Mid-upper arm circumference, central obesity and metabolic syndrome in middle-aged and elderly Chinese: the REACTION study

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Research article

Keywords: metabolic syndrome, mid-upper arm circumference, central obesity, overweight

Posted Date: October 15th, 2019

DOI: https://doi.org/10.21203/rs.2.16072/v1

Version of Record: A version of this preprint was published at BMC Endocrine Disorders on June 3rd, 2020. See the published version at https://doi.org/10.1186/s12902-020-00559-8.

Abstract

Background The mid-upper arm circumference (MUAC) is a proxy for upper body subcutaneous fat and a reliable screening measure for identification of individuals with abnormal local fat distribution. The purpose of present study was to evaluate the association between MUAC and metabolic syndrome (MetS) as well as other metabolic phenotype in the middle-aged and elderly population.

Methods We measured the MUAC in a cross-sectional sample with a total of 9787 subjects aged 40 years and older in Shanghai, China. The measurement of MUAC is performed on the right arm using a non-elastic tape held midway between the acromion and the olecranon processes in duplicate, with arm hanging loosely at the side of the body. The MetS was defined according to the Joint Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention. The association of MUAC with MetS was tested in logistic regression analyses and reported as odds ratio (OR) with 95% confidence interval (CI).

Results T he prevalence of MetS, overweight, and central obesity raised sharply from the smaller MUAC groups to the larger MUAC groups both in men and women. MUAC was positively correlated with waist circumference, BMI, fasting insulin, HOMA-IR, triglycerides, systolic and diastolic blood pressure, and inversely correlated with adiponectin and HDL-cholesterol after adjusting for age and gender. As the MetS components accumulated, the MUAC increased concomitantly. The risk of MetS in the highest MUAC quartile was significant higher (odds ratio 1.77; 95% confidence interval 1.51-2.09) than the lowest quartile after adjustment of potential confounders. Conclusion Our results indicated that large MUAC is an independent risk factor of MetS in Chinese individuals.

Background

Metabolic syndrome (MetS), which contains a cluster of metabolic abnormalities including central obesity, hypertension, dysglycemia, and dyslipidemia that together culminate in the increased risk of cardiovascular disease (CVD) and diabetes, is a major global public health problem[1]. Of note, the prevalence of MetS is up to 30% in middle-aged and elderly people in China[2, 3]. Given the continuous increase of aging population in China, high prevalence of MetS is a concerning observation which should be put on the agenda.

It is well established that upper body obesity is a high risk for hypertension, hyperlipidemia, and dysglycemia[4]. One predominant mechanism linking upper body obesity with these components of MetS is abnormally elevated free fatty acids (FFAs) flux[5]. Notably, instead of visceral fat, it is upper body subcutaneous adipose tissue as main source of excess FFA in upper body obese individuals[5, 6]. Additionally, clear evidence demonstrates that upper body subcutaneous fat, estimated by neck circumference, is a unique adipose depot which confer additional risk for MetS over general and central obesity[7, 8].

The mid-upper arm circumference (MUAC) is another feasible and valid screening tool for identifying subjects with abnormal distribution of upper body subcutaneous fat. However, to date, epidemiological population-based studies on the clinical significance of MUAC in connection with MetS are scarce. Thus, the purpose of this study is to evaluate weather MUAC is associated with MetS as well as other metabolic abnormality among Chinese middle-aged and elderly population.

Methods

Study population

The study is a portion of the Risk Evaluation of cAncers in Chinese diabeTic Individuals: A lONgitudinal (REACTION) study, a community-based cross-sectional study conducted among 259,657 Chinese individuals aged 40 years and older[9]. REACTION study performed in 25 communities across mainland China, from 2011 to 2012. The study design and methods have been described previously in detail[9–11]. The data presented in this article are based on the baseline survey of subsamples from the Chongming District, Shanghai, China. A total of 9930 eligible subjects were participated in the study. After excluding individuals with missing data about MUAC (n = 143), 9787 subjects (3156 men and 6631 women) were eventually included in the present analysis. The study protocol was approved by the Ethics Committee of Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine. Written informed consent was obtained from all participants.

