Due to both HOMA-AD and METS-IR are strongly correlate

Received for publication February 3, 2021 ; accepted April 20, 2022.

Address correspondence and reprint requests to Nur Aisiyah Widjaja, MD, PhD, Department of Child Health, Dr. Soetomo General Academic Hospital, Jl. Mayjen Prof. Dr. Moestopo No. 6-8, Surabaya, 60286, Indonesia. E-mail : nur.aisiyah.widjaja-2017@fk.unair.ac.id

with EHC, here we compared METS-IR and HOMA-AD to distinguish MetS and IR in obese adolescents and predict the cut-off value on both assessment tools using receiving operation curve (ROC) using IDF criteria and HOMA-IR cut-off value to identify IR.

METHODS

Subject Population

A cross-sectional study was conducted on obese adolescents in secondary school aged between 13–18 years. Anthropometric measurements were performed.

IR determined using HOMA-IR cut-off value ≥ 5.22 for boys and ≥ 3.82 for girls in pubertal periods (16) by using the formula :

$$HOMA-IR \equiv \left[Fasting\ blood\ glucose\ \left(\frac{mg}{dL}\right) \times insulin\ \left(\frac{\mu u}{L}\right)\right] \div 405$$

HOMA-AD was calculated by multiplying HOMA-IR with fasting adiponectin level (in µg/dl) (17). While METS-IR was calculated using formula (2) :

$$METS-IR = Ln\left[\left(2 \times FBG\ \left(\frac{mg}{dl}\right)\right) + TG\ \left(\frac{mg}{dl}\right)\right] * BMI\ \left(\frac{kg}{m2}\right) \div [Ln(HDL - c\ (\frac{mg}{dl}))]$$

In which : FBG = fasting blood glucose, TG = triglyceride, BMI = body mass index

MetS were determined using IDF criteria, central obesity must be accompanied by 2 of 4 (18) criteria described above :

For children aged 10-16 years old :

1. Central obesity, if waist circumference ≥ 90th percentile according to WHO waist circumference, that were ≥ 88 cm for boys and ≥ 85 cm for girls.
2. Blood pressure ≥ 90th percentile (systole ≥ 130/diastole ≥ 85 mmHg)
3. Hypertriglyceridaemia, if hypertriglycaeride levels ≥ 110 mg/dl
4. HDL levels ≤ 40 mg/dl
5. Fasting blood glucose ≥ 110 mg/dl

For children aged > 16 years old :

1. Central obesity, if waist circumference ≥ 90th percentile according to WHO waist circumference, that were ≥ 94 cm for boys and ≥ 80 cm for girls.
2. Blood pressure ≥ 90th percentile (systole ≥ 130/diastole ≥ 85 mmHg)
3. Hypertriglyceridaemia, if hypertriglycaeride levels ≥ 150 mg/dl
4. HDL levels ≤ 50 mg/dl
5. Fasting blood glucose ≥ 100 mg/dl (19).

Blood samples

The blood samples were withdawn via vena cubitus as much as 5 ml for profile lipid, fasting blood glucose, insulin and adiponectin investigation. After the blood samples were taken from the subjects, put on EDTA-containing tube and placed on icebox and then transported to the laboratory. Lipid profiles, fasting blood glucose, adiponectin and insulin levels were measured.

Statistical analysis

A descriptive analysis was conducted for subjects's characteristic, while fasting blood glucose (FBG), fasting insulin, adiponectin, lipid profile, blood pressures and anthropometric indicator for obesity were analysed using independent sample T-test and Mann Witney U test, depend on the homogenicity and normality. Spearman's Rho correlation were conducted between assessment tools (METS-IR and HOMA-AD) to identify the correlation with MetS component (lipid profile, FBG, and blood pressures). A receiving operation curve (ROC) performed to find area under curve (AUC) and cut-off points based on the biggest Youden index.

RESULTS

250 subjects were enrolled the study, the characteristic of subject's were summarized on table 1. The study found 103 subjects had MetS. Gender and age distributed normally and homogenous. 56.4% are boys, 43.65% are girls. Average age is 180.39 ± 17.38 months, min-max (147 - 226 months). Average body weight is 83.70 ± 13.66 kg, min-max (53.50-130.00 kg), and average of body height is 160.89 ± 7.76 cm, min-max (140.80-186.00 cm).

The incidence of MetS and IR counts 39%. Abdominal obesity is the biggest incidence in this study, counts 91.6%. Hypertension, hypertriglyceridemia, and low level of HDL-c counts ≥ 40%. Only hyperglycaemia is the lowest incidence (4%).

Table 1. Subject's characteristics of obese adolescents

Subjects characteristic	n (%)
Gender	
- Boys	141 (56.4%)
- Girls	109 (43.6%)
Metabolic syndrome	99 (39.6%)
Insulin resistance	99 (39.6%)
Abdominal obesity	229 (91.6%)
Hypertension	102 (40.8%)
Hyperglycaemia	10 (4.0%)
Hypertriglyceridemia	101 (40.4%)
Low level of HDL-c	106 (42.4%)
Hypoadiponectinemia	59 (23.6%)

HOMA-AD has a very weak correlation with BMI (r = 0.153, p = 0.015), WC (r = 0.246, p = 0.000), HC (r = 0.199, p = 0.000) and WHtR (r = 0.249, p = 0.000), but does not correlate with WHR (r = 0.057, p = 0.256). METS-IR correlates strongly with BMI (r = 0.876, p = 0.000), waist circumference (r = 0.530, p = 0.000), hip circumference (r = 0.639, p = 0.000) and WHtR (r = 0.517, p = 0.000), but did not correlated with WHR (r = 0.041, p = 0.517). Correlation of METS-IR and HOMA-AD with FBG, lipid profile and blood pressure were summarized at table 2.

The correlation of METS-IR and HOMA-AD with fasting blood glucose, lipid profile, and blood pressure were summarized on table 2. METS-IR correlates with all lipid profile and blood pressures (p < 0.05), but does not correlate with FBG (p > 0.05). While HOMA-AD only correlates weakly with TG (r = 0.356, p = 0.000) and correlates very weak with systolic-BP (r = 0.188, p = 0.003), and correlates negatively with HDL-c levels (r = -0.249, p = 0.000).

