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Original Article

Levels of Blood Glucose, Lipid Profile, and Non-Insulin-Based Insulin Resistance Indices in Thai Adults Without Non-Communicable Diseases (NCDs) in Rangsit Municipality Community, Pathum Thani, Thailand

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Abstract

Predicting the risk of non-communicable diseases (NCDs) is important for early detection and prevention for the diseases. Non-insulin-based insulin resistance indices are a simple tool that can help assess insulin resistance (IR) and predict the risk of NCDs. This study aims to examine levels of blood glucose, lipid profile, and non-insulin-based insulin resistance indices of Thai adults without NCD using the health data of the annual health examination in 2019 (n = 320). A retrospective cross-sectional study was conducted by collecting and analyzing data from 320 Thai adults without NCDs in Rangsit Municipality community, Pathum Thani. Four non-insulin-based insulin resistance indices were calculated: the metabolic score for insulin resistance (METS-IR), the triglycerides and glucose index (TyG), the triglycerides glucose-body mass index (TyG-BMI), and the triglycerides to high-density lipoprotein-cholesterol ratio (TG/HDL-C). No significant differences in METS-IR, TyG, TyG-BMI, TG/HDL-C, and BMI were observed between male and female participants. METS-IR was significantly positively correlated with body weight, systolic and diastolic blood pressures (SBP and DBP), body mass index (BMI), fasting plasma glucose (FPG), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and other non-insulin-based insulin resistance indices, including TyG, TyG-BMI, and TG/HDL-C, while exhibiting an inverse correlation with high-density lipoprotein cholesterol (HDL-C). Quartile studies of METS-IR showed a significant increasing trend across quartiles in percentage of female sex, body weight, SBP, DBP, BMI, FPG, and TG levels, while HDL-C levels were significantly lower across groups. These findings support the utility of METS-IR as a surrogate marker for insulin resistance. As a non-insulin-based calculation, METS-IR offers a cost-effective approach for screening insulin resistance, particularly in adults without diagnosed NCDs among the health check-up population. The results provide valuable information for predicting the risks of developing NCDs, including diabetes and cardiovascular disease in the studied population, leading to the development of public health policies and strategies for preventive measures.

Keywords: Blood glucose, Lipid profile, METS-IR, Non-insulin-based insulin resistance indices, Thai subjects without NCDs

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ระดับน้ำตาล ไขมันในเลือด และดัชนีบ่งชี้ภาวะดื้ออินซูลินที่ไม่ได้มาจากค่าอินซูลินในคนไทยที่ไม่เป็นโรคไม่ติดต่อเรื้อรังในชุมชนเทศบาลนครรังสิต จังหวัดปทุมธานี

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บทคัดย่อ

การคาดการณ์ความเสี่ยงของโรคไม่ติดต่อเรื้อรัง (NCDs) ถือเป็นสิ่งสำคัญสำหรับการตรวจพบและการป้องกันโรคในระยะเริ่มต้น ดัชนีบ่งชี้ภาวะดื้ออินซูลินที่ไม่ได้มาจากค่าอินซูลินเป็นเครื่องมือง่าย ๆ ที่สามารถช่วยประเมินการดื้อต่ออินซูลินและคาดการณ์ความเสี่ยงของโรค NCDs การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาระดับน้ำตาลและไขมันในเลือด รวมถึงค่าดัชนีบ่งชี้ภาวะดื้ออินซูลินที่ไม่ได้มาจากค่าอินซูลิน ในคนไทยที่ไม่เป็นโรค NCDs โดยใช้ข้อมูลสุขภาพจากการตรวจสุขภาพประจำปี 2562 (n = 320) เป็นการศึกษาแบบภาคตัดขวางย้อนหลังจากการรวบรวมและวิเคราะห์ข้อมูลจากคนไทยที่ไม่เป็นโรค NCDs จำนวน 320 ราย ในชุมชนเทศบาลนครรังสิต จังหวัดปทุมธานี โดยศึกษาดัชนีบ่งชี้ภาวะดื้ออินซูลินที่ไม่ได้มาจากค่าอินซูลิน 4 ชนิด ได้แก่ metabolic score for insulin resistance (METS-IR) ดัชนีไตรกลีเซอไรด์และกลูโคส (TyG) ดัชนีไตรกลีเซอไรด์และกลูโคสและดัชนีมวลกาย (TyG-BMI) และอัตราส่วนไตรกลีเซอไรด์ต่อ HDL-C (TG/HDL-C) จากการศึกษาไม่พบความแตกต่างอย่างมีนัยสำคัญของค่า METS-IR, TyG, TyG-BMI, TG/HDL-C และ BMI ระหว่างผู้เข้าร่วมการศึกษาทั้งชายและหญิง ค่า METS-IR แสดงความสัมพันธ์เชิงบวกอย่างมีนัยสำคัญกับน้ำหนักตัว ค่าความดันโลหิตซิสโตลิกและไดแอสโตลิก (SBP และ DBP) ดัชนีมวลกาย (BMI) ระดับน้ำตาลในเลือดขณะอดอาหาร (FPG) ไตรกลีเซอไรด์ (TG) low-density lipoprotein cholesterol (LDL-C) และดัชนีบ่งชี้ภาวะดื้ออินซูลินที่ไม่ได้มาจากค่าอินซูลิน ได้แก่ TyG, TyG-BMI และ TG/HDL-C การศึกษาพบว่าค่า METS-IR แสดงความสัมพันธ์แบบผกผันกับค่า high-density lipoprotein cholesterol (HDL-C) การศึกษาควอไทล์ของ METS-IR แสดงให้เห็นแนวโน้มที่เพิ่มขึ้นอย่างมีนัยสำคัญในอัตราร้อยละของเพศหญิง น้ำหนักตัว ค่า SBP, DBP, BMI, FPG และ TG ขณะที่ระดับ HDL-C ลดลงอย่างมีนัยสำคัญในทุกกลุ่ม ผลการศึกษานี้สนับสนุนประโยชน์ของ METS-IR ในฐานะค่าทดแทนที่สะท้อนผลจากภาวะดื้อต่ออินซูลิน เนื่องจากเป็นค่าจากการคำนวณที่ไม่ใช้อินซูลิน METS-IR จึงเป็นแนวทางที่คุ้มต้นทุนสำหรับการคัดกรองภาวะดื้อต่ออินซูลิน โดยเฉพาะในผู้ใหญ่ที่ไม่ได้รับการวินิจฉัยว่าเป็นโรค NCDs ในกลุ่มประชากรที่เข้ารับการตรวจสุขภาพ ผลการศึกษานี้ให้ข้อมูลที่มีประโยชน์ในการทำนายความเสี่ยงต่อการเกิดโรค NCDs ซึ่งรวมถึงโรคเบาหวาน โรคหัวใจและหลอดเลือด ในกลุ่มประชากรที่ศึกษา นำไปสู่การพัฒนานโยบาย กลยุทธ์และมาตรการป้องกันด้านสาธารณสุขต่อไป