Data collection

A standardized questionnaire was applied by trained physicians to collect essential information, including sex, age, lifestyle factors, education status, physical activity and previous medical history. Anthropometric measurements were collected by certified physicians using standard protocols in duplicate base on the NHANES Anthropometry Procedures Manual (https://wwwn.cdc.gov/nchs/data/nhanes/2015–2016/manuals/2016_Anthropometry_Procedures_Manual.pdf). The measurement of MUAC is performed on the right arm using a non-elastic tape held midway between the acromion and the olecranon processes, with arm hanging loosely at the side of the body. Waist circumference was measured with a non-elastic tape held midway between the lower rib margin and the iliac crest at the end of a gentle expiration. Blood pressure (BP) was measured with an automated electronic device (OMRON Model1 Plus; Omron Company, Kyoto, Japan). Overweight was defined as body mass index (BMI) ≥24 kg/m^2, central obesity was defined as WC ≥85 cm for men and ≥80 cm for women.

Biochemical measurements

Peripheral venous blood samples were collected after an overnight fast for at least 10 hours. The plasma glucose level was measured by glucose oxidase method (ADVIA–1650 Chemistry System, Bayer,

Leverkusen, Germany). Total cholesterol, triglycerides, low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol were assessed by an automatic analyzer (Hitachi 7080; Tokyo, Japan). Hemoglobin A1c was measured with HPLC method (BIO-RAD, D10, CA). Fasting insulin was determined by RIA (Linco Research, St.Charles, MO). Insulin resistance was evaluated by the homeostasis model of assessment for insulin resistance (HOMA-IR).

Definition of MetS

The MetS was defined based on the Joint Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity[1] as presenting at least three of the following five components: (1) waist circumference ≥85 cm in men or ≥80 cm in women, (2) triglycerides ≥1.7 mmol/L, (3) HDL cholesterol <1.0 mmol/L in men or <1.3 mmol/L in women, (4) systolic blood pressure (SBP) ≥130 and/or diastolic blood pressure (DBP) ≥85 mm Hg or current use of antihypertensive medications, (5) fasting plasma glucose ≥5.6 mmol/L, previous diagnosis of type 2 diabetes or use of antidiabetic agents.

Statistical analysis

Normally distributed data were reported as means ± SD, whereas variables with a skewed distribution were expressed as median (interquartile range) and log transformed to approximate normality before analysis. Categorical variables were depicted by frequency and percentage. Analysis of covariance for continuous variables and multivariate logistic regression analysis for categorical variables were applied for the comparison according to MUAC quartiles. Correlation coefficients between MUAC and metabolic features were calculated by partial correlation analysis after adjusted age and gender. Multivariate logistic regression models were used to estimate the odds ratios (ORs) for MetS and its components. Potential confounding variables including age, gender, smoking, alcohol drinking, physical activity, educational status, self-reported CVD, C-reactive protein (CRP), adiponectin, BMI, and HOMA-IR were controlled in the regression models. Data management and statistical analysis were performed with SPSS (version 23.0). P<0.05 was considered statistically significant.

Results

Characteristics of participants according to MUAC quartiles

The mean of MUAC were 29.24 cm for male and 28.41 cm for female (P <0.001), respectively. The individuals were divided into four groups based on the quartiles of MUAC. When analyzed by quartiles of MUAC levels, as summarized in Table 1, the subjects with larger MUAC were more likely to be smokers, alcohol drinkers, and with comorbidities including hypertension, hyperlipidemia, diabetes (all P <0.05). With regard to metabolic parameters, the individuals in the higher MUAC quartiles showed higher levels of

SBP, DBP, BMI, waist circumference or waist-to-hip ratio, fasting glucose, insulin, HOMA-IR, CRP, triglycerides (all P <0.001), and LDL cholesterol (P = 0.003). Conversely, the subjects with larger MUAC displayed lower plasma adiponectin and HDL cholesterol levels (both P <0.001). However, elevated MUAC exhibited no association with the levels of total cholesterol in this study.

Association between MUAC and MetS

Partial correlation analysis shown that MUAC has the strongest correlation with waist circumference after adjusted for age and gender (Table 2). Additionally, MUAC was also strongly correlated with BMI and insulin.

