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# WRIST CIRCUMFERENCE: AN INDEPENDENT PREDICTOR OF BOTH INSULIN RESISTANCE AND CHRONIC KIDNEY DISEASE IN AN ELDERLY POPULATION

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## Abstract

**Background and aim:** *It was recently reported that wrist circumference is associated with insulin resistance (IR) both in children and adults. We aimed to evaluate whether wrist circumference is a useful anthropometrical parameter for the evaluation of IR in an elderly population.* **Material and method:** *We performed a study on 40 subjects, 20 with type 2 diabetes (T2D) and 20 control subjects. IR was evaluated using the homeostasis model assessment of insulin resistance (HOMA-IR). We measured the following anthropometrical parameters: weight, height, waist circumference (WC), hip circumference, wrist circumference, waist to hip ratio (WHR), waist to height ratio (WHtR), body mass index (BMI) and body adiposity index (BAI).* **Results:** *We found statistically significant differences between the subjects with T2D and the control group for all the analyzed parameters. Statistically significant correlations between all the anthropometrical parameters and HOMA-IR were observed. However, only WC was an independent predictor of IR. Wrist circumference was the only parameter negatively correlated with the estimated glomerular filtration rate (eGFR). Furthermore, this measurement was an independent predictor of chronic kidney disease (CKD) in the studied subjects.* **Conclusion:** *Wrist circumference can be used in the general practice as a surrogate marker of IR in the elderly, being both easily determined and a cost-free method.*

**key words**: *insulin resistance, elderly population, anthropometrical parameters, wrist circumference*

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## Background and Aim

Obesity and diabetes, especially type 2 diabetes (T2D), represent some of the most concerning public health issues of the 21st Century. With more than 371 million people living with diabetes in 2012 [1], number that is continuously increasing, both the economic and social costs related to this pathology and its complications are extremely high, more than 471 billion USD being spent on healthcare for diabetes [1]. Therefore, the need to find better cost-effective predictors of T2D arises.

Despite the fact that worldwide T2D has a higher prevalence in the 40-59 age group, an increase in the number of cases in the elderly population (over 65 years old) was observed in developed countries, leading to the prediction that by 2030 the number of diabetic subjects aged between 60 and 79 will increase to almost 200 million people [2].

Defined as an inadequate response of the insulin target tissues (skeletal muscle, liver, and adipose tissue) to the physiologic effects of circulating insulin [3], insulin resistance (IR) is associated with both obesity and T2D, as well as with diabetes chronic complications. The golden standard for the evaluation of IR, hyperinsulinemic euglycemic clamp, cannot be used on a large scale in the general population and even in clinical studies, its usefulness being restricted by its invasive nature. Consequently, many other methods of evaluating IR have been developed over the years. Among these, one of the most used remains the homeostasis model assessment of insulin resistance (HOMA-IR) [4-5], but anthropometrical parameters and biological markers [6-9] have gained a greater interest in this field. Nevertheless, the latter are not currently used in general practice, but only in clinical studies, being expensive methods.

One novel anthropometric parameter associated with IR is wrist circumference. Recently described in the medical literature, wrist circumference was associated with IR both in children and adults [10,11]. Furthermore, wrist circumference proved to be a significant predictor of diabetes in both genders of adult population, but its predictability was independent of BMI or WC only in females [11].

Another public health problem is represented by chronic kidney disease (CKD), a condition strongly related to both age and glucose metabolism [12]. Therefore, a measurement that could reflect IR as well as the risk of developing CKD would be useful in the general practice.

Taking all these into consideration, we aimed to evaluate whether wrist circumference is a useful anthropometrical parameter for the evaluation of IR in an elderly Italian population, as well as the relationship existent between anthropometrical parameters and eGFR.

## Material and Method

The study group included 40 subjects, 20 subjects with T2D and 20 control subjects age and sex matched, recruited from the Out-patient Department of the Endocrinology and Diabetology Department of Campus Bio-Medico of Rome University. The study was approved by the ethics committee of the University. For all the subjects included in the study, the following inclusion criteria were met: age over 65 years old, no recent history of acute diseases, no history of oncological diseases, subjects with normal liver function and with an estimated glomerular filtration rate (eGFR) calculated by CKD-EPI formula over 30mL/min/1.73m$^2$. Regarding the subjects with T2D, we included in the study subjects with a history of T2D of at least 1 year. In the control group, the diagnosis of T2D was excluded after performing both blood fasting glycemia (BFG) and glycated haemoglobin (HbA1c) that had values within the normal range.

