DOI: 10.4149/BLL_2021_116

Bratisl Med J 2021; 122 (10)

727 – 731

CLINICAL STUDY

The use of anthropometrical variables for detection of homeostatic measurement assessment-insulin resistance (HOMA-IR) in female participants of a physical exercise program

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ABSTRACT

BACKGROUND: The Homeostatic Measurement Assessment-Insulin Resistance (HOMA-IR) is a recognized and validated method which uses the levels of fasting glucose in blood and insulin of patients to evaluate the insulin resistance.

AIMS: The purpose of the present study was to assess the cut-off values for anthropological variables to identify the (HOMA-IR) index in female participants of a physical exercise program. In addition, the association and prediction of insulin resistance by anthropological variables was studied.

METHODS: A total of 143 participants (45.64 ± 13.17 years) volunteered for this study. Clinical data were collected by means of a self-reported questionnaire. Body weight and BMI were assessed by bioelectrical impedance analysis and skinfold thickness was taken using a caliper. Girths were assessed with a flexible metallic tape measures and finally, the HOMA-IR was calculated by the formula as follows: fasting plasma insulin ((μU/ml) x fasting plasma glucose (mmol/L).

RESULTS: The outcomes of the study indicated that the AUC of anthropometrical variables for identifying HOMA-IR are reflected primarily in weight, waist-to-hip ratio, waist-to-thigh ratio, subscapular skinfold thickness, abdominal skinfold thickness, hip circumference, chest circumference, upper arm muscular girths (tensed and relaxed) (all, $p \leq 0.001$), triceps skinfold thickness ($p < 0.01$), and waist circumference ($p < 0.05$). In that respect, the optimal cut-off values, sensitivity, specificity and possibility of predicting variables for detecting HOMA-IR showed that hip circumference > 100 cm (specificity: 98.4 %), chest circumference > 109 cm (specificity: 99.2 waist circumference > 116 cm (specificity: 99.2 %) and abdomen skinfold < 8.8 (specificity: 97.6 %), predict the HOMA-IR in 35.29 %, 29.41 %, 23.53 % and 23.53 %, respectively.

CONCLUSION: The present empirical study demonstrates that hip, chest and waist circumference on the one hand, and abdomen skinfold on the other hand are markers that are relevant to the identification of HOMA-IR index in females *(Tab. 3, Ref. 33)*. Text in PDF *www.elis.sk*

KEY WORDS: insulin resistance, anthropometry, cut-off value, women, HOMA-IR.

Introduction

Changes in body composition are considered one of the major causes of chronic diseases of adult and ageing people (1–2) and have become a primary concern (3). Body composition is an important marker of health, predictor of comorbidities (4), and component of good health and disease prevention associated with physical fitness and exercise (5). Skeletal muscle mass (SMM) and fat mass (FM) are body composition states that change continuously (6). In fact, these changes can be seen in variations in body composition after middle age (7) through the increase in FM, reduction in SMM (8–9) and decrease in fat-free mass (FFM) (10). Furthermore, maximum levels of FFM are present at 20 years of age. After that, the latter levels begin to decrease, and by 70 years of age, the decrease reaches 40 %, primarily in form of skeletal muscle loss (11). This is the major drawback of body mass index (BMI) (10). Nevertheless, BMI is a suitable method when it is necessary to classify the medical risk by weight status (12) such as obesity (13).

Obesity is considered a widespread health problem in the developing countries, where it is accompanied by chronic morbidities, functional impairment and premature mortality (14). Moreover, obesity is associated with the prevalence of diseases such as diabetes, hypertension, arthritis, cardiovascular risk, T2 diabetes (15) or metabolic syndrome (15, 16). Majority of those diseases show a considerable resistance to insulin (17) and association with mortality, increased secretion and decreased sensibility to this hepatic hormone (18).