As presented in Figure1, the prevalence of MetS, overweight, and central obesity raised sharply from the smaller MUAC groups to the larger MUAC groups both in men and women (Fig. 1). In addition, women seem to have higher prevalence of MetS and central obesity compared with men. From 1st to 4th quartile (Q1 to Q4), the prevalence of MetS were 32.0%; 45.6%;59.3%; 72.4% (P = 0.007) in men, and 35.4%; 49.4%; 64.5%; 75.1% (P <0.001) in women, respectively. In the largest MUAC subgroups (Q4), the prevalence of overweight was 83.6% in men and 83.3% in women while the prevalence of central obesity was 84.7% in men and 88.4% in women.

Furthermore, with the accumulation of MetS components, MUAC was gradually increased both in male and female (Fig. 2). It is worth noting that as the components of MetS increased one by one, the relationship between MUAC and MetS was statistically significant, both in subjects with Mets (number of MetS components ≥3) and the subjects without MetS (number of MetS components <3). On this ground, MUAC may be directly or indirectly related to each MetS component.

As is shown in Table 3, the ORs for MetS and its components were significantly higher with increasing MUAC quartiles (P <0.001). In the highest MUAC quartile, the ORs were 5.71 [95% confidence interval (CI) (4.97–6.56)] for MetS, 14.70(12.49–17.31) for central obesity, 2.23(1.90–2.62) for elevated triglycerides, 2.11(1.86–2.40) for elevated blood pressure, 2.06(1.79–2.37)for reduced HDL cholesterol, 1.54(1.35–1.76) for elevated fasting glucose after adjusting for age, gender, smoking, alcohol consumption, education status, physical activity, CRP, adiponectin, and self-reported CVD (Model 2). Further adjustment for HOMA-IR, CRP, and adiponectin the OR was 3.24 (Model 3, 95% CI, 2.79–3.76) for MetS in the highest MUAC quartile. Moreover, the correlation between MUAC and MetS was still statistically significant by additional adjustment for BMI (Model 4, OR 1.77; 95% CI, 1.51–2.09; P <0.001).

Discussion

We observed a significant and independent association between large MUAC and the increased risk of MetS and its key components in a large-scale population study. Furthermore, we found that MUAC is strongly correlated with BMI, waist circumference, and insulin, which indicated that large MUAC is a potential screening tool for identifying overweight, central obesity, and insulin resistance.

BMI and waist circumference are commonly screening tool for identifying individuals with abnormal distribution of body fat. Nevertheless, BMI cannot provide accurate information about the local distribution of body fat and it is difficult to obtain height and weight for patients who cannot stand. As for waist circumference, the deficiency of daily application lies in the big difference of preprandial and postprandial measurements. In view of above reasons, MUAC began to show diagnostic value for assessing nutritional status. Compared to other anthropometric measurements, MUAC is not only easier to obtain, but also has other advantages such as being more accurate, convenient and low-cost. Small MUAC has shown excellent performance in assessing malnutrition and predicting mortality both in children[12] and older individuals[13, 14]. More recently, large MUAC has been recognized as a valid tool for detecting overweight and obesity in children and adolescents[15, 16]. However, the study about whether MUAC is associated with obesity-related metabolic abnormality, such as MetS, is scare. Currently, we demonstrate that large MUAC, as a proxy of upper-body subcutaneous adipose, is a risk factor of MetS. Moreover, consistent with previous studies, we found large MUAC also tightly correlated with overweight and central obesity among Chinese middle-aged and older subjects.