MetS profile in obesity

Table 3 summarized the characteristic of anthropometric, lipid profile, fasting blood glucose, fasting insulin, adiponectin, blood pressure, HOMA-IR, HOMA-AD and METS-IR on MetS and non-MetS group. There is no significant difference in WHR, WHtR, FBG and total cholesterol (p > 0.05) in both MetS and non-MetS. While BMI (33.04 ± 4.22 vs. 31.65 ± 4.23), waist circumference (100.51 ± 10.55 vs. 95.87 ± 10.08 cm), hip circumference (109.65 ± 9.28 vs. 106.66 ± 9.53 cm), insulin (28.06 ± 19.04 vs. 18.89 ± 9.52 µU/mL), triglyceride (144.71 ± 64.99 vs. 95.40 ± 56.72 mg/dL), LDL-c (117.73 ± 22.20

vs. 110.83 ± 30.88 mg/dL) and blood pressure are higher in MetS than non-MetS ($p < 0.05$), while adiponectin (11.29 ± 5.55 vs. 14.69 ± 7.91 µg/dL) and HDL-c (38.93 ± 6.68 vs. 46.23 ± 6.91 mg/dL) significantly lower ($P > 0.05$). HOMA-IR (6.06 ± 4.31 vs. 3.95 ± 2.05), HOMA-AD (0.78 ± 1.14 vs. 0.36 ± 1.31) and METS-IR (52.17 ± 7.80 vs. 46.13 ± 6.91) index is bigger in MetS than non-MetS significantly.

Receiver operation curve (ROC) of METS-IR and HOMA-AD to determine MetS were presented on picture 1. Area under curve (AUC) of METS-IR for MetS took place at 0.740, $p = 0.000$, 95% CI (0.679-0.802). Cut-off point for METS-IR to determines MetS in obese adolescents is ≥ 46.53 with sensitivity of 64.24% and specificity of 75.76%. While AUC for HOMA-AD laid on 0.625, $p = 0.000$, 95% CI (0.625-0.759) with cut-off point to determine MetS was ≥ 0.43 with sensitivity of 71.52% and specificity of 59.60%. ΔAUC for METS-IR and HOMA-AD to determines MetS is 0.115, lower than 15% or 0.15 of minimum expected difference, so there is no difference in AUC for both assessment tools in determines MetS.

Table 2. Correlation between METS-IR index and HOMA-AD with fasting blood glucose, lipid profile, and blood pressure

	METS-IR index		HOMA-AD	
	r	p	r	p
FBG	-0.022	0.726	0.094	0.139
Total cholesterol	0.171**	0.000	0.083	0.192
Triglyceride	0.427**	0.000	0.357**	0.000
LDL-c	0.251**	0.000	0.087	0.171
HDL-c	-0.541*	0.000	-0.249**	0.000
Systolic-BP	0.313**	0.000	0.188**	0.003
Diastolic-BP	0.164**	0.009	0.064	0.315

Table 3. Anthropometric, lipid profile, fasting blood glucose, fasting insulin, adiponectin and MetS assessment in MetS and non-MetS

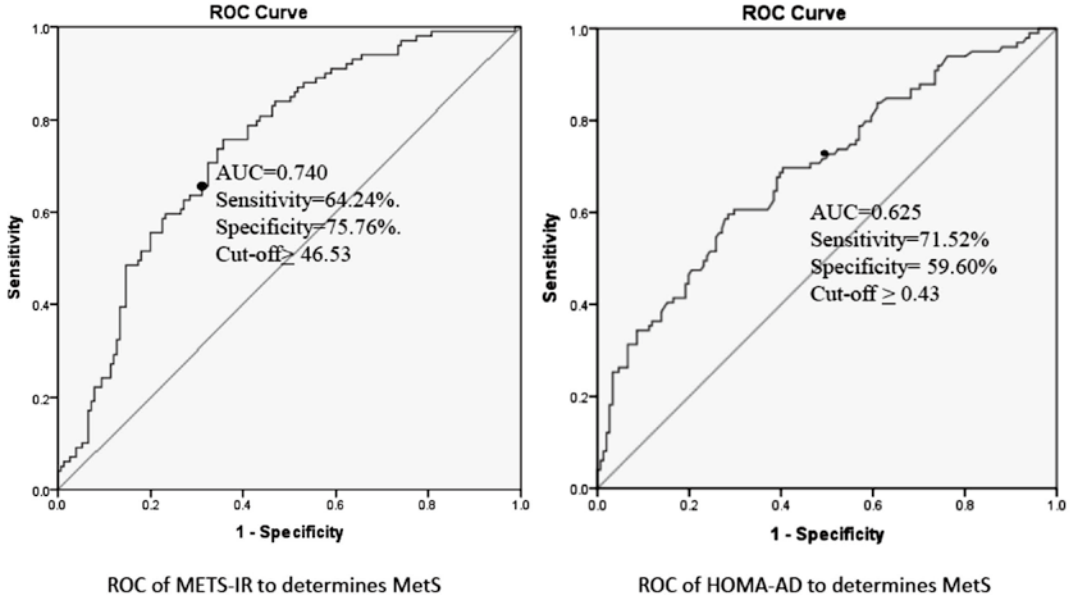
Variables	MetS (n=99)	Non-MetS (n=151)	p
Gender, n (%) - Boys - Girls	 63 (63.64) 36 (36.36)	 78 (51.66) 73 (48.34)	0.069**
BMI (kg/m²), *mean ± SD*	33.04 ± 4.22	31.65 ± 4.23	0.016
Waist circumference (cm), *mean ± SD*	100.51 ± 10.55	95.87 ± 10.08	0.001
Hip circumference (cm), *mean ± SD*	109.65 ± 9.28	106.66 ± 9.53	0.015
Waist-to-hip circumference ratio, *mean ± SD*	0.91 ± 0.07	0.90 ± 0.07	0.052
Waist-to-height ratio, *mean ± SD*	0.62 ± 0.063	0.60 ± 0.059	0.077
FBG (mg/dL), *mean ± SD*	86.37 ± 8.53	84.61 ± 6.29	0.061
Fasting insulin (µU/mL), *mean ± SD*	28.06 ± 19.04	18.89 ± 9.52	0.000*
Adiponectin ((µg/dL), mean ± SD	11.29 ± 5.55	14.69 ± 7.91	0.000*
Total cholesterol (mg/dL), mean ± SD	176.39 ± 26.44	170.72 ± 35.43	0.069*
LDL-c (mg/dL), *mean ± SD*	117.73 ± 22.20	110.83 ± 30.88	0.013*
HDL-c (mg/dL), *mean ± SD*	38.93 ± 6.68	46.23 ± 6.91	0.000
Triglyceride (mg/dL), *mean ± SD*	144.71 ± 64.99	95.40 ± 56.72	0.000*
Systole-BP (mmHg), *mean ± SD*	130.20 ± 10.86	119.63 ± 12.76	0.000
Diastole-BP (mmHg), *mean ± SD*	86.82 ± 9.56	78.31 ± 9.33	0.000
HOMA IR, mean ± SD	6.06 ± 4.31	3.95 ± 2.05	0.000*
HOMA-AD, mean ± SD	0.78 ± 1.14	0.36 ± 1.31	0.000*
METS-IR, mean ± SD	52.17 ± 7.80	46.13 ± 6.91	0.000