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The Homeostatic Measurement Assessment-Insulin Resistance (HOMA-IR) is a recognized and validated method which uses the level of fasting glucose in blood and insulin of patients to evaluate insulin resistance. It is a common method standardized in epidemiological researches since 1985 (19). However, previous studies have not yet obtained conclusions about the use of cut-off points in the diagnosis of insulin resistance (20). On the other hand, several studies have been carried out with anthropometrical variables such as BMI, circumferences, subcutaneous skinfold thickness or muscular girths to predict the level of insulin resistance (21, 22).

The present study aimed to assess the cut-off values for anthropological variables to identify HOMA-IR index in female participants of a physical exercise program. In addition, we studied the association and prediction of insulin resistance by anthropological variables.

Tab. 1. Clinical characteristics of the study samples (n = 143).

	Mean	SD	Minimum	Maximum	Normal Distribution
Age	45.6	13.2	22	76	0.013
BMI	25.2	4.1	17.9	37.6	0.004
Body weight	67.3	10.6	47	100	<0.001
waist-to-hip ratio	0.8	0.1	0.6	1.1	<0.001
waist-to-thigh ratio	1.4	0.2	0.7	2.1	0.002
waist-to-height ratio	0.5	0.7	0.4	0.7	0.007
Subscapularis sk	19.7	7.9	6	42.8	<0.001
Triceps sk	21.4	5.7	8.5	36.8	0.527
Abdomen sk	25.9	8.9	7.2	43	0.002
Thigh sk	33.9	8.3	12.5	47.4	0.038
Medial calf sk	21.7	7.6	8.8	44.5	0.051
Waist circumference	102.4	7.9	84	132	<0.001
Hip circumference	80.1	11.1	59.5	111	0.002
Upper arm muscular girths (tensed)	29.5	3.9	3	47	<0.001
Upper arm muscular girths (relaxed)	28.2	3.4	22	45	<0.001
Chest circumference	92.6	8.3	75.5	116	0.004
HOMA-IR	1.3	0.9	0.2	4.7	<0.001

HOMA-IR – Homeostatic Model Assessment-Insulin Resistance, sk – skinfold, SD – standard deviation

Tab. 2. Area under the ROC curve of anthropometrical variables for identification of HOMA-IR.

HOMA-IR						
Variable classifiers	AUC	SE	95% CI	p	Youden Index	Cut-off value
Body weight	0.768	0.066	0.690–0.835	<0.001	0.434	>77
waist-to-hip ratio	0.774	0.058	0.696–0.840	<0.001	0.501	>0.81
waist-to-thigh ratio	0.764	0.058	0.685–0.831	<0.001	0.514	>1.43
waist-to-height ratio	0.756	0.065	0.677–0.824	<0.001	0.466	>0.52
Subscapularis sk	0.775	0.052	0.698–0.841	<0.001	0.504	>21.13
Triceps sk	0.699	0.071	0.616–0.773	0.005	0.356	0.36
Abdomen sk	0.815	0.063	0.742–0.875	<0.001	0.624	>32
Thigh sk	0.576	0.061	0.490–0.658	0.211	0.248	>27.33
Medial calf sk	0.526	0.089	0.440–0.610	0.772	0.268	≤18.13
Waist circumference	0.685	0.079	0.602–0.760	0.019	0.364	>105
Hip circumference	0.798	0.061	0.722–0.861	<0.001	0.538	>86.51
Upper arm muscular girths (tensed)	0.743	0.057	0.663–0.812	<0.001	0.381	>29
Upper arm muscular girths (relaxed)	0.75	0.062	0.670–0.819	<0.001	0.404	>28
Chest circumference	0.818	0.061	0.744–0.878	<0.001	0.581	>96.50

HOMA-IR: Homeostatic Model Assessment-Insulin Resistance, sk: skinfold, AUC: area under the ROC curve, SE: standard error, CI: confidence interval, P-value calculated by ROC curve

Material and methods

Participants

The participants of present study were recruited from a fitness programs via letter or telephone. Female participants were attendants of a Pilates and aerobic-physical exercise interventional program conducted by the Faculty of Sport of Novi Sad (Serbia) (23).

