New surrogate anthropometrical markers for early detection of insulin resistance

Naveen Bhartia Porwal, Shraddha Singh, N.S Verma, Sandeep Bhattacharya, Amit Kumar Madeshiya, Kalpana Singh, Pravesh Kumar and Sunita Tiwari

Department of Physiology, King George Medical University Lucknow, India

*Correspondence Info:
Dr Sunita Tiwari,
Professor and Head,
Department of Physiology,
King George Medical University Lucknow, India
E-mail: email-sunita_kgmu@yahoo.com

Abstract

Background: Insulin resistance is the pathophysiological basis of several cardiometabolic risk conditions. The early identification of insulin resistance decreases the risk of cardiometabolic complications. The correlation between the increase in visceral fat, central obesity and with insulin resistance is an important indicator. Present study was conducted to find the correlation between various anthropometric measurements and insulin resistance (HOMA-IR) and to find out the anthropometric marker, which correlates most significantly with insulin resistance.

Material and methods: This is a population based cross-sectional study. Total 100 apparently healthy subjects (n=55 male and n=45 female) aged between 18-25 years were recruited with prior ethical approval and with written informed consent. All the anthropometrical measurements were done as per the standard methods. Fasting glucose and insulin were estimated by using commercially available kit. Insulin resistance was quantified using homeostasis model.

Results: There was positive correlation between HOMA-IR and waist circumference (r=0.395, p=0.0001). However, significant positive & mild correlation between HOMA-IR and waist hip ratio was found (r=0.263, p=0.008). The correlation between HOMA-IR and waist height ratio was also observed to be positive and moderate.

Conclusion: As per the findings we concluded that, waist circumference and waist height ratio are better predictors of insulin resistance compared to the other anthropometric measurements in apparently healthy north Indian subjects.

Keywords: Insulin resistance, waist circumference, waist height ratio, waist hip ratio.

1. Introduction

Insulin resistance (IR) syndrome is one of the important risk factor for cardiovascular diseases[1-7]. The evaluation of the insulin resistance has received considerable attention in the last few years. The laboratorial methods for the determination of insulin resistance are expensive and with standardization deficiencies for its execution, limiting its application in clinical practice [8].

Direct quantification of insulin resistance is difficult; the hyperinsulinemic-euglycemic clamp technique, based on direct intravenous insulin and glucose infusion, is considered as the gold standard procedure, but its complexity limits its clinical use. Therefore, indirect methods have been developed, out of which homeostasis model assessment (HOMA) index is one of the most commonly used method to assess the insulin resistance. This index shows a good correlation to the clamp procedure[9]. Indian adolescents have an increased sensitivity to obesity especially abdominal obesity [10,11].

Studies in adolescents have shown that visceral obesity is associated with the development of insulin resistance in this age group, with evidence of a 50% increase in insulin resistance in overweight adolescents with every half unit increase in body mass index (BMI)[12-14]. Therefore it is of growing interest in studying different anthropometric measures as indicators of insulin resistance and
diabetes, in order to understand the increased susceptibility of leaner Indian populations to diabetes. Measurement of waist circumference (WC) is a useful measure of obesity-related diabetes risk in Indians, who are more prone to abdominal obesity at normal BMI[15,16]. Furthermore, Indians have greater amounts of visceral adipose tissue and a higher percentage of body fat than individuals of European population[17,18]. Percent of body fat and central obesity, measured by waist hip ratio (WHR) as compared to generalize obesity (measured by BMI) have been evaluated as risk factors for diabetes with conflicting reports in Indian populations.

In the INTERHEART study, waist hip ratio was the strongest marker of myocardial infarction in South Asians, followed by waist circumference and then BMI[19]. Other anthropometric measures, such as Waist-Height Ratio (WHtR), and body fat percent (BF%), have been also found to be correlated with Type 2 Diabetes, but their predictive value for insulin resistance remains to be fully understood[20,21]. Therefore, due to the lack of consensus on a single anthropometric measure as the best indicator of insulin resistance in Indian population we undertook this study to investigate the correlation between the anthropometrical parameters and insulin resistance in north Indian adult population.

2. Material and Method

2.1 Ethical statement and subject recruitment

This is population based cross-sectional study conducted in the Department of Physiology, King George’s Medical University (KGMU), Lucknow. Total 100 apparently healthy subjects (n=55 male and n=45 female) aged between 18-25 years were recruited with prior ethical approval and with written informed consent. The sample size was statistically calculated with 80% of power. Subjects having history of diabetes mellitus, endocrine disorder, metabolic disorder, and use of medication that affect carbohydrate and lipid metabolism were excluded from the study. 2 ml venous fasting blood sample (> 8 hours) was collected from each subject and out of which 1 ml blood was collected in fluoride vial, and remaining 1 ml blood in plain vial. Serum and plasma were separated immediately, aliquot prepared and stored at -80°C till further analysis.