Obesity, characterized by the expansion of adipose tissue, is a key causative factor in the development of MetS. The abnormal accumulation of fat affects adipose tissue metabolic capacities, endocrine, and immune function and leads to altered production of lipid mediators, adipokines, pro- or anti-inflammatory cytokines, and impaired signalling pathways that contribute to obesity related metabolic abnormality[17]. Obesity increases the flux of fatty acids from adipose tissue to peripheral tissues[18]. The increased free fatty acids (FFAs) derived from adipose tissue is predominantly mediated by the resistance of adipose tissue to the anti-lipolytic effects of insulin[19]. There is compelling evidence that abnormally increased visceral fat is a maker of excessive systemic FFAs release[20], but it is worth noting that it is upper body subcutaneous fat released the majority of FFAs[6]. Large MUAC means excessive subcutaneous fat accumulation, which contributes a greater portion of the fatty acids release into the circulation. Circulating FFAs is a crucial mediator in the development of metabolic disorder[21]. Elevated plasma FFAs induce insulin resistance, inflammation, and increase the synthesis and ectopic deposition of triglycerides[22–25]. Concomitantly, excessive FFAs also affects glucose metabolism by inhibiting glucose uptake, oxidation, glycogen synthesis, and increasing output hepatic glucose[26]. Additionally, increased FFAs can trigger oxidative stress which is an early instigator of MetS[27], and endoplasmic reticulum stress which intersects with many different inflammatory and stress signaling pathways by unfolded protein response[28–30]. The excess FFAs release derived from excess accumulation of arm subcutaneous adipose might be a potential mechanism to partly explain the correlation between MUAC and MetS.

Moreover, the adipose tissue is not only a depot of excess energy but also a highly active metabolic endocrine organ that secretes numerous biologically active molecules, which are collectively termed adipokines[31]. When adipose tissue expands, the capacity of adipocytes to function as endocrine cells and secrete various adipokines is altered in individuals with obesity and MetS[27, 32]. These abnormal levels of adipokine, including adiponectin, leptin, and retinol-binding protein 4, are linked to insulin resistance, impaired triglyceride storage and increased fatty acids in circulation[33]. Furthermore, as fat

accumulation, substantial infiltration of immune cells occurs, and there is a specific crown-like disposition of macrophages around single necrotic adipocytes in obese people[34] and subjects with MetS[32]. Subsequently, proinflammatory pathways were activated, and certain proinflammatory cytokines and chemokines (i.e. TNF-α, IL−1β, IL−6 and MCP−1) were overflowed that result in low-grade inflammation and insulin resistance[17, 32]. In line with previous studies, our findings also indicated that MUAC is positive correlated with CRP and negative correlated with adiponectin, which is a well-documented adipokine with potent anti-inflammatory activity. Overall, adipose dysfunctions, inflammation, and stress linking mid-upper arm obesity to insulin resistance and MetS.

To our knowledge, this is the first study to evaluate the association between MUAC and Mets among large-scale middle-aged and older people. The major strength of this study is the analysis based on a large sample. Potential covariates were strictly controlled in the analysis, so as to eliminated the possibility of residual confounding effects. Nevertheless, there are several limitations in this study. For one thing, we did not measure tissue composition of the mid-upper arm. Due to limitations of epidemiological screening conditions, we could not quantify the adipose accumulation by more accurate radiographic measures. Therefore, the amount and size of subcutaneous adipocyte and muscle fat are not clear. For another, due to the present study is a cross-sectional analysis, we cannot draw the causality from our findings. Additionally, it is still unclear whether our findings in middle-aged/older Chinese subjects can be generalized to younger populations or individuals of other ethnicities.

In brief, our study demonstrated that large MUAC is correlated with an elevated risk of having MetS even after adjustment for potential covariates. These findings provide a novel insight in the association between upper body obesity and MetS, and a potential screening tool for identifying individuals with MetS. Further investigation of the underlying pathophysiological mechanism is needed to explain the positive association of mid-upper arm subcutaneous fat with MetS.

Conclusion

In summary, in this population-based study, large MUAC is strongly and independently associated with overweight, central obesity, and elevated risk of MetS in Chinese middle-aged and elderly population. Based on the observations, including MUAC in the routine clinical measurement to evaluate the high-risk population of metabolic diseases such as T2D and CVD is necessary.

Abbreviations

MUAC: mid-upper arm circumference

MetS: metabolic syndrome

FFAs: free fatty acids

BMI: body mass index

HDL: high-density lipoprotein

LDL: low-density lipoprotein

CVD: cardiovascular disease

T2D: type 2 diabetes

HOMA-IR: homeostasis model of assessment for insulin resistance

SBP: systolic blood pressure

DBP: diastolic blood pressure

OR: odds ratios

CI: confidence interval

CRP: C-reactive protein

SD: standard deviation

Declarations

Acknowledgements

The authors thank all subjects who participated in the study and hospital staffs for their contribution in sample and data collection.