คำสำคัญ: ระดับน้ำตาลในเลือด, ระดับไขมัน, METS-IR, non-insulin-based insulin resistance indices, คนไทยที่ไม่เป็นโรคไม่ติดต่อเรื้อรัง

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1. Introduction

NCDs were also known as lifestyle diseases, posing significant challenges to the government sector, requiring an annual expenditure of 139 billion Baht on patient treatments.[1] These diseases are substantial barriers to the country's economic and social progress, particularly affecting the quality of human resources. Premature deaths reduce the workforce potential. Insulin resistance (IR) or decreased insulin sensitivity causes ineffective insulin activity in peripheral tissues, resulting in elevated insulin levels and disrupted lipid and glucose regulation. IR constitutes a risk factor for the onset of type 2 diabetes (T2D) and cardiovascular disease, contributing significantly to global health burdens.

Although the fasting insulin-based indices, such as the homeostatic model assessment for insulin resistance (HOMA-IR), have traditionally been used as standard tools for assessing IR.[3] However, their clinical utility is limited by the need for insulin measurements, which are subject to variability and practicality issues. To address these limitations, non-insulin-based insulin resistance indices have been developed, replacing insulin measurements with parameters such as fasting triglycerides (TG), fasting plasma glucose (FPG), and lipoproteins including metabolic score for insulin resistance (METS-IR)[2, 3] triglycerides and glucose index (TyG),[4] triglycerides glucose-body mass index (TyG-BMI),[5] and triglycerides to high-density lipoprotein cholesterol ratio (TG/HDL-C).[2] METS-IR, which is calculated from TG, FPG, HDL-cholesterol (HDL-C), and body mass index (BMI), is considered a new alternative biomarker for indicating IR. This index showed a strong correlation with IR measured by hyperinsulinemic-euglycemic clamp (gold standard method). It is associated with fasting insulin and hepatic fat accumulation. Visceral fat and subcutaneous fat, which are key mechanisms in the development of IR.[3, 6] A positive correlation has been found between the METS-IR index and diseases related to metabolism or inflammation, including diabetes,[7] metabolic syndrome (MetS),[8] high blood pressure[9] and non-alcoholic fatty liver disease[10] which are important risk factors for the development of cardiovascular diseases (CVDs). METS-IR is a more effective predictor than other IR indices in patients with diabetes, such as TyG and TG/HDL-C.[3] In addition, METS-IR was shown to be an independent risk factor in both male and female participants.[8]

However, there is currently limited information on its relationship between non-insulin-based insulin resistance indices and the risks of NCDs development in the general population. Annual health examination is an important activity in monitoring and promoting health, preventing and controlling NCDs in the community.[11] It is useful health information for changing lifestyle behaviors and improving the government's health policy. NCD situation in Pathum Thani Province tends to increase over the year, with high rates of illness from diabetes and CVDs.[12] Therefore, the study of clinical parameters indicating NCDs in the Rangsit Municipality community, Pathum Thani, is needed for the management of the health of the people in the community.

The objective of this study was to analyze annual health checkup data, particularly glucose, lipid profile and non-insulin-based insulin resistance indices in the population of the Rangsit Municipality community, Pathum Thani to predict the risk of NCDs development in the future.

2. Materials and methods

2.1 Study design and population

A retrospective cross-sectional study was conducted on 320 Thai subjects without NCDs attended in the annual health examination in July 2019 project, organized by the Subdistrict Administrative Organization (SAO) and the Healthcare Service Center, Faculty of Allied Health Sciences, Thammasat University in

July 2019. As shown in Fig. 1, the age of subjects in this study was in the range of 20 to 60 years old and living in the Rangsit Municipality community, Pathum Thani (Table 1). Subjects provided general and clinical information in the screening interview. The subjects with underlying diseases including NCDs, thyroid disease, gout and thalassemia, as well as those with incomplete or unavailable general, clinical and laboratory data were excluded from the study. All subjects' data were collected while ensuring the privacy of participants. The study protocol was reviewed and approved by the Human Research Ethics Committee of Thammasat University (Science) (HREC-TUSc), Thammasat University (COA No. 026/2566).