Independent sample T-test *Mann Witney U Test **Fischer exact test, significant if $p < 0.05$

IR profile in obesity

Table 4 summarized the characteristic of anthropometric, lipid profile, fasting blood glucose, fasting insulin, adiponectin, blood pressure, HOMA-IR, HOMA-AD and METS-IR on IR and non-IR group. There is no significant difference in WHR (0.90 ± 0.07 vs. 0.91± 0.07), adiponectin (12.01 ± 5.62 vs. 14.21 ± 8.04 µg/dL) and diastole blood pressure (82.39 ± 10.73 vs. 81.21 ± 9.99 mmHg) for IR and non-IR group ($p > 0.05$).

Anthropometric measurements : BMI (33.17 ± 4.83 vs. 31.56 ± 3.75), waist circumference (99.72 ± 11.43 vs. 96.39 ± 9.66 cm), hip circumference (110.25 ± 10.37 vs. 110.25 ± 8.60 cm), WHtR (0.62 ± .07 vs. 0.60 ± 0.06), FBG (87.37 ± 8.22 vs. 83.95 ± 6.29 mg/dL), fasting insulin (35.06 ± 9.02 vs. 14.30 ± 4.50 µU/mL), total



Picture 1. Receiving operation characteristic (ROC) for METS-IR and HOMA-AD to determine MetS in obese adolescent population

Table 4. Anthropometric, lipid profile, fasting blood glucose, fasting insulin, adiponectin and MetS assessment in IR and non-IR

Variables	IR (n=99)	Non-IR (n=151)	p
Gender, n (%) - Boys - Girls	 47 (47.47) 52 (52.53)	 94 (62.25) 57 (37.75)	0.027**
BMI (kg/m^2), *mean ± SD*	33.17 ± 4.83	31.56 ± 3.75	0.006*
Waist circumference (cm), *mean ± SD*	99.72 ± 11.43	96.39 ± 9.66	0.025*
Hip circumference (cm), *mean ± SD*	110.25 ± 10.37	110.25 ± 8.60	0.001
Waist-to-hip circumference ratio, *mean ± SD*	0.90 ± 0.07	0.91 ± 0.07	0.674
Waist-to-height ratio, *mean ± SD*	0.62 ± 0.07	0.60 ± 0.06	0.009
FBG (mg/dL), *mean ± SD*	87.37 ± 8.22	83.95 ± 6.29	0.000
Fasting insulin (µU/mL), *mean ± SD*	35.06 ± 9.02	14.30 ± 4.50	0.000*
Adiponectin (µg/dL), *mean ± SD*	12.01 ± 5.62	14.21 ± 8.04	0.076*
Total cholesterol (mg/dL), *mean ± SD*	180.57 ± 31.87	167.98 ± 31.59	0.002
LDL-c (mg/dL), *mean ± SD*	120.13 ± 28.56	109.26 ± 26.72	0.002
HDL-c (mg/dL), *mean ± SD*	41.59 ± 8.10	44.48 ± 7.21	0.004
Triglyceride (mg/dL), *mean ± SD*	135.19 ± 67.09	101.63 ± 59.64	0.000
Systole-BP (mmHg), *mean ± SD*	126.02 ± 11.97	122.37 ± 13.62	0.031
Diastole-BP (mmHg), *mean ± SD*	82.39 ± 10.73	81.21 ± 9.99	0.375
HOMA IR, *mean ± SD*	7.57 ± 3.65	2.96 ± 3.65	0.000*
HOMA-AD, *mean ± SD*	0.88 ± 1.11	0.29 ± 0.26	0.000*
METS-IR, *mean ± SD*	51.39 ± 9.02	46.65 ± 6.32	0.000*

Independent sample T-test *Mann Witney U Test **Fischer exact test, significant if $p<0.05$

cholesterol (180.57 ± 31.87 vs. 167.98 ± 31.59 mg/dL), LDL-c (120.13 ± 28.56 vs. 109.26 ± 26.72 mg/dL), triglyceride (135.19 ± 67.09 vs. 101.63 ± 59.64 mg/dL), systole-BP (126.02 ± 11.97 vs. 122.37 ± 13.62 mmHg) and the assessment index : HOMA-IR (7.57 ± 3.65 vs. 2.96 ± 3.65), HOMA-AD (0.88 ± 1.11 vs. 0.29 ± 0.26) and METS-IR (51.39 ± 9.02 vs. 46.65 ± 6.32) shows a significant difference, higher in IR than non-IR ($p < 0.05$). Except HDL-c (41.59 ± 8.10 vs. 44.48 ± 7.21), lower in IR ($p > 0.05$).

