Acta Sci. Pol. Technol. Aliment. 21(2) 2022, 139–143

www.food.actapol.net pISSN 1644-0730 eISSN 1898-9594 http://dx.doi.org/10.17306/J.AFS.2022.1021

ORIGINAL PAPER

Received: 6.12.2021
Accepted: 12.12.2021

NECK CIRCUMFERENCE – A MARKER OF INSULIN RESISTANCE IN THE NORMAL-WEIGHT POLISH

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ABSTRACT

Background. Insulin resistance (IR) is an underlying mechanism in various disorders, including metabolic syndrome, cardiovascular diseases, several types of cancer and endocrinopathies. Previous research has confirmed that neck circumference (NC) could be a good predictor of metabolic disorders, including IR in overweight individuals. The aim of our study is to investigate the association between the NC and IR in normal-weight Polish individuals to evaluate if this simple measurement could potentially be used as a screening method of IR.
Materials and methods. The study participants were 73 Caucasian men and women who were 19–65 years old and of normal weight. The anthropometric parameters were measured using validated tools. Insulin resistance was defined using Matthew's method.
Result. There was no significant relationship between NC and serum insulin level or IR.
Conclusion. According to our study, NC is not a good predictor of IR in normal-weight Polish individuals. However, larger population studies are needed to further investigate the association between these two parameters.

Keywords: insulin resistance, normal-weight obesity, neck circumference, risk factor

INTRODUCTION

Insulin is a vital anabolic hormone which is responsible for maintaining glucose homeostasis, i.e., lowering postprandial glucose levels by stimulating glucose uptake in the muscles and adipose tissue, as well as supressing the production of glucose in the liver. A permanently elevated concentration of insulin along with reduced peripheral sensitivity to this hormone are associated with insulin resistance (IR) – a pathological condition which results in impaired glucose uptake and abnormal organ function (Kolb et al., 2020; Whillier, 2020). Insulin Resistance – IR is an underlying mechanism in various disorders, including metabolic syndrome, several types of cancer and endocrinopathies (Guo, 2014; Rogowicz-Frontczak et al., 2017; World…, 2018). Moreover, insulin resistant patients are at greater risk of developing type 2 diabetes (Ling et al., 2020), dyslipidaemia, cardiovascular disease (CVD; Abel et al., 2012; Ormazabal et al., 2018), and non-alcoholic fatty liver disease (NAFLD; Watt et al., 2019). The prevalence of IR varies across the world from 15.5 to

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46.5% of adults (Fahed et al., 2020). One of the fundamental risk factors of this condition is obesity, which is associated with excessive body fat. Dysfunctional adipose organ alerts many metabolic pathways through proinflammatory and insulin-desensitizing signals (Di Francesco et al., 2010). Although much less common, IR can also occur in individuals who are classified as normal-weight. Obesity is often diagnosed using Body Mass Index (BMI), which is not a measure of adiposity. Various research shows that fat mass is also associated with IR in normal-weight subjects (Chen et al., 2014; Martinez et al., 2017; Patwardhan et al., 2019).

The gold standard of IR diagnosis is the glucose clamp or the frequently sampled intravenous glucose tolerance test. Both tests require glucose and/or insulin infusion and are highly invasive, which limits their use in clinical practice. Therefore, measurements of fasting glucose and insulin are much more commonly used to recognise IR. To date, The Homeostasis Model Assessment of IR (HOMA-IR) is one of the most widely used models. However, other indexes, such as Quantitative Insulin Sensitivity Check Index (QUICKI), Insulin Secretion-Sensitivity Index-2 (ISSI-2) and Matsuda Index, have also been developed (Placzkowska et al., 2019).

There are no clear guidelines for IR diagnosis and some of the methods are not easily available. Insulin Resistance – IR is a pathological condition that may lead to many complications, therefore, finding an easy and effective screening method is really important. Research has confirmed that waist-to-hip ratio may be one of the methods of assessing IR in both obese and normal-weight individuals (Benites-Zapata et at., 2019; Liu et al., 2018). A recent meta-analysis indicates that neck circumference is also positively correlated with glycaemic parameters, including serum fasting insulin level and HOMA-IR (Saneei et al., 2019). The association of neck circumference (NC) with IR has been confirmed among NAFLD patients, women with polycystic ovarian syndrome (PCOS) and in older people (Boemeke et al., 2019; Chen et al., 2021; Saad et al., 2017). Most of the studies included only overweight and obese subjects. The aim of our study is to investigate the association between neck circumference and IR in normal-weight Polish individuals to evaluate if this simple measurement could potentially be used as a screening method for IR.

MATERIALS AND METHODS

Study groups

The study protocol was approved by the Bioethical Commission of Poznan University of Medical Sciences (no. 579/18). Study participants were Caucasian men and women who were 19–65 years old. All subjects had normal weight according to BMI (18.5–24.9 kg/m^2) and stable body mass 3 months prior to the research. The exclusion criteria were as follows: diabetes, polycystic ovary syndrome, manifestation of neoplastic and autoimmune diseases; clinical signs of hepatic, renal, adrenal, or thyroid diseases; acute infection in the months prior to the study; pregnant or breastfeeding women; using metformin or other drugs to improve insulin sensitivity; changes in diet three months prior to the study; currently smoking and alcohol or drug abuse. All participants received oral and written information about the study and signed an informed consent.