2.2 Anthropometrical measurements

For measuring weight, the subject was requested to stand still on the platform and weight measured with the help of a digital weighing machine. Height was measured using stadiometer with the help of a fixed scale. Body mass index was calculated by the formula; weight (kg)/height (m²).

Waist circumference (WC) was measured mid-way between iliac crest and lowermost margin of the ribs, in quiet breathing. Hip circumference (HC) was measured at the maximum protruding part of buttocks at the level of the greater trochanter with the subjects wearing minimal clothing. Waist hip ratio and Waist height ratio was calculated with the help of the formula WC (cm.)/HC (cm.) and WC (cm.)/height (cm.) respectively.

2.3 Biochemical analysis

Fasting plasma glucose was estimated using the glucose oxidase-peroxidase method by using commercially available kit with the help of a semi automated glucose analyzer (Microlab 300, Merck) on the same day of sample collection. Plasma insulin was estimated using a radio immuno assay kit (Immunotech) with the help of a gamma counter. Insulin resistance was quantified using homeostasis model assessment (HOMA), an index of insulin resistance (IR) [HOMA-IR = fasting insulin (µU/mL) × fasting plasma glucose (mmol/L)/22.5] [22].

2.4 Statistical analysis

Averaged data are presented as the means ± SD and frequency data are presented in percentages. The P-value <0.05 was considered as statistically significant. The Pearson Correlation Coefficient was calculated to find the direction of association between two continuous parameters. All the analyses were carried out by using SPSS 16.0 version (Chicago, Inc. USA).

3. Results

More than half (62%) of the subjects were between 20-22 years followed by >22 (21%) and <20 (17%) years. The mean age of the subjects was 21.33 years with range between 18 to 24 years (Table-1). Table-3 represents the distribution of the subjects according to anthropometrical parameters. The average height of the subjects was 163.08 (±7.21) cm. with weight 60.53 (±8.74) kg. The Body mass index (kg/m²) was 22.71 (±2.72) with minimum of 16.40 and maximum of 30.43. The mean of Hip circumference (cm) and Waist circumference (cm) were 91.25 (±6.87) and 81.93 (±7.87) respectively. The mean of Waist-hip ratio and Waist-Height ratio were 0.89 (±0.09) and 0.50 (±0.05) respectively. Similarly, the mean of Fasting blood sugar (mg/dl), Fasting serum insulin (µU/ml) and HOMA- IR were 88.39 (±9.23), 9.83 (±6.53) and 2.18 (±1.39) respectively. The correlation analysis reveals that the Body mass index, Waist circumference, Waist-hip ratio and Waist-Height ratio were positively correlated with HOMA-IR an index of insulin resistance.
Table-1: Age and gender distribution of the subjects

| Age in years | No. (n=100) | %  |
|--------------|-------------|----|
| <20          | 17          | 17.0 |
| 20-22        | 62          | 62.0 |
| >22          | 21          | 21.0 |

| Gender       |            |    |
|--------------|------------|---|
| Male         | 55         | 55.0 |
| Female       | 45         | 45.0 |

Table-2: Distribution of the subjects according to anthropometric parameters.

| Parameters                  | No. (n=100) (Mean±SD) | Minimum | Maximum |
|-----------------------------|------------------------|---------|---------|
| Height (cm)                 | 163.08±7.21            | 149     | 178     |
| Weight (kg)                 | 60.53±8.74             | 42      | 89      |
| Body mass index (kg/m²)     | 22.71±2.72             | 16.40   | 30.43   |
| Hip circumference (cm)      | 91.52±6.87             | 65.00   | 110.00  |
| Waist circumference (cm)    | 81.93±7.87             | 64.00   | 101.00  |
| Waist-hip ratio             | 0.89±0.09              | 0.65    | 1.16    |
| Waist-Height ratio          | 0.50±0.05              | 0.38    | 0.65    |
| Fasting blood sugar (mg/dl) | 88.39±9.23             | 76.00   | 152.00  |
| Fasting serum insulin (µU/ml)| 9.83±6.53            | 0.22    | 59.05   |
| HOMA-1R                     | 2.18±1.39              | 0.05    | 11.95   |