2.1 Clinical data and laboratory investigation

General and clinical data were obtained from records in the Healthcare Service Center, Faculty of Allied Health Sciences, Thammasat University, including age, gender, and systolic and diastolic blood pressures (SBP and DBP). The clinical laboratory data were collected from 1,675 healthy subjects aged between 20 and 60 years old from single blood samples in July 2019 who underwent annual health examination. Since the prevalence of NCD was the primary consideration for sample size estimation, the following formula was applied.[13]

$$n = \frac{\mathrm{Z}^2 P(1-P)}{d^2}$$

Where n is the sample size, Z is the statistic corresponding to the level of confidence (1.96 for 95% confidence), P is the expected prevalence (0.218), and d is the precision (0.05). According to the recent study by Phaiyarom M, *et al*. (2021), the NCD prevalence in Thai adults was 21.8%.[14] Data from participants who have complete data with no history of underlying disease (n = 529) were subjected to random sampling using Microsoft Excel™ 2013 and data analysis for 320 subjects. The tests included fasting plasma glucose (FPG), total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein (LDL-C) and related parameters including body mass index (BMI) (Fig. 1). The levels of each laboratory parameter were measured from the participant's plasma or serum using Furuno CA-800 clinical chemistry analyzer (Furuno Electric Co., Ltd, Japan). All laboratory examinations were performed following the standard procedures: FPG by enzymatic hexokinase, TC by enzymatic colorimetric test (CHOD-PAP method), TG by enzymatic colorimetric test (GPO-PAP method), LDL-C and HDL-C by direct enzymatic assay. All laboratory reagents used were from Centronic GmbH, Germany. Body weight was measured using a TANITA WB-380 H digital scale based on the strain gauge load cell principle. (Tanita Corporation, Tokyo, Japan). Standing height was measured using a TANITA WB-380H digital stadiometer, which uses an electronic sensor to measure the vertical distance from the platform to the headpiece. (Tanita Corporation, Tokyo, Japan). Blood pressure was assessed using a Raycome RBP-9805 device, which operates based on dual-sensor oscillometric technology. (Raycome Health Technology Co., Ltd., Shenzhen, China)

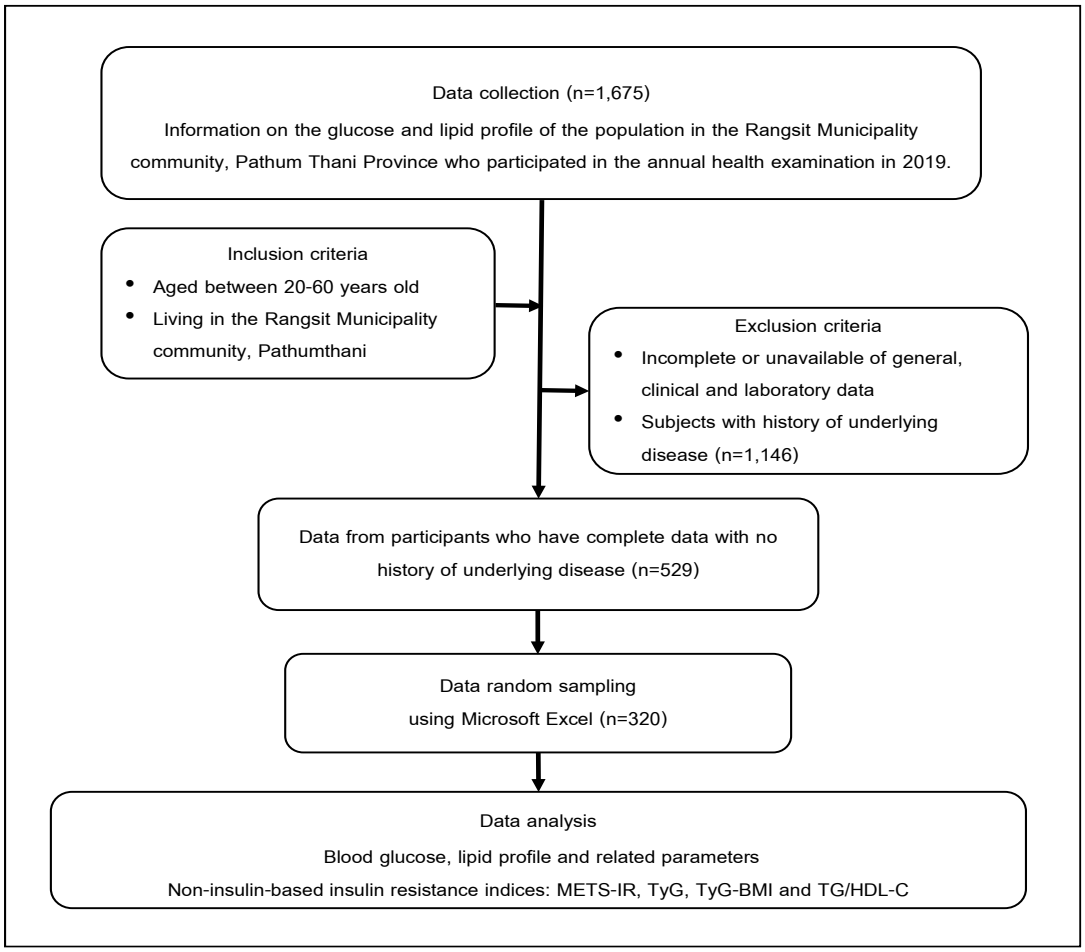


Fig. 1 Conceptual framework of the study of blood glucose, lipid profile, and related parameters and non-insulin-based insulin resistance indices in the Thai subjects without NCDs in the Rangsit Municipality community, Pathum Thani.