Receiver operation curve (ROC) of METS-IR and HOMA-AD to determine IR were presented on picture 2. Area under curve (AUC) of METS-IR for IR laid at 0.664, p=0.000, 95% CI (0.594-0.735). Cut-off point for METS-IR index to determines IR in obese adolescents is ≥ 52.01 with sensitivity of 83.44% and specificity of 44.44%. AUC for HOMA-AD laid on 0.862, p=0.000, 95% CI (0.816-0.907) with cut-off point to determine IR was ≥ 0.37 with sensitivity of 74.17% and specificity of 84.85%. Δ AUC of METS-IR and HOMA-AD is 0.198 (>15% of minimum expected difference), so there is significant difference of AUC in both assessment tools to determine IR.

DISCUSSION

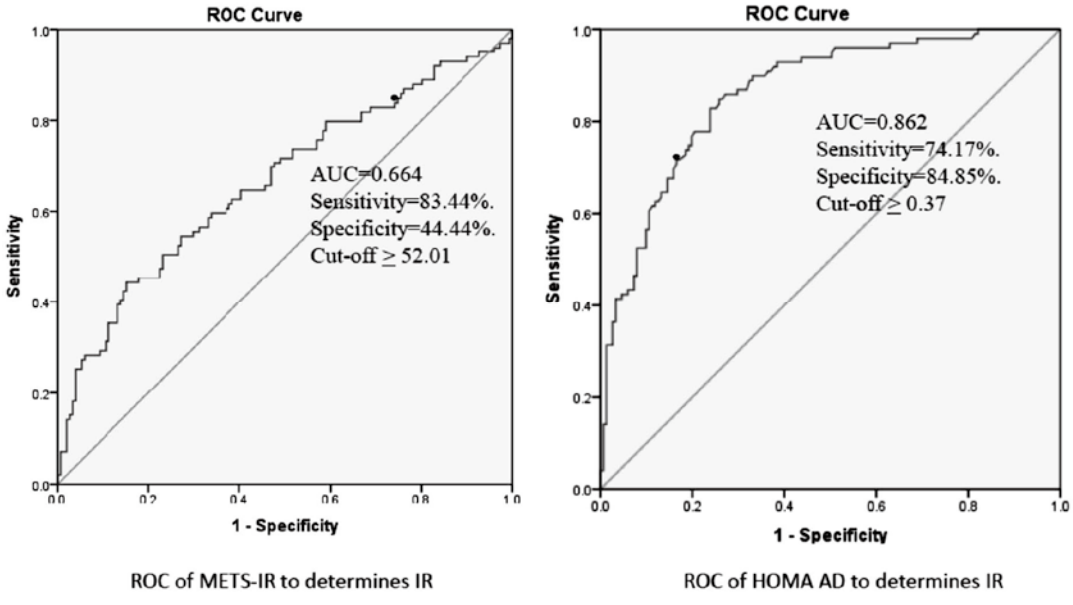
IR is a condition in which insulin fails to suppress lipolysis and Fox01 (plays on the regulation of gluconeogenesis and glycongenolysis by insulin signalling), but activate rapamycin complex-1 (mTORC1). Insulin failure to suppress Fox01 causes the elevation of microsomal triglyceride transfer protein (MTTP) expression and apoCIII, and later cause the over production of VLDL and reduce their clearance (20).

Obese adolescents are still a double burden in Indonesia, the prevalence has increased more than five-fold over three years from 1.4% in 2010 to 7.3% in 2013 (21). Obese children and adolescents are at risk to develop adult obesity (22), and strongly associated with the development of vascular disease, type 2 diabetes (T2DM), orthopaedic problems and mental disorders (23). A multivariate study in Indonesia showed that adolescent BMI were affected on blood pressure and adult BMI (23) due to early adiposity rebound (the age at which BMI starts to rise after infancy), and linked on insulin resistance at the age of 12 years (24).

Until now there is no data of HOMA-AD and METS-IR index performed on Malay ethnic group especially Indonesia. Several study performed on European population (2, 17). Other were performed on Japanese (11) and India (25) which were difference on races and staple food consumption. High carbohydrate diet (high glycemic index) for example rice, affecting in lipid storage (adipose tissue). Obesity represents an expansion of adipose tissue mass, and one explanation for obesity-related insulin resistance is the production of factors by adipose tissue that render some subjects more insulin resistant than others. Plasma adiponectin was highly in non obese and obese subjects expressed significantly lower levels of adiponectin. Low adiponectin cause obesity- insulin resistance (26).

European mostly ate bread which is wheat-based. A study stated that the prevalence of obesity is associated positively with wheat consumption, but correlates negatively with rice (27). Although Japanese and Indian also consumed rice as the main carbohydrate sources (staple foods), but there are many genetic variations on glycaemic index value which is affecting on glucose metabolism. A study conducted on Cambodia the incidence of T2DM cases were reduced when the population turn their rice consumption from Phka Rumdual variety to IR66 variety by 27% after 10 years (27). Moreover, the study conducted on those study mostly performed on young adult and elderly, or on the population with disease onset. While our study was conducted on healthy obese adolescents with the early sign of insulin resistance.

To our study both HOMA-AD and METS-IR correlates with anthropometric indicator for obesity except WHR ($p > 0.05$). It has been proved that adipokines were associated with central obesity, lipid metabolism, MetS and IR (28). As the marker of both IR and MetS, METS-IR and HOMA-AD correlate with waist circumference. WHtR associated with abdominal fat (29), and has been used to identify obesity in children and sense the inflammatory and cardiometabolic risk in pediatric population



Picture 2. Receiving operation characteristic (ROC) for METS-IR and HOMA-AD to determine IR in obese adolescent population

(30). WHtR also sense body fat distribution (31). Although BMI does not measure adiposity directly, it has been showed as an alternative indirect measure of fat mass (31). Both MetS and IR is the result of adiposity inflammatory in which the assessment used in this study correlates with BMI. BMI, waist circumference and WHtR are the most promising anthropometric in assessing insulin sensitivity (32).