Table-3: Correlation between anthropometric parameters and HOMA-IR parameters

| Parameters                  | r-value | p-value |
|-----------------------------|---------|---------|
| Body mass index (kg/m²)     | 0.30    | 0.002*  |
| Hip circumference (cm)      | 0.13    | 0.29    |
| Waist circumference (cm)    | 0.39    | 0.0001**|
| Waist-hip ratio             | 0.26    | 0.008*  |
| Waist-Height ratio          | 0.39    | 0.0001**|

*Significant p<0.05, p=0.0001

4. Discussion

It is a established fact that obesity, especially central obesity, induces insulin resistance because excessive free fatty acids and inflammatory substances alter insulin receptor signaling in different organs[23,24]. Furthermore, insulin resistance causes the metabolic alterations that finally results in metabolic syndrome (MetS)[23-27] and prevalence of MetS is directly proportional to the obesity[28-30]. A recent study in Medellin on 851 adolescents aged between 10 to 18 years old revealed rates of 25%, 4.1%, and 4.9% for overweight, MetS, and insulin resistance respectively[26]. The biological findings associated with this disease suggest that the β-pancreatic cells of these adolescents are forced to produce more insulin to maintain normoglycaemia, which predisposes them to hyperglycaemia and Diabetes Mellitus type 2[27,31,32]. Therefore an early detection of insulin resistance amongst obese adolescents may prove to better preventive measures to reduce the incidence of such chronic diseases [33].

Thus, the purpose of this study was to evaluate which of the following anthropometric parameter, i.e. body mass index, hip circumference, waist circumference, waist hip ratio and Waist height ratio, were more strongly related to insulin resistance among the north Indian population. Using Pearson correlation coefficient, present results showed that, body mass index, waist circumference and Waist height ratio were positively correlated with insulin resistance. However, the waist circumference and Waist height ratio were more strongly associated with insulin resistance compared to the other anthropometric parameter in our study population. Additionally the hip circumference had no correlation with the insulin resistance in our study population. There are few studies which have examined the associations between anthropometric measures of obesity and insulin resistance in children or adolescents[34-39]. Our findings are partially in line with those of other researchers.

In a study that focused on Brazilians from Sao Paulo, which examined body mass index, waist circumference, and waist height ratio, it was found that Waist height ratio was an acceptable method to determine insulin senstivity; however, their results were based on a gender-mixed sample[40]. The Manios et al. have also reported a stronger association of Waist height ratio and waist circumference with insulin resistance compared to waist hip ratio, among Greek populations[34,35]. However, in a Turkish population based study, both body mass index and waist circumference were identified as better predictors of insulin resistance compared to waist hip ratio[41]. Similar results have been observed in adults, where a small number of
studies have dealt with comparing the correlations between different anthropometric and insulin resistance. On the other hand, most studies have focused on identifying the best obesity-related indicator of Type 2 Diabetes and waist circumference has emerged as the best predictor compared to body mass index, waist hip ratio and Waist height ratio[42,43]. According to Yang L, a new significant indicator of insulin resistance is the neck circumference which is correlated with visceral adiposity in WHO grade III obesity[44].

Besides some important findings this study has some potential limitations. Firstly this is a cross-sectional study and may not be appropriate for cause–effect relationships. Secondly, the sample size is very small so that the findings may not be applicable for any generalized population.

5. Conclusion

On the basis of our results we concluded that the waist circumference, waist hip ratio, body mass index and waist height ratio are good surrogate marker of insulin resistance among which waist circumference and waist height ratio are better predictor of insulin resistance in apparently healthy Indian subjects. However, to achieve more confirmatory results further studies on larger sample size are needed in Indian population as well as in other worldwide population.

Conflict of interest

Authors declare no Conflict of interest.

Acknowledgement

Authors are thankful to the all medical students for participating in the study. Authors are grateful to the Head, Department of Physiology, King George’s Medical University, Lucknow, India, for their support in the study. We are also thankful to the colleagues and faculty members of Department of Physiology, King George’s Medical University, Lucknow, India, for their support in the study.