Anthropometric parameters

Anthropometric measurements: body weight, height, and NC were measured using a scale with a stadiometer (Charder MS4900) and measuring tape (Seca 201) with an accuracy of 0.1 kg for weight and 0.5 cm for height and NC. The measurements were obtained from fasting individuals wearing only underwear.

Laboratory measurements

Venous blood samples were collected from a cubital vein (in the morning, 10–14 hours after the last meal). The samples were frozen at –80°C. Glucose and insulin concentrations were determined using standardised commercial tests. Insulin Resistance – IR was defined using Matthew's method: fasting insulin, µIU/mL × fasting glucose, mg/dL / 22.5 with a cut-off point of more than 2.1 (Matthews et al., 1985; Szurkowska et al., 2005).

Data analysis

All analyses were performed using Dell Statistica, version 13 software (Dell Inc., Round Rock, TX, USA, 2016). All results were first verified by a normality test. Since the test confirmed the normal distribution, the paired t-test was used. To compare the variables with the lack of normality, the non-parametric

Mann-Whitney U test was used. The Spearman's correlation coefficient was used to analyse the correlations between neck circumference and biochemical data. A p-value of less than 0.05 was considered significant.

RESULTS

We evaluated 73 subjects with normal body weight. Depending on HOMA-IR, we divided them into two groups with and without IR. There were no significant differences in numbers, age, or BMI in each group. The groups also did not differ in terms of NC. The general characteristics of the two groups are presented in Table 1.

Table 1. Characteristic of the groups

Parameters	Research group	Control group	p-value
All subjects	30	43	
Men	4	13	
Women	26	30	
Age, years	44.90 ±12.92	42.16 ±12.21	>0.05
BMI, kg/m^2	21.59 ±1.94	22.66 ±1.72	>0.05
Glucose, mg/dL	98.67 ±15.07	84.63 ±11.11	0.0002
Insulin, mmol/L	19.81 ±9.09	5.77 ±3.05	0.0001
HOMA-IR	4.76 ±2.01	1.20 ±0.45	0.0001
Neck circumference, cm	32.81 ±2.00	34.27 ±3.05	>0.05

HOMA-IR – Homeostasis Model Assessment of Insulin Resistance, BMI – body mass index.

The correlation between NC and the parameters of carbohydrate metabolism were analysed in each group and overall (Table 2). There was no significant relationship between NC and serum insulin level or HOMA-IR in any group. A weak correlation between NC and serum glucose level was only observed in the control group.

DISCUSSION

In this study, we did not find a correlation between NC and IR in normal-weight Polish individuals. To our knowledge, this is the first study to evaluate the aforementioned relationship in this population. Previous research confirmed that NC could be a good predictor of metabolic syndrome and cardiovascular disease (Ebrahimi et al., 2021; Mendes et al., 2020, Silva et al., 2020). A meta-analysis from 2019 showed a strong association between NC and glycaemic parameters, including IR (Saneei et al., 2019). However, only two of the nine studies investigating the relationship between NC and IR included subjects with normal BMI (less than 25 kg/m^2) alone (Aoi et al., 2014; Li et al., 2015). The remaining studies focused on overweight or obese people or those with other body types. The first study included 69 healthy postmenopausal Japanese women and showed a positive correlation between NC and HOMA-IR (R = 0.263; p = 0.039; Aoi et al., 2014). However, the research only included women going through significant hormonal changes. The second study included 2668 normal-weight individuals with NAFLD, and in contrast to our research, it confirmed the positive correlation between NC and IR in both genders (R = 0.12 for men; R = 0.17 for women; p < 0.01; Li et al., 2015). Nonetheless, it was

Table 2. The correlation between neck circumference and parameters of carbohydrate metabolism

	Spearman's R-value					
	overall	p-value	research group	p-value	control group	p-value
Glucose, mg/dL	0.13	>0.05	0.19	>0.05	0.34	<0.05
Insulin, mmol/L	–0.18		–0.19		0.08	>0.05
HOMA-IR	–0.16		–0.17		0.16	

HOMA-IR – Homeostasis Model Assessment of Insulin Resistance.

a specific study group with an increased risk of IR and a tendency towards abdominal obesity. Moreover, this study, along with other research, confirmed the positive correlation between NC and other anthropometric measurements such as BMI, waist circumference, and fat deposition (Li et al., 2014; Li et al., 2015; Wang et al., 2015). The IR in non-obese subjects could be related to abnormal body composition (increased percentage of body fat; Martinez et al., 2017), but also with a broad group of endocrinopathies such as hyperprolactinemia, hypercortisolism, and thyroid diseases (Rogowicz-Frontczak et al., 2017). Based on this knowledge, it could be speculated that if IR has a cause other than abnormal body composition, it will not be related with NC.

It is worth noting that this is the first study to evaluate the relationship between IR and NC in the normal-weight population. However, we are aware of our study limitations. Firstly, a relatively small group was examined. Secondly, no gender distinction was made, which seems to be justified due to anatomical differences. Nonetheless, further investigation in the larger population could be an important part of IR research.

CONCLUSIONS

According to our study, NC is not a good predictor of IR in normal-weight Polish individuals. However, larger population studies are needed to further investigate the association between these two parameters.

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