Funding

This work was supported by the National Natural Science Foundation of China (81670743 to QS, 81370953 to ZY), Shanghai Health System Outstanding Young Talents Training Program (XYQ2013098 to ZY), Shanghai Health and Family Planning Commission (21740173 to LQ). The funding body had no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Availability of data and materials

The study is a part of the Risk Evaluation of cAncers in Chinese diabeTic Individuals: A lONgitudinal (REACTION) study. All data generated and analysed during this study are included in REACTION study. The data are held in a secure and confidential database which can only be assessed by members of the REACTION group. The REACTION has a website http://www.rjh.com.cn/pages/neifenmike/REACTION/index.shtml.

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Authors Contributions

ZY, LQ, and QS designed the study. YN, WZ, XL, HZ, NL, HG, JW, and GN recruited the subjects, processed samples, and contributed to acquisition of data. ZY, YN, WZ, NL and JS analyzed the data. JS wrote the manuscript. ZY revised the manuscript. All authors have read and approved the final manuscript.

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Ethics declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine. Written informed consent was obtained from all participants.

Consent for publication

All authors have read the paper and agree that it can be published.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1

Characteristics of study participants according to MUAC quartiles

Characteristics	Q1 (n=2524)	Q2 (n=2409)	Q3 (n=2427)	Q4 (n=2427)	P value
	≤26.70	26.71-28.60	28.61-30.50	≥30.51	
MUAC (cm)	24.93±1.53	27.78±0.56	29.61±0.53	32.53±1.72	<0.001
Age (yr) [b]	55.59±8.21	56.06±7.81	56.53±7.62	56.47±7.59	<0.001
Male (%) [b]	24.0	29.1	37.1	39.1	<0.001
Smoking (yes, %)	14.3	17.2	18.1	19.9	<0.001
Alcohol (yes, %)	18.1	24.5	26.0	28.1	<0.001
Education (%)					
0-6	20.7	21.7	21.8	25.4	0.003
7-9	50.0	49.1	48.6	48.2	
≥10	29.3	29.2	29.6	26.4	
Physical activity (%)					
Low	70.8	72.5	71.6	72.2	0.281
Moderate	21.4	19.6	21.2	19.7	
High	7.8	7.9	7.2	8.1	
SBP (mm Hg)	126.96±19.00	129.72±18.42	132.23±17.76	134.55±18.94	<0.001
DBP (mm Hg)	79.02±9.51	80.29±9.71	81.13±9.50	82.50±9.40	<0.001
BMI (kg/m^2)	22.79±2.90	24.47±2.48	25.46±2.61	26.94±3.08	<0.001
Waist circumference (cm)	78.38±11.41	82.94±8.49	86.54±8.75	91.11±8.77	<0.001
Waist to hip ratio	0.86±0.08	0.87±0.09	0.89±0.17	0.90±0.07	<0.001
Fasting glucose (mmol/L)	6.20±1.82	6.23±1.73	6.33±1.65	6.38±1.52	<0.001
2-h glucose (mmol/L)	8.30±4.01	8.61±3.94	8.91±3.79	9.18±3.73	<0.001
Insulin (mU/L) [c]	6.25(3.90-7.20)	7.18(4.50-8.50)	7.75(5.20-9.20)	9.40(6.10-11.50)	<0.001
HOMA-IR [c]	1.70(0.98-1.99)	2.00(1.22-2.45)	2.22(1.38-2.68)	2.70(1.65-3.38)	<0.001
CRP (ug/ml)	4.79±5.74	4.94±5.85	5.13±6.12	5.24±6.27	<0.001
Adiponectin (ug/ml)	12.34(7.92-15.67)	10.93(6.72-13.15)	8.17(5.24-11.33)	6.29(4.78-9.75)	<0.001
Triglycerides (mmol/L) [c]	1.44(0.83-1.66)	1.67(0.94-1.94)	1.83(1.03-2.13)	1.96(1.12-2.34)	<0.001
Total cholesterol (mmol/L)	4.64±1.05	4.62±1.03	4.65±1.04	4.67±1.03	0.291
LDL cholesterol (mmol/L)	2.58±0.78	2.59±0.76	2.63±0.77	2.65±0.76	0.003
HDL cholesterol (mmol/L)	1.32±0.34	1.23±0.32	1.19±0.30	1.16±0.28	<0.001
Comorbidities (%)					
Hypertension	20.8	25.0	31.4	36.9	<0.001
Hyperlipidemia	2.8	3.4	5.8	6.2	<0.001
Diabetes	8.8	9.3	10.8	10.8	0.036
CVD [d]	2.6	3.9	3.2	4.1	0.014

[a] Data are means ± SD, median (interquartile range), or percentage; P value was calculated after adjustment for age and gender.