1. Data analysis

Blood glucose and lipid levels and related parameters data were analyzed together with insulin resistance (IR) data using non-insulin-based insulin resistance indices, including metabolic score for insulin resistance (METS-IR),[3] triglycerides and glucose index (TyG),[4] triglycerides glucose-body mass index (TyG-BMI),[5] and triglycerides to high-density lipoprotein cholesterol ratio (TG/HDL-C)[2] using Microsoft Excel, utilizing the following calculation formulas:

$$\text{METS-IR} = \text{Ln}\,[(2 \times \text{FPG (mg/dl)}) + \text{TG (mg/dl)}] \times \text{BMI (kg/m}^2) \div \text{Ln}\,[\text{HDL-C (mg/dl)}]$$

$$\text{TyG} = \text{Ln}\,[\text{TG (mg/dl)} \times \text{FPG (mg/dl)}] \div 2$$

$$\text{TyG-BMI} = \text{TyG} \times \text{BMI (kg/m}^2)$$

$$\text{TG/HDL-C} = \text{TG (mg/dl)} \div \text{HDL-C (mg/dl)}$$

$$\text{BMI} = \text{weight (kg)} / \text{height (m}^2)$$

The data were analyzed using descriptive statistics and presented as the sample characteristics, such as median and interquartile range: 25th to 75th percentile (IQR 25-75). The normality of the sample distribution was tested with the Kolmogorov-Smirnov (K-S) test. Spearman correlation was used to calculate the correlations among METS-IR and the other parameters and non-insulin-based insulin resistance indices.[15] According to the recent study, METS-IR values were categorized into quartiles as follows: Q1 (≤28.2), Q2 (28.3-32.4), Q3 (32.5-37.8), and Q4 (≥37.9).[16] The Kruskal-Wallis test was performed to assess differences in median values across METS-IR quartiles. The level of statistical significance at 0.05 was determined using the program IBM SPSS Statistics for Windows, v.20.0.

3. Results

3.1 Characteristics of the participants

A total of 320 participants aged 24-60 years were included in the study in 2019. All participants met the inclusion criteria, and none were excluded. The characteristics of the participants including ages, body weight, systolic and diastolic blood pressures (SBP and DBP), body mass index (BMI), fasting plasma glucose (FPG), total cholesterol (TC), triglycerides (TG), low-density lipoprotein-cholesterol (LDL-C), and high-density lipoprotein (HDL-C) were summarized. (Table 1)

Table 1 Clinical and laboratory characteristics of Thai subjects without NCDs (n = 320).

Parameters	Results*
Age (years)	49 (24-60)
Body weight (kg)	59.5 (52-68)
SBP (mmHg)	127 (118-137)
DBP (mmHg)	82 (76-89)
BMI (kg/m^2)	23.85 (21.3-26.22)
FPG (mg/dl)	90 (85-97)
TC (mg/dl)	227.50 (205-261)
TG (mg/dl)	121 (84-184)
LDL-C (mg/dl)	135 (109-159)
HDL-C (mg/dl)	67 (57-79)

*Data: age shown as mean (minimum-maximum) and others (*) shown as median (IQR 25-75)

3.2 Non-insulin-based insulin resistance indices characteristics

The analysis of non-insulin-based insulin resistance indices: METS-IR, TyG, TyG-BMI, and TG/HDL-C in healthy adults (n = 320). (Table 2)

Table 2 Non-insulin-based insulin resistance indices in Thai subjects without NCDs.

Parameters	Results*
METS-IR	32.52 (28.31-37.93)
TyG	4.65 (4.46-4.89)
TyG-BMI	110.75 (97.40-126.60)
TG/HDL-C	1.82 (1.15-3.04)

*Data shown as median (IQR 25-75)

3.3 Gender and non-insulin-based insulin resistance indices

Based on gender, there were 83 (25.94%) male and 237 (74.06%) female participants. There was no significant difference in METS-IR, TyG, TyG-BMI, TG/HDL-C, and BMI for both male and female participants. (Table 3)

Table 3 Effect of gender on non-insulin-based insulin resistance indices (n = 320: Men = 83, Women = 237).

Parameters	Sex	Results*	*p*-value
METS-IR	Men	32.21 (28.19-36.91)	0.354
	Women	32.59 (28.45-38.44)	
TyG	Men	4.69 (4.48-4.89)	0.560
	Women	4.63 (4.46-4.89)	
TyG-BMI	Men	112.3 (95.8-124.3)	0.374
	Women	110.1 (97.9-128.1)	
TG/HDL-C	Men	1.96 (1.11-3.17)	0.622
	Women	1.76 (1.16-3.02)	
BMI (kg/m^2)	Men	23.53 (20.90-25.89)	0.235
	Women	24.03 (21.48-26.55)	

*p-values were calculated using Mann-Whitney U test, data shown as median (IQR 25-75) and a p-value <0.05 was significant.

3.4 The correlation of METS-IR with glucose and lipid profile and non-insulin-based insulin resistance indices

This study showed that body weight, SBP, DBP, BMI, FPG, TG, LDL-C, TyG, TyG-BMI, and TG/HDL-C had a significantly positive correlation with METS-IR. However, HDL-C showed significantly negative correlation with METS-IR (r = -0.606, p < 0.001). Age and TC showed no significantly correlated with METS-IR with r = 0.039 (p = 0.490) and r = 0.088 (p = 0.117), respectively. (Table 4)

Table 4 The Spearman correlation analysis of METS-IR with other parameters and non-insulin-based insulin resistance indices. (n = 320)

Parameters	Spearman's Correlation Coefficient (r)	*p*-value
Age (years)	0.039	0.490
Body weight (kg)	0.850	<0.001*
SBP (mmHg)	0.345	<0.001*
DBP (mmHg)	0.381	<0.001*
BMI (kg/m^2)	0.933	<0.001*
FPG (mg/dl)	0.448	<0.001*
TC (mg/dl)	0.088	0.117
TG (mg/dl)	0.578	<0.001*
LDL-C (mg/dl)	0.112	0.046*
HDL-C (mg/dl)	-0.606	<0.001*
TyG	0.615	<0.001*
TyG-BMI	0.973	<0.001*
TG/HDL-C	0.682	<0.001*

*Correlation is significant at the 0.01 level (2-tailed) and a *p*-value <0.05 was significant.

