Neck circumference positively related with central obesity, overweight and metabolic syndrome in Chinese people with type 2 diabetes: Beijing Community Diabetes Study -4

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Objective: To investigate the association between neck circumference and central obesity, overweight as well as metabolic syndrome in Chinese individuals with type 2 diabetes.

Research Design and Methods: 3182 diabetic subjects (20-80 years) were recruited from 15 community health centers in Beijing using a multi-stage random sampling approach.

Results: Receiver operating characteristics analysis showed that the area under curve for the neck circumference and central obesity was 0.77 for men, 0.75 for women, respectively (p<0.001). Furthermore, neck circumference ≥38 cm for men and ≥35 cm for women were best cutoff points for determining overweight people. Neck circumference ≥39 cm for men, and ≥35 cm for women were best cutoff points to determine people with metabolic syndrome.

Conclusions: In the present study, neck circumference is positively related with body mass index, waist circumference and metabolic syndrome in Chinese individuals with type 2 diabetes.

Neck circumference (NC), as an index for upper-body subcutaneous adipose tissue distribution, was evaluated in relation to cardiovascular risk factors, insulin resistance and biochemical components of metabolic syndrome (MS)(1-4). However, epidemiological population-based studies on the clinical significance of NC in connection with overweight and MS in diabetic people are lacking. The aim of this study was to determine whether NC alone can predict overweight and central obesity and to evaluate the association between NC and MS.

RESEARCH DESIGN AND METHODS
15 community health centers in Beijing were selected by multi-stage random sampling approach. People with type 2 diabetes (20-80 years) who had lived in the community over five years were recruited between August 2008 and July 2009. A total of 3182 diabetic subjects with measurement of NC were available for analysis. People with severe disabled, hepatic failure, renal failure, schizophrene or goiter were excluded. Written informed consent was obtained from all participants.

Past medical history was determined with a standardized questionnaire. Blood pressure was measured twice after each subject had been seated for 10 min. The average was used for analysis. Waist circumference (WC) was measured at the level midway between the lower rib margin and the iliac crest. NC was measured with people’s head erect and eye facing forward, horizontally at the upper margin of the laryngeal prominence (Adam's apple). Fasting glucose and lipid profiles were determined using an autoanalyzer.

Overweight was defined as BMI ≥24 kg/m², central obesity was defined as WC ≥85 cm for men and ≥80 cm for women (5-6). MS was defined according to the Chinese Diabetes Society definition of MS (7).

Receiver operating characteristics (ROC) curve analyses were performed using SPSS 11.5 software. The Youden’s index, defined as “sensitivity+specificity-1”, was used to determine the optimal NC cut-off points.

RESULTS
The study sample consisted of 1294 men and 1888 women having a mean age of 64.0±10.1 years. With a mean of 38.4 ±3.6 cm in men, this group’s NC was 3cm wider than the women’s with 35.4±3.3 cm (p<0.001). NC correlated positively with BMI (men, r=0.41; women, r=0.84; each, p< 0.0001). NC also correlated positively with WC (men, r=0.47;
women, $r=0.47$; each, $p<0.0001$).

All subjects were divided into subgroups based on their BMI. The BMI limits were set at $<24$, 24-28, and $>28$ kg/m$^2$ respectively. NC was positively correlated with WC in the three BMI subgroups in men ($r=0.352, 0.261, 0.340, p$ all $<0.001$). Similar results were found for the female group ($r=0.318, 0.277, 0.356, p$ all $<0.001$). Each BMI subgroup was further divided into three subgroups based on percentile 25, 25-75, 75 of WC. In the male and female group, NC increased from the lower WC subgroups to higher WC subgroups within each BMI subgroup. (Figure 1A).

The prevalence of central obesity was 87.2%. ROC analysis showed that the area under the curve (AUC) for NC and central obesity was 0.77 for men, 0.75 for women, respectively. NC $\geq$ 37 cm for men and $\geq$ 35 cm for women were the best cut-off points for determining subjects with central obesity (Figure 1B).

The prevalence of overweight was 65.0%. NC in the overweight group was 36.2 ±3.1 cm, higher than in the BMI $<24$ kg/m$^2$ group (33.8±3.0 cm)($p<0.001$). NC $\geq$38 cm for men and $\geq$35 cm for women were the best cut-off levels for determining subjects with overweight. The AUC was 0.72 for men and 0.73 for women (Figure 1C).

2709 People with MS had 1.5 cm wider NC than the “without MS” group (36.8±3.7 cm vs 35.3±3.4 cm, $P<0.001$). NC $\geq$ 39 cm for men and $\geq$ 35 cm for women were the best cut-off levels for determining people with MS (Figure 1D). Each BMI subgroup was further divided into three subgroups based on percentile 25, 25-75, 75 of NC. In the male and female group, the prevalence of MS had a tendency to increase from the lower BMI and NC subgroups to higher subgroups. (Figure 1E). A logistic regression analysis, using MS as the dependent variable, showed that the relationship between NC and MS after adjusting for gender and age was statistically significant (OR 1.20 (95% CI : 1.16~1.24) , $p<0.001$.

**CONCLUSIONS**

The present study showed that NC $\geq$ 37 cm for men and $\geq$ 35 cm for women were best cut-off points to determine subjects with central obesity. NC $\geq$38 cm for men and $\geq$35 cm for women were best cut-off points to determine subjects with overweight.

The NC cut-off points for evaluating overweight or obesity have been differently defined in different studies (4, 8). The discrepancy with this study’s results may be due to different diagnostic standards or study populations. Prevalence of overweight and obesity in diabetic people is higher than in the general population, this might be one cause for the discrepancy.

In this cross-sectional analysis of diabetic population-based data we found NC to be independently related to MS indicating that NC may be used as a simple test for identifying MS. This is in accordance with previous studies (2, 4).The optimal NC cut-off points for evaluating MS and obesity were found to be different. MS is a constellation of a variety of metabolic risk factors, one of the being obesity. Thus, the correlation between NC and MS is less pronounced compared with the NC and central obesity correlation. Further, the prevalence of MS in this study was higher than the prevalence in the general population. These may be possible explanations for the different NC cut-off points for MS and central obesity.

This study of diabetic population has certain limitations. Further studies are needed to identify the relationship of NC with central obesity and MS in general population. Additionally, the reproducibility of the NC cut-off point results should be further studied.

In summary, in this community diabetic population-based study, NC is related with BMI, WC and MS in Chinese people with type 2 diabetes. NC seems thus suitable to be
used in a clinical setting as a strong indicator for central obesity and metabolic abnormalities in type 2 diabetic subjects.

**Author contributions.** Guang-ran Yang: Researched data, contributed to discussion and wrote manuscript. Shen-yuan Yuan: Contributed to discussion, wrote manuscript and reviewed manuscript. Han-jing Fu: Researched data, contributed to discussion and reviewed manuscript. Gang Wan: Researched data. Liang-xiang Zhu: Researched data and reviewed manuscript. Xiang-lei Bu: Researched data. Jian-dong Zhang, Xue-ping Du, Yu-ling Li, Yu Ji, Xiao-ning Gu and Yue Li: Researched data.

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**REFERENCES**
Figure 1: Neck circumference in the BMI and waist circumference subgroups (A), Receiver operating characteristics curves related to neck circumference and central obesity (B), overweight (C) and metabolic syndrome (D) in men and women, the prevalence of metabolic syndrome in the BMI and neck circumference subgroups (E).