A total of 143 female participants and 8 male participants volunteered for this study. It was decided to exclude the men due to their low attendance. The women's age ranged between 40 and 80 years. The participants were informed of the purpose of this study and voluntarily agreed to participate by signing the informed consent. The inclusion criterions of participants were as follows: i) not to have acute or terminal illness, ii) not to have functional mobility limited, iii) to be able to communicate (Tab. 1).

Measurements obtained were age, BMI, body weight, waist-to-hip ratio, waist-to-thigh ratio, waist-to-height ratio, subcutaneous skinfold thickness (subscapularis, triceps, abdomen, front thigh and medial calf), waist and hip circumference, muscular girths (upper arm relaxed, upper arm flexed and tensed), chest circumference and HOMA-IR.

Written informed consent was accepted by all participants after receiving detailed information about the main objective and study procedures of the current project which complied with the guidelines of the Declaration of Helsinki. The present study was reviewed and approved by the Ethics Committee of the University of Novi Sad.

Measurements

Clinical data were collected by means of a self-reported questionnaire.

Body weight and BMI were gained by using bioelectrical impedance analysis with a Tanita SC 330s with participants wearing light indoor clothing and no shoes. Measurements were performed following the standardized techniques adopted by the International Society for the Advancement of Kinanthropometry (ISAK) (24). The technical error of measurement was lower than 5 % for skinfold thickness and lower than 1 % for the rest of other measurements. Skinfold thickness was taken using a caliper with a precision of 0.2 mm (Holtain Ltd, Crymych, UK). Girth data were obtained with a flexible metallic tape measure with a precision of 0.1 mm. The HOMA-IR was calculated by a formula as follows: fasting plasma insulin ((μU/ml) x fasting plasma glucose (mmol/L) (19).

Tab. 3. Cut-off value, sensitivity, specificity, likelihood ratios, positive predictive value and negative predictive value of anthropometric variables for detection of HOMA-IR in female participants.

	Cut-off value	Sens	95% CI	Spec	95% CI	± LR	95% CI	-LR	95% CI	± PV	95% CI	-PV	95% CI
Body weight	>92	17.65	3.8–43.4	100	97.1–100.0			0.82	0.7–1.0	100	29.2–100.0	89.9	83.7–94.4
waist-to-hip ratio	>0.96	11.76	1.5–36.4	99.2	95.6–100.0	14.71	1.4–153.6	0.89	0.7–1.1	66.7	9.4–99.2	89.2	82.8–93.8
waist-to-thigh ratio	>2.02	5.88	0.1–28.7	100	97.1–100.0			0.94	0.8–1.1	100	2.5–100.0	88.7	82.2–93.4
waist-to-height ratio	>0.67	5.88	0.1–28.7	100	97.1–100.0			0.94	0.8–1.1	100	2.5–100.0	88.7	82.2–93.4
Subscapularis sk	>42.87	0	0.0–19.5	100	97.1–100.0			1	1.0–1.0			88	81.5–92.9
Triceps sk	33.33	11.76	1.5–36.4	99.2	95.6–100.0	14.71	1.4–153.6	0.89	0.7–1.1	66.7	9.4–99.2	89.2	82.8–93.8
Abdomen sk	>39.87	23.53	6.8–49.9	97.6	93.1–99.5	9.8	2.4–40.1	0.78	0.6–1.0	57.1	18.4–90.1	90.4	84.1–94.8
Thigh sk	>47.13	0	0.0–19.5	100	97.1–100.0			1	1.0–1.0			88	81.5–92.9
Medial calf sk	<8.8	0	0.0–19.5	100	97.1–100.0			1	1.0–1.0			88	81.5–92.9
Waist circumference	>116	23.53	6.8–49.9	99.2	95.6–100.0	29.41	3.5–248.0	0.77	0.6–1.0	80	28.4–99.5	90.5	84.3–9.9
Hip circumference	>100	35.29	14.2–61.7	98.4	94.3–99.8	22.06	4.8–100.7	0.66	0.5–0.9	75	34.9–96.8	91.8	85.8–95.8
Upper arm muscular girths (tensed)	>34	11.76	1.5–36.4	100	97.1–100.0			0.88	0.7–1.0	100	15.8–100.0	89.3	82.9–93.9
Upper arm muscular girths (relaxed)	>34	11.76	1.5–36.4	100	97.1–100.0			0.88	0.7–1.0	100	15.8–100.0	89.3	82.9–93.9
Chest circumference	>109	29.41	10.3–56.0	99.2	95.6–100.0	36.76	4.6–296.2	0.71	0.5–1.0	83.3	35.9–99.6	91.2	85.1–95.4