3.5 Baseline characteristics by METS-IR Quartile

Quartile studies of METS-IR stratify populations into four groups (Q1-Q4).[16] Table 5 shows baseline characteristics of the study population and related parameters across METS-IR quartiles. Participants were categorized into four quartiles: Q1 (≤28.2), Q2 (28.3-32.4), Q3 (32.5-37.8), and Q4 (≥37.9), comprising 78 (24.4%), 81 (25.3%), 81 (25.3%), and 80 (25.0%) participants, respectively. Significantly increasing trends were observed across quartiles in female sex (%), body weight, SBP, DBP, BMI, FPG, and TG levels, while HDL-C levels were significantly lower across groups (all $p < 0.001$). However, no significant differences were found in age, TC, and LDL-C across quartiles.

Table 5 The characteristics of the study population and related parameters according to METS-IR quartiles. (n = 320)

Parameters	METS-IR quartiles				*p*-value
	Q1 n = 78	Q2 n = 81	Q3 n = 81	Q4 n = 80	
METS-IR	≤28.2	28.3-32.4	32.5-37.8	≥37.9	
Female sex (%)	71.8	74.1	72.8	77.5	<0.001*
Age (years)	47 (40-57)	50 (43-56)	52 (46-56)	49 (42-56)	0.111
Body weight (kg)	49 (46-52)	56 (52-61)	61 (58-67)	74 (69-82)	<0.001*
SBP (mmHg)	121 (112-129)	122 (116-134)	129 (121-140)	133 (126-141)	<0.001*
DBP (mmHg)	76 (72-86)	80 (74-85)	86 (79-90)	86 (80-94)	<0.001*
BMI (kg/m^2)	20.1 (18.8-21.0)	22.8 (21.5-23.8)	23.9 (24.9-25.9)	29.1 (27.3-31.5)	<0.001*
FPG (mg/dl)	85 (82-90)	89 (84-93)	92 (87-99)	95 (90-101)	<0.001*
TC (mg/dl)	219 (200-253)	225 (200-258)	234 (216-265)	229 (205-274)	0.316
TG (mg/dl)	83 (70-103)	102 (83-145)	140 (106-198)	189 (134-247)	<0.001*
LDL-C (mg/dl)	124 (106-154)	132 (106-157)	145 (112-162)	135 (113-165)	0.147
HDL-C (mg/dl)	80 (72-89)	70 (62-80)	63 (58-73)	56 (49-63)	<0.001*

*p-values were calculated using Kruskal-Wallis test, data shown as median (IQR 25-75), and a p-value <0.05

4. Discussion

The analysis of the health data from annual health examinations in a community-based population of Thai subjects without NCDs without underlying disease including diabetes was performed. We reported medians of body weight, SBP, DBP, BMI, FPG, lipid profile and non-insulin-based IR indices, METS-IR, TyG, TyG-BMI and TG/HDL-C. These results suggested that most Thai subjects without NCDs in this study had relatively good health. However, some parameters in this study were slightly higher than the normal range. For instance, the average TC was 227.5 mg/dL (normal: <200 mg/dL), LDL-C averaged 135 mg/dL (normal: ≤130 mg/dL), and the mean SBP and DBP were 127 and 82 (normal: ≤120 mmHg and ≤80 mmHg), respectively. These mildly elevated values suggest there were early signs of NCDs in some individuals in this population.[17]

The analysis demonstrated that METS-IR was positively correlated with body weight, SBP, DBP, BMI, FPG, TG, LDL-C, and other non-insulin-based indices, including TyG, TyG-BMI, TG/HDL-C.[18,19] Similar to previous studies, METS-IR showed strong positive correlations with BMI[21] and other non-insulin-based insulin resistance indices, particularly TyG-BMI.[16] In contrast, the correlations with TyG and TG/HDL-C were relatively weaker. This relationship may be attributed to the shared components between METS-IR and TyG-BMI.[3] Furthermore, obesity is a well-established contributor to insulin resistance, and previous studies demonstrated that the TyG-BMI offers superior predictive performance over other TyG-derived indices in identifying insulin resistance among adults.[16] However, we found no significant correlation between METS-IR and either TC or age, consistent with previous studies.[18,21] However, the relationship between METS-IR and age remains inconclusive, as findings vary across studies and populations. While some studies have

reported a significant positive correlation,[20] while others find none,[21] depending on factors like population characteristics.[22]–METS-IR demonstrated strong diagnostic performance in both male and female subjects, with comparable effectiveness across sexes.[23,24]—Additionally, this study found that all five non-insulin-based insulin resistance indices showed no significant differences based on gender, which is similar to a previous study.[23]

A previous study on METS-IR values in participants without diabetes reported a mean METS-IR of 33.8 (27.3-40.3),[16] which is similar to our findings, where we observed a mean METS-IR of 32.52 (28.31-37.93). Recently, a study on the Thai population without MetS reported a mean METS-IR of 34.21 (26.95-41.47),[25] slightly higher than our data. However, METS-IR values may vary depending on the study population and methodology.[16, 25] Our results are consistent with the findings of previous studies,[16] the analysis showed that METS-IR quartiles (Q1-Q4) were positively associated with increasing trends in body weight, SBP, DBP, BMI, FPG, and TG levels. In contrast to the findings.[16] our analysis revealed no statistically significant differences in age or TC across METS-IR quartiles. This variation may be attributable to differences in population characteristics.[22] However, no statistically significant differences in LDL-C levels were observed across the METS-IR quartiles, consistent with findings reported in a previous study.[26] In addition, this lack of statistical significance may be attributed to the limited overall sample size and the underrepresentation of male participants in the study. Previous studies has demonstrated that Thai men tend to have higher TC and LDL-C levels than women,[27] and that elevated LDL-C poses a more substantial cardiovascular risk in men.[28] Therefore, future studies with a larger and more balanced male representation are needed to explore the associations between TC, LDL-C, and METS-IR.