References

[1] Silva EA, Flexa F, Zanella MT. Obesidade abdominal, resistência à insulina e hipertensão: impacto sobre a massa e a função do ventrículo esquerdo em mulheres. Arq Bras Cardiol. 2007; 89 (2): 86-92.
[2] Boden-Albala B, Sacco RL, Lee HS, Grahame-Clarke C, Rundek T, Elkind MV, et al. Metabolic syndrome and ischemic stroke risk: Northern Manhattan Study. Stroke. 2008; 39 (1): 30-5.
[3] Ribeiro Filho FF, Mariosa LS, Ferreira SR, Zanella MT. Gordura visceral síndrome metabólica: mais que uma simples associação. Arq Bras Endocrinol Metab. 2006; 50 (2): 230-8.
[4] Haffner S.M. and et al. Prospective analysis of the insulin-resistance syndrome (syndrome X). Diabetes 1992; 41: 715–722.
[5] Ferrannini E, Haffner SM and Mitchell BD, Stern MP. 1991. Hyperinsulinemia: the key feature of a cardiovascular and metabolic syndrome. Diabetologia 3: 416 – 422.
[6] Reaven G.M. 1988. “Role of insulin resistance in human disease”. Diabetes 37: 1595–1607.
[7] Eckel R, Grundy S, Zimmet P. The metabolic syndrome. Lancet. 2005; 365:1415-28.
[8] Vasques ACJ, Rosado LEPFL, Alfenas RCG, Geloneze B. Análise crítica douso dos índices do Homeostasis Model Assessment (HOMA) na avaliação da resistência à insulina e capacidade funcional das células b pancreáticas. Arq Bras Endocrinol Metab. 2008; 52 (1): 32-9.
[9] Mathews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985; 28:412-9.
[10] Misra A, Vikram NK. Insulin resistance syndrome (metabolic syndrome) and obesity in Asian Indians: evidence and implications. Nutrition 2004; 20: 482-491.
[11] Misra A, Vikram NK, Arya S, Pandey RM, Dhingra V, et al. High prevalence of insulin resistance in postpubertal Asian Indian children is associated with adverse trunkal body fat patterning, abdominal adiposity and excess body fat. Int J Obes Relat Metab Disord. 2004; 28:1217-1226.
[12] Bacha F, Saad R, Gungor N, Janosky J, Arslanian SA. Obesity, regional fat distribution, and syndrome X in obese black versus white adolescents: race differential in diabetogenic and atherogenic risk factors. J Clin Endocrinol Metab. 2003; 88: 2534-2540.
[13] Krokoukia M, Nannis GP, Psarra G, Skenderi K, Chatouros GP, et al. Elevated total and central adiposity and low physical activity are associated with insulin resistance in children. Metabolism 2007; 56: 206-213.
[14] Keskin M, Kurtoglu S, Kendirci M, Atabek ME, Yazici C. Homeostasis model assessment is more reliable than the fasting glucose/insulin ratio and quantitative insulin sensitivity check index for assessing insulin resistance among obese children and adolescents. Pediatrics 2005; 115: e500-3.
[15] Balkau B, Deanfield JE, Despres JP, Bassand JP, Fox KA, et al. International Day for the Evaluation of Abdominal Obesity (IDEA): a study of waist circumference, cardiovascular disease, and diabetes mellitus in 168,000 primary care patients in 63 countries. Circulation 2007; 116:1942-1951.
[16] Ramachandran A, Snehalatha C, Dharmaraj D, Viswanathan M. Prevalence of glucose intolerance in Asian Indians. Urban-rural difference and significance of upper body adiposity. Diabetes Care 1992; 15: 1348-1355.
[17] Chandalia M, Abate N, Garg A, Stray-Gundersen J, Grundy SM. Relationship between generalized and upper body obesity to insulin resistance in Asian
Indian men. *J Clin Endocrinol Metab.* 1999; 84: 2329-2335.

[18] Shelgikar KM, Hockaday TD, Yajnik CS. Central rather than generalized obesity is related to hyperglycaemia in Asian Indian subjects. *Diabet Med.* 1991; 8: 712-717.

[19] Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, et al. *Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study.* *Lancet.* 2005; 366: 1640-1649.

[20] Snijder MB, Dekker JM, Visser M, Bouter LM, Stehouwer CD, et al. *Associations of hip and thigh circumferences independent of waist circumference with the incidence of type 2 diabetes: the Hoorn Study.* *Am J Clin Nutr.* 2003; 77: 1192-1197.

[21] Berber A, Gomez-Santos R, Fanghanel G, Sanchez-Reyes L. *Anthropometric indexes in the prediction of type 2 diabetes mellitus, hypertension and dyslipidemia in a Mexican population.* *Int J Obes and Related Meta Diso* 2001; 25: 1794-1799.

[22] World Health Organization. (2000) The Asia-Pacific Perspective: Redefining Obesity and its Treatment. World Health Organization, Geneva.

[23] Hajer GR, van Haeften TW, Visseren FLJ: *Adipose tissue dysfunction in obesity, diabetes, and vascular diseases.* *Eur Heart J* 2008; 29:2959–2971.

[24] Valerio G, Licenziati MR, Iannuzzi A, Franzese A, Siani P, Riccardi G: *Insulin resistance and impaired glucose tolerance in obese children and adolescents from Southern Italy.* *Nutr Metab Cardiovasc Dis* 2006; 16:279–284.