While lipid profile and blood pressure showed strong association with METS-IR compared to HOMA-AD, which implying that METS-IR is better in sensing metabolic syndrome in obesity. HOMA AD did not correlate with FBG, but a study in neurofibromatosis type 1 (NF1) showed it correlate with FBG (33) which is contrast with this study. Other study proved METS-IR correlates with blood pressure level (15) which is in line with this study, so in the healthy adult population, METS-IR correlates with the incidence of hypertension. Other has been showed it correlates with arterial stiffness and good to be used as complement predictor in systole-BP (14).

The AUC of METS-IR to identify IR in this study is similar with previous study in identifying IR (0.66 vs 0.67 of previous study) (2) and found out that the AUC in T2D is lower than healthy adults (2), which is supported by a study performed on healthy non-obese adults, had greater AUC value (0.79, IR determined using HOMA IR) (34). However the index for determine IR using SI index obtained from the FSIVGT, while our study using HOMA IR to determine IR. The low of AUC in this result due to our population is obese adolescents with high risk of IR, T2D and cardiovascular disease, but the disease onset had been not occurred which was supported the statement above. It is stated that METS-IR is linked with the body fat content (2). However, this index is better to use on healthy, non-obese, non-insulin population, because it is more useful to identify people at risk of IR in non-diabetic eurothyroid adults (34).

In contrast on accessing IR, the AUC of METS-IR to identify MetS in this study is bigger than to identify IR (0.74 vs. 0.66), so METS-IR is better to identify MetS in obese adolescents than IR. A study on female with knee osteoarthritis (40–97 years) showed the bigger result of AUC to determine MetS (0.85 vs. 0.74) (35), while previous study were performed on young adult and elderly with T2DM to assess IR (2), so the evidence of the usefulness this index on assessing MetS especially on adolescents with obesity is still limited. It was stated that an index or tools is determined to be credible used as diagnostic tool due to it has discrimination value between 0.7 to 0.8 (36), and the values for the AUC above 0.70 are considered to show good discriminatory capacity (17).

HOMA-AD is good in assessing IR to our study, but other showed it can't be used to sense IR in HCV (hepatitis C virus) lean patients (37), while others found it is useful in identifying IR, even better than HOMA-IR (12, 17) which is in line with this study. The previous study noted AUC of HOMA-AD for IR was 0.844 using CLAMP (17, 38), while on this study 0.862 using HOMA IR. A study on obese children age 13.7 ± 1.1 years noted AUC of HOMA-AD to determine IR was 0.68 (39).

But to determine MetS, HOMA-AD had lower AUC than other (0.692 vs. 0.806) (25) on middle age subject, but similar with the previous study on young adult and elderly (0.692 vs. 0.703) (38). Although HOMA-AD is good to determine MetS on young adult and elderly, but it has not been used for adolescents with the increment of IR during puberty (38), especially with obesity. It also correlates with EHC stronger than HOMA-IR (r = 0.64 vs. r=0.56) and showed bigger AUC (38).

CONCLUSION

METS-IR is better surrogate to determine MetS with cut-off point of ≥ 46.53, while HOMA-AD is better to determine IR with cut-off point ≥ 0.37 in obese adolescents.

FUNDING

The author(s) received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTERESTS

The author(s) declares no conflict of interest.

ACKNOWLEDGMENT

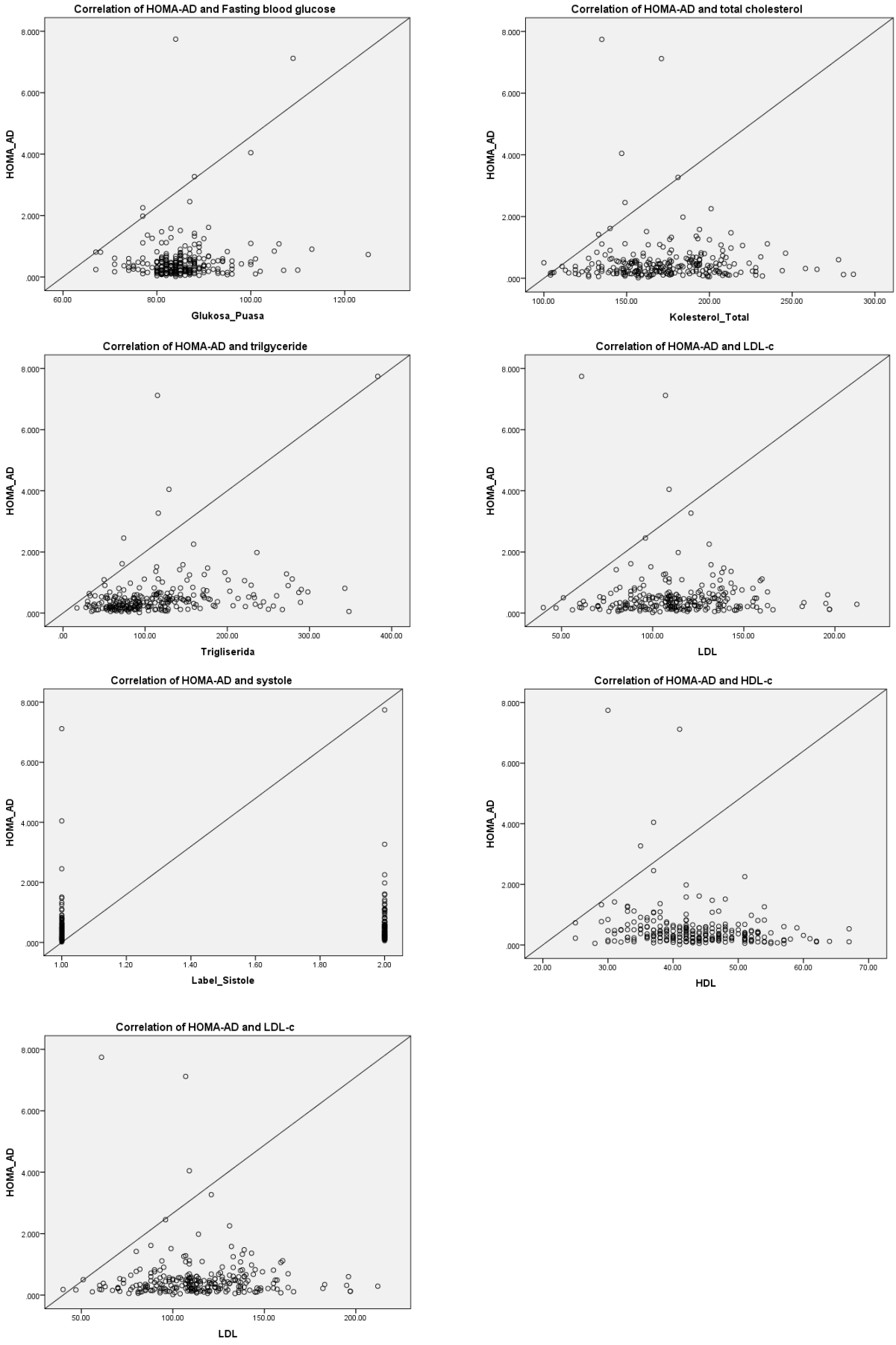
Special thanks to Mrs. Eva Ardianah in supporting this article.

