

OBSERVATIONS

# Neck Circumference and Insulin Resistance in Chinese Adults: The Cardiometabolic Risk in Chinese (CRC) Study

Neck circumference (NC) is a proxy for upper-body fat and a reliable screening measure for the identification of individuals with abnormal fat distribution. Recently, compelling evidence indicates that NC is positively associated with insulin resistance (IR) and a variety of cardiometabolic abnormalities, independent of overall adiposity and central obesity in Caucasians (1) or Chinese diabetic patients (2). However, it remains unknown whether NC affects IR in the general Chinese population.

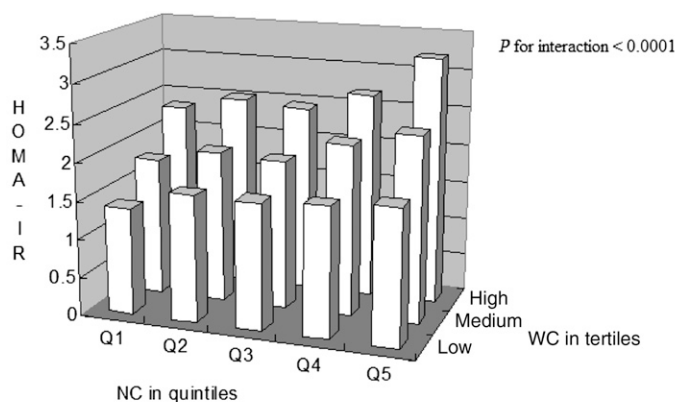
In the current study, we analyzed the associations of NC with IR and cardiometabolic risk factors in 2,588 apparently healthy Chinese adults (20–87 years of age) from the Cardiometabolic Risk in Chinese (CRC) study (3). We found a significant association between NC and an increasing trend of homeostasis model assessment of insulin resistance (HOMA-IR), adjusting for age and other cardiometabolic risk factors, in both men ( $P = 0.02$ ) and women ( $P = 0.004$ ). The differences in HOMA-IR between the extreme quintiles of NC appeared more evident in men than in women; however, the test for the heterogeneity between men and women was not significant. Further adjustment for BMI and waist circumference (WC) did not appreciably change the associations between NC and IR. In addition, high NC was significantly related to a decreasing trend of HDL levels in both sexes and was significantly related to an increasing trend of plasma triglyceride and uric acid levels only in men ( $P$  for sex difference  $< 0.03$ ), after adjustment for covariates including BMI or WC and HOMA-IR.

We also found significant interactions of NC with BMI and WC ( $P$  for interaction  $< 0.0001$ ) in relation to HOMA-IR (Fig. 1). It appears that the associations between NC and HOMA-IR were more evident in those with a higher BMI or WC.

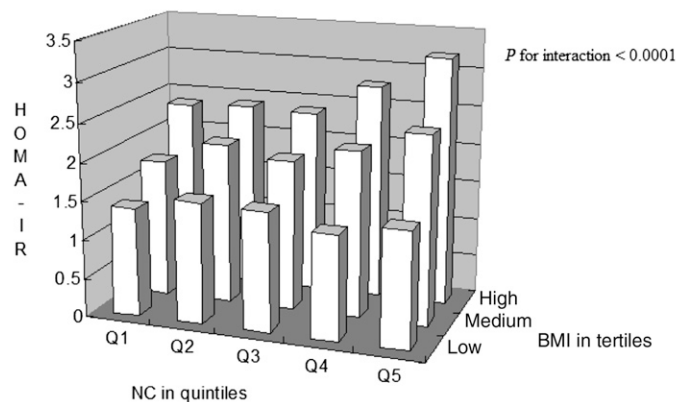
To our knowledge, the current study is among the first to assess the associations of NC with IR and metabolic risk in a general population of Chinese adults. Our findings are in line with the results from several previous studies in Caucasians and Chinese diabetic patients (1,2). In the Framingham Study, it was found that NC was associated with IR and cardiovascular risk factors in a sex-specific manner (1). It has been documented that high NC was a significant predictor of obstructive sleep apnea syndrome (4), which has been associated with risk of IR and diabetes. Obstructive sleep apnea syndrome aggravates glycemic control, even at the earliest stages of glucose intolerance. In addition, intermittent hypoxemia

and sleep fragmentation increase the risk of IR (5). Our data, together with evidence from other studies, suggest that body fat accumulated in the upper body segment may contribute to the adverse metabolic consequence.

In conclusion, we found significant associations of high NC with increased risk of IR and a variety of cardiometabolic risk factors in apparently healthy Chinese adults, and found sexual dimorphism for associations with certain risk factors. Our findings support a recommendation for the inclusion of NC in the routine clinical assessment of adults to identify those at high risk of cardiometabolic diseases such as type 2 diabetes and heart disease.



Low: WC < 74cm for women, WC < 86cm for men;  $P$  for trend = 0.0003  
 Medium: 74cm ≤ WC < 81cm for women, 86cm ≤ WC < 93cm for men;  $P$  for trend = 0.0023  
 High: WC ≥ 81cm for women, WC ≥ 93cm for men;  $P$  for trend < 0.0001



Low: 22.99 < BMI;  $P$  for trend = 0.5948  
 Medium: 22.99 ≤ BMI < 25.65;  $P$  for trend = 0.0004  
 High: BMI ≥ 25.65;  $P$  for trend < 0.0001

**Figure 1**—The joint effect of NC (in quintiles) with WC and BMI (low, medium, and high levels) on HOMA-IR.

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J.L. wrote and reviewed the manuscript. F.T. wrote the manuscript. Y.L. and X.L. performed statistical analyses. C.Z. and Y.W. contributed to discussion. H.L. edited the manuscript. L.Q. researched data and wrote the manuscript. L.Q. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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