[b] Not adjusted for itself.

[c] These variables were log transformed before analysis.

[d] Self-reported CVD including stroke and coronary heart disease.

Table 2

Partial correlation coefficients among MUAC and other clinical parameters

Variable	MUAC	
	r	P
BMI	0.334	<0.001
Waist circumference	0.437	<0.001
SBP	0.124	<0.001
DBP	0.123	<0.001
Fasting plasma glucose	0.045	0.043
2-h postload glucose	0.074	<0.001
Insulin	0.348	<0.001
HOMA-IR	0.134	<0.001
CRP	0.110	0.008
Adiponectin	-0.147	<0.001
HDL cholesterol	-0.176	<0.001
LDL cholesterol	0.024	0.016
Triglycerides	0.138	<0.001

All correlation coefficients were calculated after adjustment for age and gender.

Table 3

Adjusted ORs (95% CI) of MetS according to quartiles of MUAC

	ORs (95% CI)				P value for trend
	Q1	Q2	Q3	Q4	
MetS					
Model 1[a]	1.00	1.79(1.60-2.02)	3.28(2.91-3.70)	5.77(5.08-6.54)	<0.001
Model 2[b]	1.00	1.77(1.56-2.01)	3.25(2.85-3.70)	5.71(4.97-6.56)	<0.001
Model 3[c]	1.00	1.55(1.35-1.78)	2.49(2.17-2.86)	3.24(2.79-3.76)	<0.001
Model 4[d]	1.00	1.23(1.07-1.42)	1.68(1.45-1.95)	1.77(1.51-2.09)	<0.001
Central obesity					
Model 1[a]	1.00	2.50(2.22-2.81)	5.67(5.00-6.43)	15.31(13.17-17.81)	<0.001
Model 2[b]	1.00	2.47(2.18-2.81)	5.52(4.82-6.31)	14.70(12.49-17.31)	<0.001
Model 3[c]	1.00	2.29(2.00-2.61)	4.69(4.08-5.40)	10.57(8.93-12.52)	<0.001
Model 4[d]	1.00	1.41(1.20-1.65)	2.03(1.71-2.40)	3.46(2.81-4.25)	<0.001
Elevated blood pressure					
Model 1[a]	1.00	1.27(1.13-1.43)	1.66(1.48-1.87)	2.15(1.91-2.42)	<0.001
Model 2[b]	1.00	1.26(1.11-1.43)	1.64(1.45-1.86)	2.11(1.86-2.40)	<0.001
Model 3[c]	1.00	1.18(1.03-1.34)	1.45 (1.27-1.65)	1.65 (1.44-1.88)	<0.001
Model 4[d]	1.00	1.04(0.91-1.18)	1.16(1.02-1.33)	1.17(1.01-1.35)	<0.001
Elevated triglycerides					
Model 1[a]	1.00	1.44(1.23-1.69)	1.81(1.55-2.11)	2.34(2.02-2.72)	<0.001
Model 2[b]	1.00	1.39(1.17-1.65)	1.81(1.54-2.14)	2.23(1.90-2.62)	<0.001
Model 3[c]	1.00	1.26(1.06-1.50)	1.49(1.26-1.77)	1.52(1.28-1.80)	<0.001
Model 4[d]	1.00	1.21(1.02-1.45)	1.40(1.17-1.67)	1.36(1.14-1.64)	0.001
Reduced HDL cholesterol					
Model 1[a]	1.00	1.45(1.27-1.66)	1.70(1.49-1.93)	2.18(1.91-2.48)	<0.001
Model 2[b]	1.00	1.36(1.18-1.58)	1.68(1.45-1.94)	2.06(1.79-2.37)	<0.001
Model 3[c]	1.00	1.29(1.11-1.50)	1.50(1.30-1.74)	1.68(1.45-1.95)	<0.001
Model 4[d]	1.00	1.23(1.06-1.43)	1.38(1.19-1.61)	1.46(1.24-1.71)	<0.001
Elevated fasting glucose					
Model 1[a]	1.00	1.28(1.13-1.45)	1.48(1.32-1.72)	1.51(1.33-1.73)	<0.001
Model 2[b]	1.00	1.28(1.12-1.47)	1.51(1.04-1.34)	1.54(1.35-1.76)	<0.001
Model 3[c]	1.00	1.23(1.08-1.41)	1.41(1.23-1.61)	1.38(1.20-1.57)	<0.001
Model 4[d]	1.00	1.14(0.99-1.32)	1.15(1.00-1.32)	1.25(1.09-1.44)	<0.001