REFERENCES

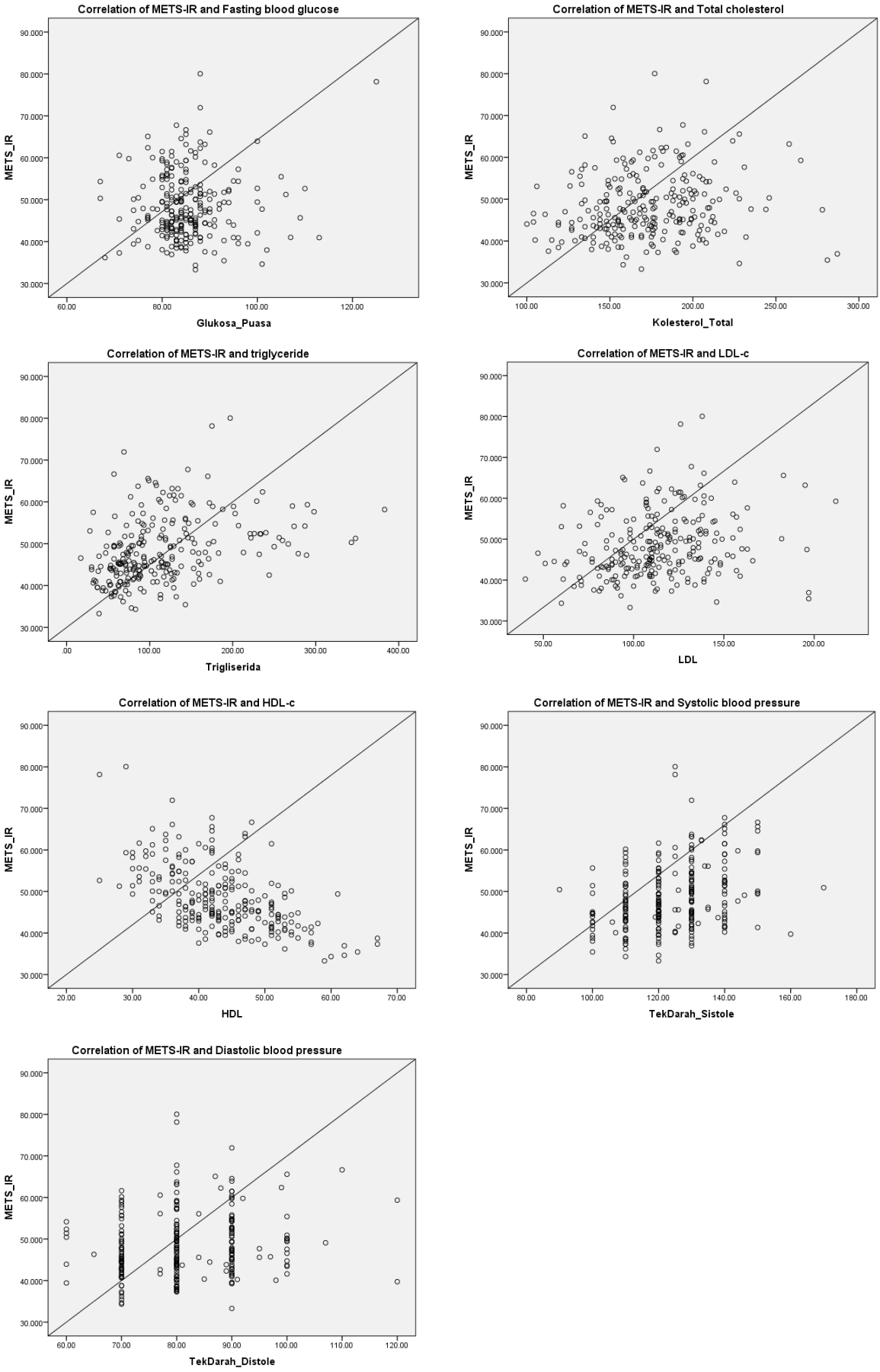
1. Piya MK, McTernan PG, Kumar S : Adipokine inflammation insulin resistance : The role of glucose, lipids and endotoxin. J Endocrinol 216(1) : 2013. doi : 10.1530/JOE-12-0498
2. Bello-Chavolla OY, Almeda-Valdes P, Gomez-Velasco D, Viveros-Ruiz T, Cruz-Bautista I, Romo-Romo A, Sánchez-Lázaro D, Meza-Oviedo D, Vargas-Vázquez A, Campos OA, Sevilla-González MDR, Martagón AJ, Hernández LM, Mehta R, Caballeros-Barragán CR, Aguilar-Salinas CA : METS-IR, a novel score to evaluate insulin sensitivity, is predictive of visceral adiposity and incident type 2 diabetes. Eur J Endocrinol 178(5) : 533-544, 2018. doi : 10.1530/EJE-17-0883
3. Li R, Li Q, Cui M, Yin Z, Li L, Zhong T, Huo Y, Xie P : Clinical surrogate markers for predicting metabolic syndrome in middle-aged and elderly Chinese. J Diabetes Investig 9(2) : 411-418. doi : 10.1111/jdi.12708
4. Dada SA, Fadare JO, Ajayi DD, Ajayi OA : Triglyceride-Glucose Index and Related Parameters. Metab Syndr Relat Disord XX(Xx) : 1-7, 2020. doi : 10.1089/met.2020.0092
5. Weyer C, Funahashi T, Tanaka S, Hotta K, Matsuzawa Y, Pratley RE, Tataranni PA : Hypoadiponectinemia in obesity and type 2 diabetes : close association with insulin resistance and hyperinsulinemia. J Clin Endocrinol Metab 86(5) : 1930-5, 2001. doi : 10.1210/jcem.86.5.7463
6. Von Frankenberg AD, Reis AF, Gerchman F : Relationships between adiponectin levels, the metabolic syndrome, and type 2 diabetes : A literature review. Arch Endocrinol Metab 61(6) : 614-622, 2017. doi : 10.1590/2359-3997000000316
7. Yanai H, Yoshida H : Beneficial effects of adiponectin on glucose and lipid metabolism and atherosclerotic progression : Mechanisms and perspectives. Int J Mol Sci 20(5) : 1-25, 2019. doi : 10.3390/ijms20051190
8. Xu X, Lai Y, Yang G, Yang M, Li L, Zhang Q, Liu H, Zheng H, Zhu D : Adiponectin/(FBG×FIns) as a predictor of insulin sensitivity and metabolic syndrome in patients with polycystic ovary syndrome. Med (United States) 95(49) : e5524, 2016. doi : 10.1097/MD.0000000000005524
9. Aradillas-García C, Rodríguez-Morán M, Garay-Sevilla ME, Malacara JM, Rascon-Pacheco RA, Guerrero-Romero F : Distribution of the homeostasis model assessment of