[25] Ochoa Agudelo GM, Arias Arteaga R: *Prevalence of the metabolic syndrome in school children and adolescents of the urban area of Medellín, Colombia.* *Iatreia* 2008; 21:260–270.

[26] Agudelo G, Velásquez C, Bedoya G, Estrada A, Manjarres L, Patiño F: *Variations in the prevalence of metabolic syndrome in adolescents according to different criteria used for diagnosis: Which definition should be chosen for this age group?* *Metab Syndr Relat Disord* 2014; 12:202–209.

[27] Prentki M, Nolan CJ: *Islet β cell failure in type 2 diabetes.* *J Clin Invest* 2006; 116:1802–1812.

[28] Friend A, Craig I, Turner S: *The prevalence of metabolic syndrome in children: a systematic review of the literature.* *Metab Syndr Relat Disord* 2013, 11:71–80.

[29] Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW: *Obesity and metabolic syndrome in children and adolescents.* *N Engl J Med* 2004, 350:2362–2374.

[30] Celik T, Iyiyoju A, Yuksel UC: *Pediatric metabolic syndrome: a growing threat.* *Int J Cardiol* 2010, 142:302–303.

[31] Olivares Reyes JA, Arellano Plancarte A: *Bases Moleculares de las Acciones de la Insulina.* *Revista Educ Bioquím* 2008; 27:9–18.

[32] Garmendia ML, Lera L, Sánchez H, Uauy R, Albala C: *Homeostasis model assessment (HOMA) values in Chilean elderly subjects.* *Med Chile* 2009, 137:1409–1416.

[33] Acosta García E, Carias D, Páez Valery M, Naddaf G, Zury D: *Exceso de peso, resistencia a la insulina y dislipidemia en adolescentes.* *Acta Bioquím Clin Latinoam* 2012; 46:365–373.

[34] Manios Y, Kouralba G, Kafatos A et al. *Associations of several anthropometric indices with insulin resistance in children: the children study.* *Acta Paediatr* 2008; 97:494–499.

[35] Manios Y, Moschos G, Kouralba G et al. *Prevalence and independent predictors of insulin resistance in children from Crete, Greece: the children study.* *Diabet Med* 2008; 25:65–72.

[36] Misra A, Madhavan M, Vikram N et al. *Simple anthropometric measures identify fasting hyperinsulinemia and clustering of cardiovascular risk factors in Asian Indian adolescents.* *Metabolism* 2006; 55:1569–1573.

[37] Rodriguez-Rodriguez E, Palmers-Essex C, Lopez-Sobaler AM, et al. *Preliminary data on the association between waist circumference and insulin resistance in children without a previous diagnosis.* *Eur J Pediatr* 2011; 170(1):35–43.

[38] Thorsdottir I, Gunnarsdottir I, Palsson GI et al. (2006) *Anthropometric predictors of serum fasting insulin in 9- and 15-year-old children and adolescents.* *Nutr Metab Cardiovasc Dis* 16:263–271.

[39] Yan W, Wang X, Yao H et al. *Waist-to-height ratio and Body Mass Index predict different cardiovascular risk factors in Chinese children.* *Diab Care* 2006; 29:2760–2761.

[40] Matos LN, Giorelli Gde V, Dias CB. *Correlation of anthropometric indicators for identifying insulin sensitivity and resistance.* *Sao Paulo Med J* 2011; 129: 30-35.

[41] Can AS, Borsot TP, Gonen M. *Anthropometric indices and their relationship with cardiometabolic risk factors in a sample of Turkish adults.* *Public Health Nutr* 2009; 12:538–546.

[42] Lopatynski J, Mardarowicz G, Szczesniak G. *A comparative evaluation of waist circumference, waist-to-hip ratio, waist-toheight ratio and body mass index as indicators of impaired glucose tolerance and as risk factors for type-2 diabetes mellitus.* *Ann Univ Mariae Curie Sklodowska Med* 2003; 58:413–419.

[43] Mesa JL, Ortega FB, Ruiz JR et al. *Anthropometric determinants of a clustering of lipid-related metabolic risk factors in over weight and non-over weight adolescents— influence of cardiorespiratory fitness.* *The Avena study.* *Ann Nutr Metab* 2006; 50:519–527.

[44] Yang L, Samarasinge YP, Kane P et al. *Visceral adiposity is closely correlated with neck circumference and represents a significant indicator of insulin resistance in WHO grade III obesity.* *Clin Endocrinol (Oxf)* 2009; 73(2):197–200.