HOMA-IR – Homeostatic Model Assessment-Insulin Resistance, Sens – sensitivity, Spec – specificity, ±LR – positive likelihood ratios, -LR – negative likelihood ratios (–), ±PV – positive predictive value, PV – negative predictive value, sk – skinfold

Procedure

The cross-sectional study was carried out with homogeneous samples of Serbian female participants who were attending a program of educational and physical exercise based on Pilates and aerobic exercise. The data were collected in two one-week sessions. Firstly, the anthropometric measurement was carried out in a covered room with temperature in range of 17–22 °C. On the second day, the assays were carried out using the Roche modular p800 analyser for glucose and Roche modular E170 for insulin. The laboratory assays were performed in the laboratory unit of the Department of Anatomy, Faculty of Medicine, University of Novi Sad (Serbia). The measurements were obtained by the same group of trained researchers and clinicians in order to reduce inter-examiner error.

The concepts of health education were given at the beginning of sessions of the interventional program in order to orientate participants towards a healthier posture and practice of food hygiene in their daily lives. The controlled diet was established according to the recommendations of the American College of Sport Medicine guidelines (25).

Statistical analysis

The normal distribution of data was studied using the Kolmogorov-Smirnov test. The descriptive analyses were carried out to check the clinical characteristics of the participants, namely mean data, standard deviation (SD), minimum and maximum value for female participants. The receiver operating characteristics (ROC) curve of anthropometrical variables for the detection of HOMA-IR was depicted for the total of subjects in the studied sample (26). The areas under the ROC curve (AUC) with maximum Youden index were calculated to evaluate the accuracy of the anthropometrical variables. ROC curve is understood as the probability that the modeled phenotype can discriminate subjects developing end points from those without end points (0.5~1.0) (27). The sensitivity, specificity, positive and negative predictive value, and positive and negative likelihood ratios were calculated for anthropological variables at each cut-off value for detection of HOMA-IR.

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, v.17.0 for WINDOWS, SPSS Inc., Chicago, IL, USA).

Results

The clinical characteristics of participants are presented in Table 1 as means ± SD, minimum and maximum values of female participants in the present study. The mean values of age, BMI and HOMA-IR are 45.6 ± 13.2 years, 25.2 ± 4.1 Kg/m^2 and 1.3 ± 0.9, respectively. According to anthropological variables, the mean value of body weight is 67.3 ± 10.6 Kg, 0.8 ± 0.1 for waist-to-hip ratio, 1.4 ± 0.2 for waist-to-thigh ratio, 0.5 ± 0.7 for waist-to-height ratio, 19.7 ± 7.9 mm for subscapularis skinfold thickness, 21.4 ± 5.7 mm for triceps skinfold thickness, 25.9 ± 8.9 mm for abdominal skinfold thickness, 33.9 ± 8.3 mm for thigh skinfold thickness and 21.7 ± 7.6mm for medial calf skinfold thickness. The mean circumference for waist, hip and chest are 102.4 ± 7.9 cm, 80.1

± 11.1 cm and 92.6 ± 8.3, respectively. Finally, the mean muscle perimeters for upper arm muscular girths (tensed and relaxed) are 29.5 ± 3.9 cm and 28.2 ± 3.4, respectively.