METS-IR quartiles in our study demonstrated a positive association with the proportion of female participants, which contrasts with previous findings that demonstrated a positive association with percentage of male sex.[16] However, this finding was consistent with the other studies by which reported that women exhibited higher baseline METS-IR scores than men. They further demonstrated that elevated METS-IR levels were significantly associated with an increased risk of developing T2D.[29] Studies on older women showed that declining estrogen levels contribute to increased insulin resistance, thereby elevating the risk of impaired glucose metabolism and the subsequent development of T2D.[30] Alternatively, this discrepancy may also reflect the demographic composition of our data, which included a higher proportion of female participants.

IR can lead to the development of dyslipidemia, hypertension, and CVDs. IR is a fundamental pathological characteristic of MetS and a significant risk factor for developing hypertension.[31] IR-induced compensatory hyperinsulinemia triggers overactivation of the carotid body, resulting in heightened sympathetic nervous system activity, which increases peripheral vascular resistance and promotes blood pressure elevation.[31]

Previous studies have shown that insulin resistance is linked to a higher risk of CVDs in non-diabetic individuals.[32] Therefore, early identifying insulin resistance in adults at risk for future CVDs is essential for prevention and lessening the progression of the disease. The Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) is the widely used method for assessing the degree of IR.[33] However, it may introduce biases due to factors such as variations in insulin assays, including calibration settings and unit conversions.[34] Recently, the METS-IR has been recognized for its strong predictive capabilities for predicting the risk of CVDs.[16,35] METS-IR is an innovative scoring system designed to assess cardiometabolic risk in healthy individuals offering a promising method for screening insulin sensitivity.[3] METS-IR showed a

significant positive correlation with HOMA-IR.[24] It is a potential surrogate marker for insulin resistance in clinical and epidemiological settings.[24] Its non-insulin-based calculation, cost-effectiveness, and consistent diagnostic ability across demographic subgroups make it a promising alternative to HOMA-IR for predicting the development of diabetes in non-diabetic subjects.[24] The performance of METS-IR was consistent across sex and age subgroups, showing good diagnostic value for both males and females.[24, 30]

In this study, we reported medians of MET-IR in Thai subjects without NCDs as indicated in the materials and methods and also found that METS-IR had a positive correlation with FPG and lipid profile, such as TG and BMI, but a reversed correlation with HDL-C, which correlated with the previous study.[3] As low HDL-C has been suggested to contribute to the higher incidence of cardiovascular events (CVEs), the lower HDL-C levels observed in this study may suggest a risk for cardiovascular events in healthy adults.[35]

The findings of this study were also consistent with previous research, highlighting a significant correlation between METS-IR and various factors such as FPG, BMI, and HOMA-IR and associated with the highest risk of developing T2D.[3] Moreover, our findings are consistent with the findings from a study on normoglycemic individuals in Japan.[9] The METS-IR is a convenient tool for detecting IR, a key component of metabolic syndrome (MetS). It could serve as a practical alternative to conventional insulin assays, enabling early identification of cardiometabolic risks.

Some limitations were encountered in this study. Firstly, this study employed a retrospective cross-sectional design to examine characteristics of the subjects, blood glucose, lipid profile, and non-insulin-based insulin resistance indices. This is a pilot study to observe the health status of Thai subjects without NCDs, particularly the potential development of metabolic syndrome. Secondly, the present study was conducted among the Rangsit Municipality community, Pathum Thani, comprising a higher proportion of female participants (approximately 75%); however, the results reflected a real-world situation within this study population. Third, the collection of data was done from only one region of Thailand, which restricted the number of participants enrolled. Therefore, further investigation with a prospective longitudinal study in a larger population is recommended to establish data for Thai subjects without NCDs. Lastly, due to the observational study using previously collected data from a health examination database, data on some variables were limited, e.g., the underlying diseases. Notably, the underlying diseases of the subjects were collected by the screening questionnaire and general interviewing, not a full clinical examination by a physician. Therefore, residual confounding may have influenced the study results.

Despite the limitations discussed above, our study also encompassed considerable strengths. We believe this study could fill a significant gap in the knowledge of laboratory characteristics of blood glucose and lipid profiles of the Thai subjects without NCDs and their IR characteristics as a risk factor for the onset of T2D in Thailand. These data could serve as a foundation for future research to determine the best possible cut-off values, sensitivity, and specificity of METS-IR across diverse racial and ethnic subgroups. This would enhance the integration of METS-IR into the diagnostic toolkit for CVDs. It may also help establish guidelines for CVD prevention in clinical practice. Moreover, predicting the risk of NCDs like hypertension, T2D, and cardio CVDs allows for early detection and preventative measures to be taken, potentially reducing the burden of these diseases on individuals and healthcare systems by enabling timely lifestyle modifications and targeted treatment plans; essentially, by identifying people at high risk, proactive steps can be taken to prevent the development of these serious health conditions.[36]

Although METS-IR has emerged as a promising non-insulin-based surrogate marker for insulin resistance, further comprehensive investigation should be conducted to assess the risk of other non-communicable

diseases (NCDs), including T2D, hypertension, and CVDs. This study was conducted within a single population group, which may limit the generalizability of the findings. To strengthen the validity and applicability of METS-IR for broader clinical and public health use, future research should involve larger, more diverse cohorts across multiple populations and geographic regions. Such comprehensive data are essential before considering the integration of METS-IR into policy planning and preventive health strategies.