insulin resistance in Mexican children and adolescents. Eur J Endocrinol 166(2) : 301-306, 2012. doi : 10.1530/EJE-11-0844
10. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC : Homeostasis model assessment : insulin resistance and β-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 28(7) : 412-419, 1985. doi : 10.1007/BF00280883
11. Matsuhisa M, Yamasaki Y, Emoto M, Shimabukuro M, Funahashi T, Matsuzawa Y : A novel index of insulin resistance determined from the homeostasis model assessment index and adiponectin levels in Japanese subjects. Diabetes Res Clin Pract 77(1) : 151-154, 2007. doi : 10.1016/j.diabres.2006.10.005
12. da Silva CC, Zambon MP, Vasques ACJ, Camilo DF, De Bernardi Rodrigues AM, Antonio MÂRGM, Dâmaso AR, Tufik S, de Mello MT, Campos RMDS, Geloneze B ; Brazilian Metabolic Syndrome Study (BRAMS) Investigators : Homeostatic model assessment of adiponectin (HOMA-Adiponectin) as a surrogate measure of insulin resistance in adolescents : Comparison with the hyperglycaemic clamp and homeostatic model assessment of insulin resistance. PLoS One 14(3) : e0214081, 2019. doi : 10.1371/journal.pone.0214081.
13. Bacha F, Saad R, Gungor N, Arslanian SA : Adiponectin in Youth Relation ship to visceral adiposity, insulin sensitivity and β-cell function. Diabetes Care 27(2) : 547-552, 2004. doi : 10.1038/oby.2006.182
14. Bello-Chavolla OY, Antonio-Villa NE, Vargas-Vázquez A, Martagón AJ, Mehta R, Arellano-Campos O, Gómez-Velasco DV, Almeda-Valdés P, Cruz-Bautista I, Melgarejo-Hernandez MA, Muñoz-Hernandez L, Guillén LE, Garduño-García JJ, Alvirde U, Ono-Yoshikawa Y, Choza-Romero R, Sauque-Reyna L, Garay-Sevilla ME, Malacara-Hernandez JM, Tusié-Luna MT, Gutierrez-Robledo LM, Gómez-Pérez FJ, Rojas R, Aguilar-Salinas CA : Prediction of incident hypertension and arterial stiffness using the non-insulin-based metabolic score for insulin resistance (METS-IR) index. J Clin Hypertens (Greenwich) 21(8) : 1063-1070, 2019. doi : 10.1111/jch.13614.
15. Liu XZ, Fan J, Pan SJ : METS-IR, a novel simple insulin resistance indexes, is associated with hypertension in normal-weight Chinese adults. J Clin Hypertens 21(8) : 1075-1081, 2019. doi : 10.1111/jch.13591
16. Kurtoglu S, Hatipoglu N, Mazcoglu M, Kendirci M, Keskin M, Kondolot M : Insulin resistance in obese children and adolescents : HOMA-IR cut-off levels in the prepubertal and pubertal periods. JCRPE J Clin Res Pediatr Endocrinol 2(3) : 100-106, 2010. doi : 10.4274/jcrpe.v2i3.100
17. Vilela BS, Vasques AC, Cassani RS, Forti AC, Pareja JC, Tambascia MA : BRAMS Investigators, Geloneze B. The HOMA-Adiponectin (HOMA-AD) Closely Mirrors the HOMA-IR Index in the Screening of Insulin Resistance in the Brazilian Metabolic Syndrome Study (BRAMS). PLoS One 11(8) : e0158751, 2016. doi : 10.1371/journal.pone.0158751.
18. IDF : Metabolic Factors and Non-Alcoholic Fatty Liver Disease as Co-Factors in Other Liver Diseases. Vol 28. Brussels : International Diabetes Federation : 2006. doi : 10.1159/000282084
19. Zimmet P, Alberti KG, Kaufman F, Tajima N, Silink M, Arslanian S, Wong G, Bennett P, Shaw J, Caprio S ; IDF Consensus Group : The metabolic syndrome in children and adolescents - an IDF consensus report. Pediatr Diabetes 8(5) : 299-306, 2007. doi : 10.1111/j.1399-5448.2007.00271.x.
20. Athyros VG, Doumas M, Imprialos KP, Stavropoulos K, Georgianou E, Katsimardou A, Karagiannis A : Diabetes and lipid metabolism. Hormones (Athens) 17(1) : 61-67, 2018. doi : 10.1007/s42000-018-0014-8.
21. Badan Penelitian dan Pengembangan Kesehatan : Riset Kesehatan Dasar (RISKESDAS) 20133. Jakarta : Kementerian Kesehatan RI : 2013.
22. Lee L, Sanders RA : Metabolic syndrome. Pediatr Rev 33(10) : 549-468, 2012
23. Faienza MF, Wang DQH, Frühbeck G, Garruti G, Portincasa P : The dangerous link between childhood and adulthood predictors of obesity and metabolic syndrome. Intern Emerg Med 11(2) : 175-182, 2016. doi : 10.1007/s11739-015-1382-6
