Letter to Editor

Insulin Resistance can be Easily Estimated by Body Mass Index and Waist Circumference in a General Japanese Population

To the Editor

We read with great interest the recent report by Oka and colleagues¹⁾, who successfully assessed the association of visceral and subcutaneous adipose tissue with insulin resistance in a Japanese population, using the homeostasis model for the assessment of insulin resistance (HOMA-IR)²⁾ and the Matsuda index³⁾ as indices of insulin resistance/sensitivity. Their detailed investigations also showed that body mass index (BMI) was not inferior in predicting insulin resistance to the area of visceral fat tissue evaluated by computed tomography. Furthermore, interestingly, waist circumference was significantly associated with insulin resistance even after adjustment for visceral fat tissue. These findings indicate the possibility that BMI and waist circumference by themselves would provide considerable information on insulin resistance/sensitivity in a Japanese population. Assessment of insulin resistance/sensitivity is not easy in epidemiological practice. It would be useful if average insulin resistance/sensitivity of a population could be predictively evaluated using these easy measurements. We therefore investigated the predictive impact of BMI and waist circumference on insulin resistance/sensitivity in a general Japanese population.

We used a database of 1719 Japanese employees of Amagasaki City Office whose fasting plasma glucose levels were <7.0 mmol/L and who underwent the 75-g oral glucose tolerance test (OGTT) (UMIN000002391).

None had undergone anti-diabetic treatment and none had malignant neoplasms. They were 50 ± 9 years old and 1453 subjects (85%) were male. Plasma glucose and insulin were measured at 0 and 120 min during the 75-g OGTT, from which the Matsuda index³⁾ and HOMA-IR²⁾ were calculated. The current analyses were performed after dividing the population randomly into two groups; one group ($n=860$) was used as the training data, for model derivation, and the other ($n=859$) as the test data, for model validation.

We first used the training data and developed linear regression equations whose dependent variable was either log-transformed HOMA-IR or the log-transformed Matsuda index (**Table 1**). As a result, both BMI and waist circumference were significantly associated with log-transformed HOMA-IR ($r=0.45$ and 0.41) and the log-transformed Matsuda index ($r=-0.40$ and -0.38) in univariate analysis (all $p<0.01$) (See Model 1 and 2). Furthermore, bivariate analysis showed that BMI and waist circumference were associated with these indices, independently of each other (Model 3). Their significant associations were still observed even after adjustment for age and sex (Model 4), as well as other metabolic profiles (Model 5).

We subsequently assessed the model validity of the developed regression equations (Model 1 to 5) using the test data. Estimated average values of HOMA-IR and the Matsuda index were compared to the respective average measurements in every quintile

Table 1. Linear regression model derived from the training data to estimate insulin resistance/sensitivity

Dependent variable	Model 1		Model 2		Model 3		Model 4		Model 5	
	Explanatory variable		Explanatory variable		Explanatory variable		Explanatory variable		Explanatory variable	
	<i>r</i>	(<i>p</i> value)	<i>r</i>	(<i>p</i> value)	β	(<i>p</i> value)	β	(<i>p</i> value)	β	(<i>p</i> value)
Ln HOMA-IR										
Body mass index (kg/m ²)	0.45	(<0.01)	—		0.34	(<0.01)	0.32	(<0.01)	0.21	(<0.01)
Waist circumference (cm)	—		0.41	(<0.01)	0.13	(0.02)	0.15	(0.01)	0.14	(0.01)
Ln Matsuda index										
Body mass index (kg/m ²)	-0.40	(<0.01)	—		-0.29	(<0.01)	-0.32	(<0.01)	-0.21	(<0.01)
Waist circumference (cm)	—		-0.38	(<0.01)	-0.14	(0.01)	-0.12	(0.04)	-0.10	(0.05)

Using training data ($n=860$), linear regression models were developed whose dependent variables were log-transformed Matsuda index or HOMA-IR. Data are correlation coefficients r or standardized partial regression coefficients β and their p values. Model 1, univariate model with body mass index; Model 2, univariate model with waist circumference; Model 3, bivariate model with body mass index and waist circumference; Model 4, multivariate model with body mass index and waist circumference adjusted for sex and age; Model 5, multivariate model with body mass index and waist circumference adjusted for sex, age, glucose, lipids, and blood pressure.