5. Conclusion

From a public health community perspective, METS-IR was shown to be correlated with the routine parameters for health checkup, such as body weight, SBP and DBP, BMI, levels of blood glucose, and lipid profile, including other non-insulin-based insulin resistance indices in the subjects in the Rangsit Municipality community, Pathum Thani. The results show the correlation of METS-IR and other parameters with non-insulin-based insulin resistance indices, potentially suggesting that these are the contributing factors to the incidence of cardiovascular events (CVEs). Public healthcare policies within the Thai community should be reviewed for the change of IR indices to detect the early signs of CVDs. Strategies for enhancing Thailand's healthcare welfare system should be designed. Due to its non-insulin-based formulation, cost-effectiveness, and reliable diagnostic performance across sex and age categories and diverse demographic subgroups, METS-IR represents a compelling alternative to HOMA-IR for predicting the onset of diabetes in non-diabetic individuals. The findings from this study offer valuable evidence to support the enhancement of healthcare services, particularly through the identification of risk factors for T2D and CVEs among healthy individuals. Public healthcare policies within the Thai community should consider incorporating non-insulin-based insulin resistance indices into routine health checkups.

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References

1. Ministry of Public Health of Thailand, World Health Organization (WHO), United Nations Development Programme (UNDP), and United Nations Inter-Agency Task Force (UNIATF). Prevention and Control of Noncommunicable Diseases in Thailand - The Case for Investment [monograph on the Internet] United Nations Thailand; 2021 [cited 2025 September 26]. Available from: https://www.who.int/thailand/activities/NCDs_Investment_Case_Report.
2. Abbasi F, Reaven GM. Comparison of two methods using plasma triglyceride concentration as a surrogate estimate of insulin action in nondiabetic subjects: triglycerides x glucose versus triglyceride/high-density lipoprotein cholesterol. Metabolism 2011; 60 : 1673-6.
3. Bello-Chavolla OY, Almeda-Valdes P, Gomez-Velasco D, Viveros-Ruiz T, Cruz-Bautista I, Romo-Romo A, *et al*. METS-IR, a novel score to evaluate insulin sensitivity, is predictive of visceral adiposity and incident type 2 diabetes. Eur J Endocrinol 2018; 178: 533-44.

4. Simental-Mendia LE, Simental-Mendia E, Rodriguez-Hernandez H, Rodriguez-Moran M, Guerrero-Romero F. The product of triglycerides and glucose as biomarker for screening simple steatosis and NASH in asymptomatic women. Ann Hepatol 2016; 15: 715-20.
5. Er LK, Wu S, Chou HH, Hsu LA, Teng MS, Sun YC, *et al*. Triglyceride glucose-body mass index is a simple and clinically useful surrogate marker for insulin resistance in nondiabetic individuals. PLoS One 2016; 11: e0149731.
6. Pan L, Zou H, Meng X, Li D, Li W, Chen X, *et al*. Predictive values of metabolic score for insulin resistance on risk of major adverse cardiovascular events and comparison with other insulin resistance indices among Chinese with and without diabetes mellitus: Results from the 4C cohort study. J Diabetes Investig 2023; 14: 961-72.
7. Paltrinieri S, Bressi B, Costi S, Mazzini E, Cavuto S, Ottone M, *et al*. Beyond lockdown: the potential side effects of the SARS-CoV-2 pandemic on public health. Nutrients 2021; 13: 1600.
8. Mirr M, Skrypnik D, Bogdanski P, Owecki M. Newly proposed insulin resistance indexes called TyG-NC and TyG-NHtR show efficacy in diagnosing the metabolic syndrome. J Endocrinol Invest 2021; 44: 2831-43.
9. Han KY, Gu J, Wang Z, Liu J, Zou S, Yang CX, *et al*. Association between METS-IR and prehypertension or hypertension among normoglycemia subjects in Japan: A retrospective study. Front Endocrinol (Lausanne) 2022; 13: 851338.
10. Cai X, Gao J, Hu J, Wen W, Zhu Q, Wang M, *et al*. Dose-response associations of metabolic score for insulin resistance index with nonalcoholic fatty liver disease among a nonobese Chinese population: retrospective evidence from a population-based cohort study. Dis Markers 2022; 2022: 4930355.
11. Al-Abdulla SA, Haj Bakri A, Mansaray MA, Al-Kuwari MG. Assessing the impact of annual health screenings in identifying noncommunicable disease risk factors within Qatar's primary health care corporation Qatari registered population. Front Public Health 2024; 12: 1305636.
12. Rangsit Municipality Health Insurance Fund. Non-communicable disease incidence rate in Pathum Thani Province and Rangsit Municipality, fiscal year 2013-2017 [monograph on the Internet] Thailand: Rangsit Municipality; 2018 [cited 2025 September 26]. [Available from: https://www.fundrangsit.com/index.php/main/graph/4.
13. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med 2013; 35: 121-6.
14. Phaiyarom M, Kosiyaporn H, Pudpong N, Sinam P, Suphanchaimat R, Julchoo S, *et al*. Access to non-communicable disease (NCD) services among urban refugees and asylum seekers, relative to the Thai population, 2019: a case study in Bangkok, Thailand. Risk Manag Healthc Policy 2021; 14: 3423-33.
15. Spearman C. The proof and measurement of association between two things. Int J Epidemiol 2010; 39: 1137-50.
16. Yoon J, Jung D, Lee Y, Park B. The metabolic score for insulin resistance (METS-IR) as a predictor of incident ischemic heart disease: a longitudinal study among Korean without diabetes. J Pers Med 2021; 11: 742.