IR was measured using HOMA-IR, after the determination of BFG and fasting insulinemia. We measured a series of anthropometrical parameters: weight, height, waist circumference (WC), hip circumference, wrist circumference. Wrist circumference was measured to the nearest 0.1 cm using a tape meter without any tape pressure over it while subjects held their wrist anterior surface up. In order to prevent examiner-related mistakes, all the measurements were performed by the same person. Waist to hip ratio (WHR), waist to height ratio (WHtR), body mass index (BMI) and body adiposity index (BAI) were calculated. The latter was calculated using the formula BAI = (Hip circumference/Height$^{1.5}$) - 18 [13], where hip circumference is expressed in centimetres and height in meters.

*Statistical analysis*

Recorded data were analyzed using the Statistical Package for the Social Sciences (SPSS) 17.00 software (IBM Corporation, Armonk, NY, USA). We performed the analysis of the entire study population, as well as separate statistics for the subjects with T2D vs. the control group. Furthermore, a separate statistics for males and females was performed. We used Shapiro – Wilk test for evaluating the normality of the variables distribution, followed by Student's t-test for variables with normal distribution and the nonparametric Mann – Whitney test for the variables that significantly deviate from a normal distribution. Spearman test in correlation analysis, multiple linear regressions and the analysis of the areas under the ROC curve were also utilised. P-values <0.05 were considered statistically significant.

## Results

Table 1 presents the characteristics of the study population. We found statistically significant differences between the subjects with T2D and the control group for all the analyzed parameters. Figures 1-3 present the statistically significant differences between the subjects with T2D and the control group regarding HOMA-IR, WC and wrist circumference.

**Table 1.** Subjects' characteristics (data presented as mean ± standard deviation (SD))

| Variable | Subjects with T2D (n=20) | Control group (n=20) | Statistical significance |
|---|---|---|---|
| Age (years) | 75.3±4.9 | 74±5.1 | NS |
| HOMA-IR* | 2.4±1.7 | 1.5±1.1 | p<0.05 |
| WC (cm) | 102.87±14.1 | 87.9±12.5 | p<0.05 |
| Wrist circumference (cm)* | 17.3±1.6 | 16.5±1 | p<0.05 |
| BMI (Kg/m$^2$)* | 30.5±5.4 | 26.1±3.3 | p<0.05 |
| BAI (%) | 33.22±7.6 | 26±7 | p<0.05 |
| WHR | 0.94±0.08 | 0.88±0.09 | p<0.05 |
| WHtR | 0.64±0.08 | 0.55±0.08 | p<0.05 |

*****Variables significantly deviate from a normal distribution. NS not significantly statistic

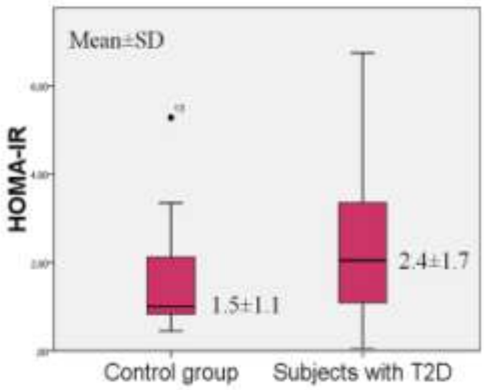


**Figure 1.** HOMA-IR values differences between the subjects with T2D and the control group (p<0.05).

We have also analyzed the relationships between the studied parameters within the entire study group and we found statistically significant correlations between all the anthropometrical parameters and HOMA-IR for the entire study population (Figure 4 and Figure 5). However, the linear regression analysis has shown that only WC is an independent predictor of IR (evaluated with HOMA-IR≥2.6) (p=0.013), data confirmed also by the analysis of the area under the ROC curve, with an area of 0.775 (p=0.017) vs. an area of 0.678 and p=0.095 obtained when wrist circumference was analyzed (Figure 6).