Fig. 1. Measurements and estimations of HOMA-IR (A) and Matsuda index (B) using the test data.

The mean measured and estimated values of HOMA-IR (A) and the Matsuda index (B) are shown for every quintile of body mass index as well as the overall population of the test data ($n=859$). The estimated values of HOMA-IR and the Matsuda index of each subject in the test data were calculated by assigning his/her values of the explanatory variables to the regression equations developed in the training data (Model 1 to 5 in Table 1). Model 1, univariate model with body mass index; Model 2, univariate model with waist circumference; Model 3, bivariate model with body mass index and waist circumference; Model 4, multivariate model with body mass index and waist circumference adjusted for sex and age; Model 5, multivariate model with body mass index and waist circumference adjusted for sex, age, glucose, lipids, and blood pressure.

of BMI as well as in the overall population of the test data (**Fig. 1**). As a result, interestingly, all the developed equations, including univariate equations, could estimate the average measurements with similar accuracy (**Fig. 1**).

Insulin resistance now attracts increasing attention in clinical practice⁴⁻⁶). The current study investigated regression equations for estimating the average measurements of insulin resistance/sensitivity by BMI and/or waist circumference in a general Japanese population. Although insulin resistance/sensitivity is often assessed using HOMA-IR and the Matsuda index in clinical practice, these indices are difficult to measure in epidemiological settings or population-based surveys. Numerous studies have demonstrated that obesity is strongly associated with impaired insulin sensi-

tivity or insulin resistance. However, little is known about to what extent some easy and familiar measurements of obesity, i.e., BMI and waist circumference, could provide predictive information for these indices of insulin resistance/sensitivity. We revealed that the average values of HOMA-IR and the Matsuda index could be assessed with considerable accuracy by either BMI or waist circumference.

In a linear regression equation, the dependent variable y can be estimated with a series of explanatory variables x_i as follows: $y = \sum_i b_i x_i + a$, where b_i and a represent the regression coefficients and intercept. The mean dependent variable of a population $\bar{y}$ can be therefore calculated as: $\bar{y} = \sum_i b_i \bar{x}_i + a = \sum_i b_i \bar{x}_i + a$, indicating that $\bar{y}$ can be easily estimated with a series of average explanatory variables $\bar{x}_i$, without an individual dataset of x_i .

The current findings suggest that the average HOMA-IR and the Matsuda index of a general Japanese population can be predicted using the average BMI or waist circumference.

Previous studies performed detailed measurements of fat distribution and investigated its association with insulin resistance¹⁾ and related diseases⁷⁻¹⁰⁾. However, little is known about whether insulin resistance can be practically estimated with easier measurements. We revealed that HOMA-IR and the Matsuda index were easily estimated by BMI or waist circumference in a general Japanese population. The developed regression equations would be useful for estimation of insulin resistance/sensitivity in epidemiological settings or population-based surveys.

Note

The developed regression equations for estimating HOMA-IR and the Matsuda index by BMI are as follows:

$$\ln(\text{HOMA-IR}) = 0.095 \times [\text{BMI}(\text{kg}/\text{m}^2)] - 2.210$$

$$\ln(\text{Matsuda index}) = -0.095 \times [\text{BMI}(\text{kg}/\text{m}^2)] + 4.521$$

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Mitsuyoshi Takahara, Hideaki Kaneto and Ichihiro Shimomura

Department of Metabolic Medicine, Osaka University Graduate School of Medicine, Osaka, Japan

Address for correspondence: Hideaki Kaneto, Department of Metabolic Medicine, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita, Osaka 565-0871, Japan

E-mail: kaneto@endmet.med.osaka-u.ac.jp

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