17. World Health Organization. Noncommunicable diseases [monograph on the Internet]. Switzerland: WHO; 2024 [cited 2025 September 26]. Available from: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases.
18. Li C, Xu J. Negative correlation between metabolic score for insulin resistance index and testosterone in male adults. Diabetol Metab Syndr 2024; 16: 113.
19. Duan M, Zhao X, Li S, Miao G, Bai L, Zhang Q, *et al*. Metabolic score for insulin resistance (METS-IR) predicts all-cause and cardiovascular mortality in the general population: evidence from NHANES 2001-2018. Cardiovasc Diabetol 2024; 23: 243.
20. Aznar-Esquivel A, Gomez-Bernal F, Garcia-Gonzalez M, Hernandez-Diaz M, Heras-Recuero E, de Vera-Gonzalez A, *et al*. The metabolic score for insulin resistance (METS-IR), a predictor of pardiovascular events, relates to disease activity in patients with rheumatoid arthritis. Diagnostics (Basel) 2025; 15: 861.
21. Boccardi V, Mancinetti F, Baroni M, Cecchetti R, Bastiani P, Ruggiero C, *et al*. Metabolic Score for Insulin Resistance (METS-IR) and circulating cytokines in older persons: The role of gender and body mass index. Nutrients 2022; 14: 3228.
22. Tazeem MS, Chandrasekaran ND, Srivatsa N. Assessing the utility of the metabolic score for insulin resistance (METS-IR) in evaluating metabolic risk among iIndividuals undergoing master health checkups in a tertiary care hospital in South India: A retrospective cohort study. Cureus 2024; 16: e70289.
23. Alshammari S, AlMasoudi AS, AlBuhayri AH, AlAtwi HM, AlHwiti SS, Alaidi HM, *et al*. Effect of COVID-19 on glycemic control, insulin resistance, and pH in elderly patients with type 2 diabetes. Cureus 2023; 15: e35390.
24. Qiu J, He S, Yu C, Yang R, Kuang M, Sheng G, *et al*. Assessing the validity of METS-IR for predicting the future onset of diabetes: an analysis using time-dependent receiver operating characteristics. BMC Endocr Disord 2024; 24: 238.
25. Rattanatham R, Tangpong J, Chatatikun M, Sun D, Kawakami F, Imai M, *et al*. Assessment of eight insulin resistance surrogate indexes for predicting metabolic syndrome and hypertension in Thai law enforcement officers. PeerJ 2023; 11: e15463.
26. Guo D, Zhang C, Zhang M, Wu Z, Liu X, Zhang Y, *et al*. Metabolic score for insulin resistance predicts major adverse cardiovascular event in premature coronary artery disease. Aging (Albany NY) 2024; 16: 6364-83.
27. Pongchaiyakul C, Hongsprabhas P, Pisprasert V, Pongchaiyakul C. Rural-urban difference in lipid levels and prevalence of dyslipidemia: a population-based study in Khon Kaen province, Thailand. J Med Assoc Thai 2006; 89: 1835-44.
28. Cupido AJ, Asselbergs FW, Schmidt AF, Hovingh GK. Low-density lipoprotein cholesterol attributable cardiovascular disease risk is sex specific. J Am Heart Assoc 2022; 11: e024248.
29. Zhang M, Liu D, Qin P, Liu Y, Sun X, Li H, *et al*. Association of metabolic score for insulin resistance and its 6-year change with incident type 2 diabetes mellitus. J Diabetes 2021; 13: 725-34.
30. De Paoli M, Zakharia A, Werstuck GH. The role of estrogen in insulin resistance: A review of clinical and preclinical data. Am J Pathol 2021; 191: 1490-8.
31. Kosmas CE, Bousvarou MD, Kostara CE, Papakonstantinou EJ, Salamou E, Guzman E. Insulin resistance and cardiovascular disease. J Int Med Res 2023; 51: 3000605231164548.

32. Qian T, Sheng X, Shen P, Fang Y, Deng Y, Zou G. Mets-IR as a predictor of cardiovascular events in the middle-aged and elderly population and mediator role of blood lipids. Front Endocrinol (Lausanne) 2023; 14: 1224967.
33. Wongwananuruk T, Rattanachaiyanont M, Leerasiri P, Indhavivadhana S, Techatraisak K, Angsuwathana S, *et al*. The usefulness of homeostatic measurement assessment-insulin resistance (HOMA-IR) for detection of glucose intolerance in Thai women of reproductive age with polycystic ovary syndrome. Int J Endocrinol 2012; 2012: 571035.
34. Manley SE, Stratton IM, Clark PM, Luzio SD. Comparison of 11 human insulin assays: implications for clinical investigation and research. Clin Chem 2007; 53: 922-32.
35. Yang W, Cai X, Hu J, Wen W, Mulalibieke H, Yao X, *et al*. The metabolic score for insulin resistance (METS-IR) predicts cardiovascular disease and Its subtypes in patients with hypertension and obstructive sleep apnea. Clin Epidemiol 2023; 15: 177-89.
36. Budreviciute A, Damiati S, Sabir DK, Onder K, Schuller-Goetzburg P, Plakys G, *et al*. Management and prevention strategies for non-communicable diseases (NCDs) and their risk factors. Front Public Health 2020; 8: 574111.