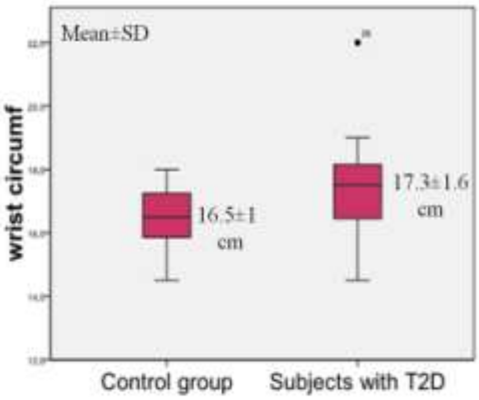


**Figure 2.** Wrist circumference values differences between the subjects with T2D and the control group (p<0.05).

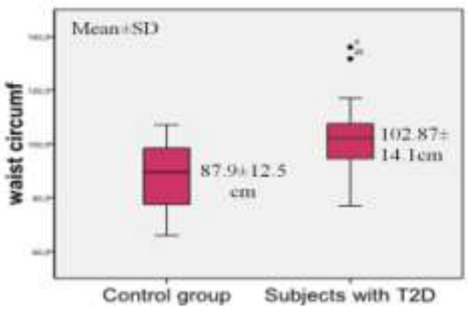


**Figure 3.** WC values differences between the subjects with T2D and the control group (p<0.05).

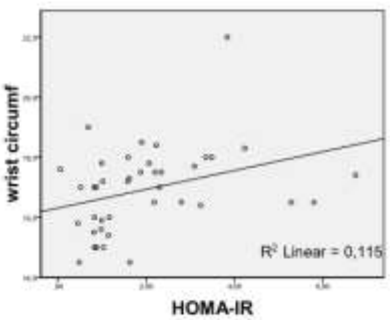


**Figure 4.** The correlation between wrist circumference and HOMA-IR in the study population (p=0.033).

Regarding the analysis according to gender, we found that in males HOMA-IR was correlated with WC (p=0.012), BMI (p=0.004), BAI (p=0.004) and WHtR (p=0.007), while in females HOMA-IR was correlated with WC (p=0.015), BAI (p=0.016) and WHtR (p=0.021).

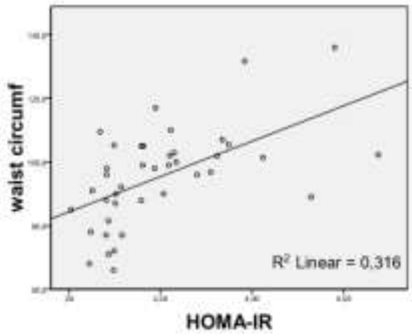


**Figure 5.** The correlation between WC and HOMA-IR in the study population (p<0.001).

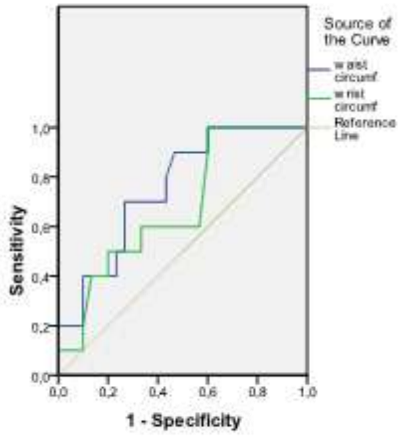


**Figure 6.** Analysis of the Area under the ROC curve for WC and wrist circumference as predictors of IR.

However, when we analyzed the relationship between the anthropometrical parameters and HOMA-IR only in the subjects with T2D, we found a statistically significant correlation only between HOMA-IR and WC (p=0.014), as shown in Figure 7.

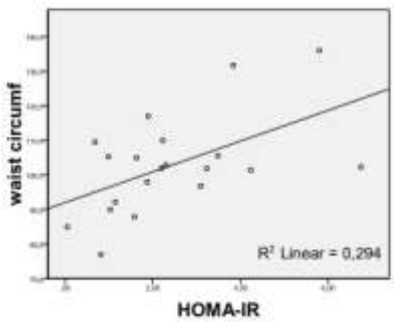


**Figure 7.** The correlation between WC and HOMA-IR in the subjects with T2D (p=0.014).

Taking into consideration that IR, obesity and T2D are known risk factors for CKD, we have also evaluated the relationship between the studied parameters and the eGFR assessed by CKD-EPI formula and we found that eGFR was negatively correlated with wrist circumference in both the whole study group (p=0.017) and in subjects with T2D (p=0.009), as depicted in Figures 8 and 9. Furthermore, wrist circumference proved to be an independent predictor of CKD (eGFR<60mL/min/1.73m$^2$) in the study population when the area under the ROC curve was analysed (area=0.775, p=0.017), as shown in Figure 10.