24. Arisaka O, Koyama S, Ichikawa G, Kariya K, Yoshida A, Shimura N : Pediatric obesity and adult metabolic syndrome. J Pediatr 164(6) : 1502, 2014. doi : 10.1016/j.jpeds.2014.02.050
25. Banerjee J, Dhas Y, Mishra N : HOMA-Adiponectin Closely Associates with Cardiometabolic Risk Markers in Middle-Aged Indians with Metabolic Syndrome. Exp Clin Endocrinol Diabetes 129(06) : 449-456, 2021. doi : 10.1055/a-1120-8163
26. Kern PA, Ranganathan S, Li C, Wood L, Ranganathan G : Adipose tissue tumor necrosis factor and interleukin-6 expression in human obesity and insulin resistance. Am J Physiol - Endocrinol Metab 280(5 43-5) : 745-751, 2001. doi : 10.1152/ajpendo.2001.280.5.e745
27. You W, Henneberg M : Cereal Crops Are not Created Equal : Wheat Consumption Associated with Obesity Prevalence Globally and Regionally. AIMS Public Heal 3(2) : 313-328, 2016. doi : 10.3934/publichealth.2016.2.313
28. Simões NF, Domingos ALG, De Oliveira FLP, Caldas IS, Guedes MR, Fajardo VC, De Freitas SN : Resistin and visfatin concentrations are related to central obesity and inflammation in Brazilian children. Nutrire 43(1) : 1-8, 2018. doi : 10.1186/s41110-018-0060-7
29. Maury E, Brichard SM : Adipokine dysregulation, adipose tissue inflammation and metabolic syndrome. Mol Cell Endocrinol 314(1) : 1-16, 2010. doi : 10.1016/j.mce.2009.07.031
30. Olza J, Aguilera CM, Gil-Campos M, Leis R, Bueno G, Valle M, Cañete R, Tojo R, Moreno LA, Gil A : Waist-to-height ratio, inflammation and CVD risk in obese children. Public Health Nutr (10) : 2378-85, 2014. doi : 10.1017/S1368980013003285.
31. Dina RC, Dobri A, Radu R, Dina CA, Dinu FC, Mo M : Clinical and biological markers of insulin resistance 17(3) : 2010
32. Matos LN, Giorelli G de V, Dias CB : Correlação dos indicadores antropométricos em identificar a sensibilidade e resistência insulínicas. Sao Paulo Med J 129(1) : 30-35, 2011. doi : 10.1590/S1516-31802011000100006
33. Martins AS, Jansen AK, Rodrigues LOC, Matos CM, Souza MLR, Miranda DM, Rezende NA : Increased insulin sensitivity in individuals with neurofibromatosis type 1. Arch Endocrinol Metab 62(1) : 41-46, 2018. doi : 10.20945/2359-3997000000007.
34. Urrunaga-Pastor D, Toro-Huamanchumo C, Benites-Zapata V, Guarnizo-Poma M, Lazaro H, Pantoja-Torres B, Paico S, Ranilla-Seguin V : Mets-Ir as a Useful Tool for the Diagnosis of Insulin Resistance in Non-Diabetic Euthyroid Adults from Lima, Peru. Metabolism : Clinical and Experimental 116 : 154665, 2021. doi : 10.1016/j.metabol.2020.154665
35. Ding L, Gao YH, Li YR, Huang YF, Wang XY, Qi X : Metabolic score for insulin resistance is correlated to adipokine disorder and inflammatory activity in female knee osteoarthritis patients in a chinese population. Diabetes, Metab Syndr Obes Targets Ther 13 : 2109-2118, 2020. doi : 10.2147/DMSO.S249025
36. Mandrekar JN : Receiver operating characteristic curve in diagnostic test assessment. J Thorac Oncol 5(9) : 1315-1316,

2010. doi : 10.1097/JTO.0b013e3181ec173d
37. Michalczuk MT, Kappel CR, Birkhan O, Bragança AC, Álvares-da-Silva MR : HOMA-AD in Assessing Insulin Resistance in Lean Noncirrhotic HCV Outpatients. Int J Hepatol 2012 : 1-7, 2012. doi : 10.1155/2012/576584
38. Vilela BS, Vasques ACJ, Cassani RSL, e Forti AC, Pareja JC, Geloneze B : Homa-adiponectin index as useful surrogate marker in the screening of insulin resistance. Diabetology & Metabolic Syndrome 7(Suppl 1), 2015. doi : 10.1186 /1758-5996-7-S1-A135
39. Makni E, Moalla W, Lac G, Aouichaoui C, Cannon D, Elloumi M, Tabka Z : The Homeostasis Model Assessment-adiponectin (HOMA-AD) is the most sensitive predictor of insulin resistance in obese children. Ann Endocrinol (Paris) 73(1) : 26-33, 2012. doi : 10.1016/j.ando.2011.12.002.



Pic. Scatter plot of HOMA-AD with fasting blood glucose, profile lipid and blood pressure



Pic. Scatter plot of MET-IR with fasting blood glucose, profile lipid and blood pressure