[a] Model 1 adjusted for age and gender.

[b] Model 2 further adjusted for smoking, alcohol drinking, education, physical activity, self-reported CVD.

[c] Model 3 further adjusted for CRP, adiponectin, and HOMA-IR.

[d] Model 4 further adjusted for BMI.

Figures

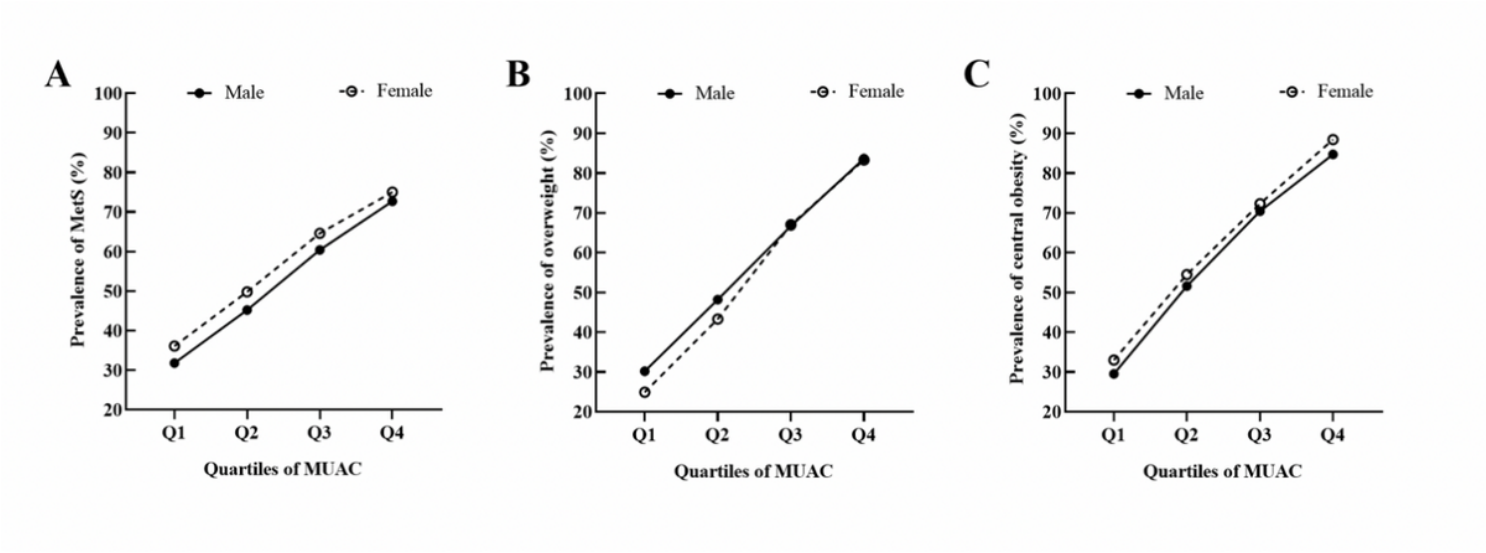

Figure 1

Prevalence of the MetS, overweight, and central obesity by quartiles of MUAC among 9787 participants. The quartiles of MUAC were calculated by gender respectively. In male, the cutoffs of MUAC were ≤27.40, 27.41-29.25, 29.26-31.10, and ≥31.11 cm; in female, the cutoffs were ≤26.45, 26.46-28.40, 28.41-30.30, and ≥30.31 cm. From 1st to 4th quartile (Q1 to Q4), the prevalence of MetS were 32.0%; 45.6%;59.3%; 