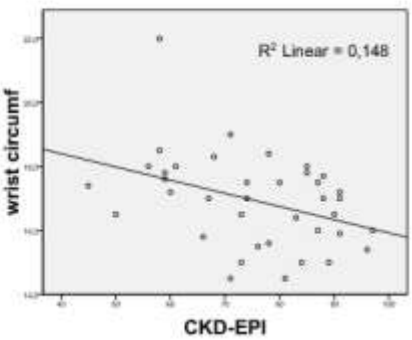


**Figure 8.** The correlation between wrist circumference and eGFR calculated by CKD-EPI formula in the study population.

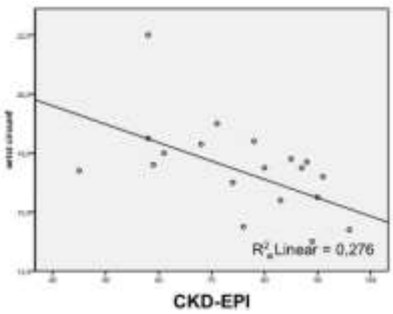


**Figure 9.** The correlation between wrist circumference and eGFR calculated by CKD-EPI formula in the subjects with T2D.

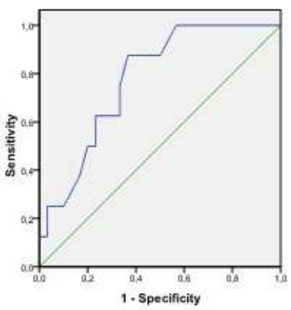


**Figure 10.** Analysis of the area under the ROC curve for wrist circumference as a predictor of CKD.

**Discussions**

When interpreting the results of our study, first of all we must take into consideration that it was performed in an elderly population. It is well known that in the elderly, the relevance of some classical anthropometrical parameters (such as BMI) is lower than in non-elderly subjects due to the aging process which involves physiological and nutritional changes manifested by height and weight loss, muscular mass loss and fat mass increase [14]. However, a recent study showed that WC is a reliable measurement, as increased WC in subjects aged 65 to 74 years old, even across BMI categories and for those who were classified as ‘underweight’ using BMI, was associated with a higher risk of mortality [15]. The results of our study demonstrated the role of WC in the evaluation of IR for an elderly population. Furthermore, this measurement was the only independent predictor of IR in our study population.

To our best knowledge, there was no previous study analyzing the importance of wrist circumference in the elderly, although this measurement proved to be a significant predictor of diabetes and metabolic syndrome in an adult population [11]. According to the results of our study, although wrist circumference was not an independent predictor of IR, it was correlated with the values of HOMA-IR.

An interesting finding was the relationship between wrist circumference and CKD. It is common knowledge that age is a non-modifiable risk factor for developing CKD. Furthermore, a recent study [12] has shown that risk factors for CKD vary by age. This study has found that annual income, use of oral analgesics, metabolic syndrome, hyperuricemia, and hemoglobin were risk factors for CKD in both elderly and non-elderly subjects, while in elderly patients, risk factors were medical history of diabetes mellitus, CKD, stroke, and not using analgesic injection

[12]. The results of our study showed that wrist circumference is an independent predictor of CKD. Furthermore, we did not find a relationship between eGFR and any of the other studied parameters.

However, when interpreting the data presented above, we must also take into consideration the limits of our study. Firstly, the small sample size of the study prevents us from drawing strong conclusions and secondly, IR was evaluated using HOMA-IR, a measurement largely used yet still controversial in elderly subjects [4,5,16].

## Conclusions

Our study proved that anthropometrical parameters are useful in the evaluation of IR in an elderly population. Wrist circumference proved to be associated with IR, but in our study population, only WC was an independent predictor of IR assessed with HOMA-IR. Wrist circumference proved to be an independent predictor of CKD, data that to our knowledge was not previously reported. Therefore, we conclude that this measurement can be used in the general practice as a surrogate marker of IR in the elderly, having the advantages of being both easily determined and a cost-free method.

Although WC proved to be a better predictor of IR compared to wrist circumference, we believe that this parameter could be largely utilised, its measurement being not affected by clothing or the postprandial state which can interfere with the determination of WC. Furthermore, as it reflects a skeletal frame size, its dimensions change only slightly over time.

However, further studies on a larger scale are needed in order to firmly establish the role of wrist circumference in the evaluation of IR, T2D and its chronic complications and in order to determine the appropriate cut-off values of this parameter in both adult and elderly populations.

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