The AUC of anthropometrical variables for identifying HOMA-IR are shown in Table 2. Female participants of the present study reported significant values in body weight, waist-to-hip ratio, waist-to-height ratio, waist-to-thigh ratio, subscapularis skinfold thickness, abdominal skinfold thickness, hip circumference, chest circumference, upper arm muscular girths (tensed and relaxed) (all, $p < 0.001$), triceps skinfold thickness ($p < 0.01$) and waist circumference ($p < 0.05$) (Tab. 2).

In that respect, the optimal cut-off values, sensitivity, specificity and possibility of predicting variables for detecting HOMA-IR in our group of female participants, as well as negative predictive value of anthropometric variables for detection of HOMA-IR are shown in Table 3. For instance, the abdominal skinfold thickness > 39.87 mm (specificity: 97.6 %) and the waist circumference > 116 cm (specificity: 99.2 %) predict the HOMA-IR in 23.53 % when the hip circumference > 100 cm (specificity: 98.4 %) and chest circumference > 109 cm (specificity: 99.2 %) predict the HOMA-IR in 35.29 % and 29.41 %, respectively (Tab. 3).

Discussion

The main objective of the present research was to assess the cut-of values for anthropological variables to identify HOMA-IR index in female participants of a physical exercise program. In addition, this study aimed to predict insulin resistance by means of anthropological variables. As it is well known, the scientific community considers HOMA-IR as a valid method of evaluating insulin resistance (28). Many investigators have taken this into consideration, which resulted in a rapid growth of the interest in this topic. However, to the best of our knowledge, there are not many specific studies investigating the HOMA-IR, different anthropological variables in a large group of women that perform long-term exercise (Pilates and aerobic exercise).

The outcome of the present study indicates that the AUC of anthropometrical variables for identifying HOMA-IR are shown significantly in weight, waist-to-hip ratio, waist-to-thigh ratio, subscapular skinfold thickness, abdominal skinfold thickness, hip circumference, chest circumference, upper arm muscular girths (tensed and relaxed), triceps skinfold thickness, and waist circumference. We can conclude that our results for AUC of anthropometrical variables were similar to the results of other studies. In this sense, Ying et al´s study (29) reported that waist circumference correlated significantly with HOMA-IR in young and middle-aged woman. Therefore, this confirmed that BMI and waist circumference (correlated coefficient) were better predictors of cardiovascular diseases and diabetes mellitus. In fact, it is also recognized that among other cases, the risk of insulin resistance increases with obesity, age or physical inactivity, (30). In this sense, previous research has shown that BMI (bicipital fold and arm circumference) are the best predictors or insulin resistance in overweight adult population (31). Therefore, our results contribute to literature by pointing to other variables that can be employed in identification of HOMA-IR index in female participants of a physical exercise program (32).

High values of hip circumference, chest circumference, waist circumference and abdomen skinfold predict the HOMA-IR in 35.29 %, 29.41 %, 23.53 % and 23.53 % respectively. These results are in accord with Geloneze et al2006, who investigated the cut-off values for HOMA-IR in non-diabetic participants (18 to 78 years old). In fact, with an updated database and a larger sample, the found value of 2.7 was equivalent, thus reinforcing the concept that it is a useful reference for adult population. In this sense, other studies showed similar cut-off values for HOMA-IR indexes in different populations (33). It is our consideration that since the interactions of insulin resistance reflect in HOMA-IR and obesity in general population (17), using HOMA-IR can be a useful and reliable tool for early identification of insulin resistance as well as predicting and detecting different risks associated with it.

Conclusions

In conclusion, the present empirical study demonstrates that hip, chest and waist circumference on the one hand and abdomen skinfold on the other hand are relevant markers for identifying the HOMA-IR index in females. Therefore, a reduction in abdominal obesity primarily by weight reduction and physical exercise may help in preventing type 2 diabetes and cardiovascular disease. It also contributes to the extensive research on the use of anthropometrical variables for detecting HOMA-IR and opens interesting avenues for future research.

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Received March 18, 2021.
Accepted April 24, 2021.