72.4% (P = 0.007) in men and 35.4%; 49.4%; 64.5%; 75.1% (P <0.001) in women, respectively. The prevalence of overweight was 30.2%; 48.2%; 66.7%; 83.6% in men, and 24.9%; 43.3%; 67.0%; 83.3% in women, both P <0.001. The prevalence of central obesity was 29.5%; 51.6%; 70.4%; 84.7% in men, and 33.0%; 54.5%; 72.3%; 88.4% in women, both P <0.001.

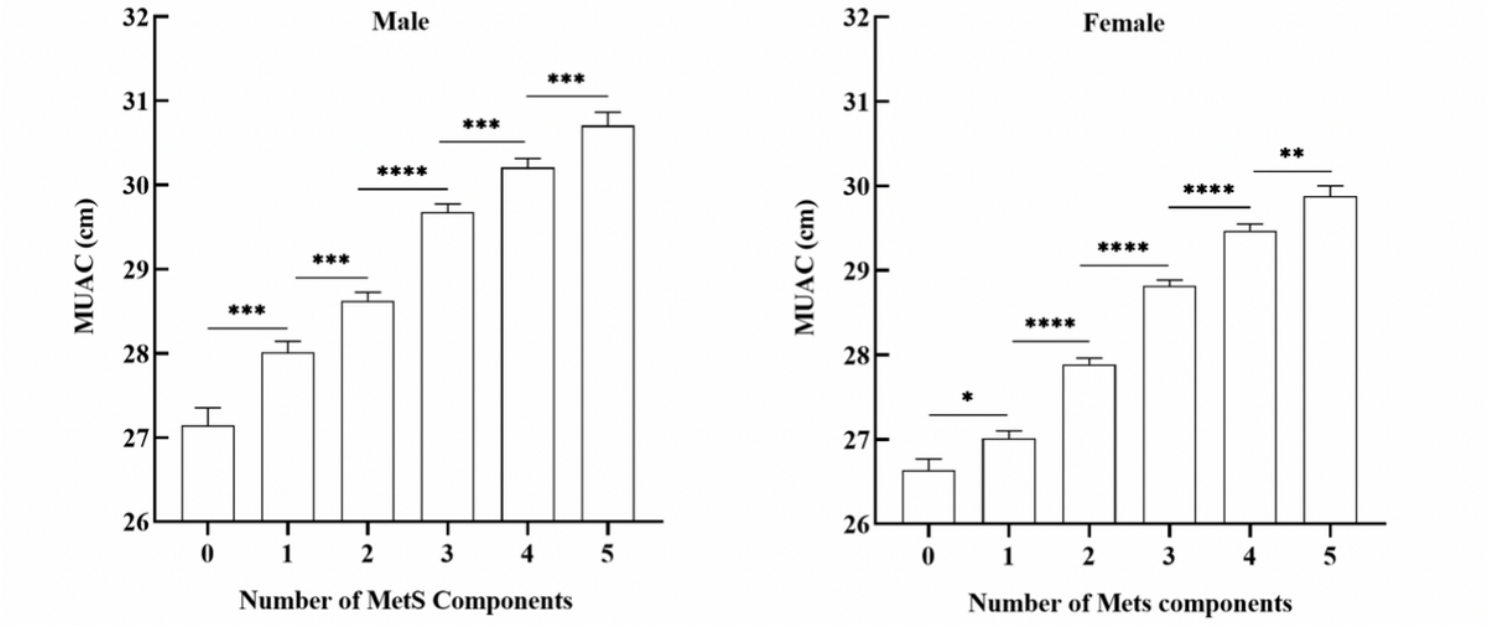

Figure 2

MUAC according to the number of MetS components. Data are shown as the means ± SEM. The mean values of MUAC for those with none to five components were 27.14, 28.01, 28.63, 29.70, 30.21, 30.71 cm for male, and 26.62, 27.00, 27.83, 28.79, 29.43, 29.8 cm for female, respectively. *: P< 0.05; **: P< 0.01; ***: P< 0.001; ****: P< 0.0001.