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Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults: study on optimal cut-off points of body mass index and waist circumference in Chinese adults

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For prevention of obesity in the Chinese population, it is necessary to define the optimal range of healthy weight and the appropriate cut-off points of body mass index (BMI) and waist circumference for Chinese adults. The Working Group on Obesity in China under the support of the International Life Sciences Institute Focal Point in China organized a meta-analysis on the relationship between BMI, waist circumference and risk factors of related chronic diseases (e.g., high diabetes, diabetes mellitus, and lipoprotein disorders). Thirteen population studies in all met the criteria for enrolment, with data of 239 972 adults (20–70 years of age) surveyed in the 1990s. Data on waist circumference was available for 111 411 persons, and data on serum lipids and glucose were available for more than 80 000. The study populations were located in 21 provinces, municipalities and autonomous regions in mainland China as well as in Taiwan. Each enrolled study provided data according to a common protocol and uniform format. The Center for Data Management in the Department of Epidemiology, Fu Wai Hospital, was responsible for the statistical analysis. The prevalence of hypertension, diabetes, dyslipidemia and clustering of risk factors all increased with increasing levels of BMI or waist circumference. A BMI of 24 with best sensitivity and specificity for identification of the risk factors was recommended as the cut-off point for overweight; a BMI of 28, which may identify the risk factors with specificity around 90%, was recommended as the cut-off point for obesity. A waist circumference over 85 cm for men and over 80 cm for women were recommended as the cut-off points for central obesity. Analysis of a population-attributable risk percentage illustrated that reducing the BMI to the normal range (<24) could prevent 45–50% of the clustering of risk factors. Treatment of obese persons (BMI = 28) with drugs could prevent 15–17% of clustering of risk factors. When waist circumference is controlled at under 85 cm for men and under 80 cm for women, it could prevent 47–58% of clustering of risk factors. Based on these guidelines, a classification of overweight and obesity for Chinese adults is recommended.

Key words: body mass index, Chinese adults, obesity, overweight, waist circumference.

Introduction

The body mass index of the Chinese population is lower than that of most Western countries, however, the trends of mean body mass index and prevalence of overweight in adults have increased significantly in the recent 15 years.[1] Overweight and obesity are closely related to risk factors and their clustering for many chronic diseases such as cardiovascular disease, diabetes mellitus, etc., and has become a risk factor for coronary heart disease and ischemic stroke.[2,3] The prevention and control of overweight and obesity have become one of the key aspects of chronic disease prophylaxis and treatment. Epidemiological surveys and population health promotion usually take body mass index (BMI: body weight {kg}/height {m^2}) as a useful indicator for measuring whole body obesity, and waist circumference (cm) as a measurement of abdominal fat accumulation, that is, the indicator of central obesity. At present, the World Health Organisation (WHO) recommends a BMI range of 25–29.9 kg/m^2 as the criteria for overweight, and ≥30 kg/m^2 for obesity. However, the data used to derive these criteria were from Western populations.[4] Scientists from Asian countries have proposed a new definition of obesity, namely, body mass indices of

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23–24.9 kg/m^2 for overweight and ≥25 kg/m^2 for obesity in Asian populations; nevertheless, the basis of this new definition did not include data from mainland China and Taiwan. In order to prevent and treat overweight and obesity in the Chinese population, it is necessary to determine the optimal range of body mass index, and the cut-off points for overweight and obesity in Chinese adults. Therefore, the Working Group on Obesity in China (WGOC), under ILSI Focal Point in China, assigned the Department of Epidemiology at the Fu Wai Hospital, Chinese Academy of Medical Sciences, as the statistical centre for meta-analysis, and organized the collection and analysis of existing study data. The meta-analyses included both cross-sectional and prospective data. The former analysed the predictive values for different cut-off points for body mass index and waist circumference to risk factors of related diseases, and the latter paid particular attention to the relation between body mass index and total mortality and the incidence of cardiovascular diseases. (This will be reported in another article.)

Study design and methods

Every participating study provided its data on a voluntary basis according to the unified protocol and forms.

Criteria for recruitment of study data

1 Period of cross-sectional survey: 1990 onwards.
2 Number of participants: at least 1000 persons aged 20 years and over.
3 Anthropometric indicators: at least body weight and height.
4 Indicators of related risk factors: at least one of the following three measurements – blood pressure, fasting blood glucose, and serum total cholesterol.
5 Rigorous quality control measures were in operation during data collection.

The selected surveys preferred a large sample size with fairly good quality and more indicators, and did not claim the data to be a representative sample of the whole nation.

Definitions of risk factors

1 High blood pressure (HBP): systolic blood pressure (SBP)≥140 mm Hg, and/or diastolic blood pressure (DBP)≥90 mm Hg, or current treatment for hypertension with medication.
2 Diabetes mellitus (DM): fasting blood glucose ≥126 mg/dL. (Owing to most of the analytical data being conducted without a glucose tolerance test, the fasting blood glucose was taken as the criterion for clinical diagnosis.) Fasting blood glucose ≥110 mg/dL. (In fact, the indicator including impaired fasting glucose and diabetes mellitus of clinical diagnosis, was expressed as 'IFG' in this article.)
3 High (serum) total cholesterol (HTC): TC ≥200 mg/dL
4 Low (serum) high density lipoprotein-cholesterol (L HDL-C): HDL- C < 35 mg/dL.
5 High (serum) triglyceride (HTG): TG ≥ 200 mg/dL.
6 Clustering of risk factors (≥ 2 RFs): subjects with two or more of the above five risk factors.

Methods of data collection

Each collaborating centre provided its data samples stratified by gender and in 10-year age groups: 20–29, 30–39, 40–49, 50–59, 60–69 and 70 years and over (overall, six age-specific groups of men and six age-specific groups of women). In addition to general description of study data, the forms included the following items: means, standard deviations and percentiles of body weight, height, body mass index and waist circumference by gender and age-specific groups; the prevalence of risk factors and clustering of risk factors by strata of body mass index by gender and age-specific groups; prevalence of risk factors, and clustering of risk factors by waist circumference by gender and age-specific groups. A few of the collaborating centres provided their data on diskettes directly; the data processing was carried out by the Statistical Center, then filled in the identical forms. All of the data were checked centrally; any problems discovered were verified by relevant centres, and then input into the computer for statistical analysis.

Methods of statistical analysis

1 Means and standard deviations of body mass index of specific gender-age group of the total population were summed by the weighted average method.
2 The total number of persons, stratified by body mass index or waist circumference, and the number of persons with different risk factors in each stratum, were summed directly. The prevalence of risk factors by gender and age-specific groups by stratum of BMI or waist circumference, the total prevalence of gender specific and age-combined groups, as well as the age-adjusted prevalence rate (based on age composition data of 1991 National Population Census) were estimated.
3 Taking the body mass indices of 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30 (kg/m2) as cut-off points, the sensitivity, specificity, positive and negative predictive values and Youden's index (sensitivity + specificity – 100) were calculated for each risk factor and clustering of risk factors by gender and age-specific groups and age-combined groups.
4 Taking the waist circumferences of 65, 70, 75, 80, 85, 90, 95, 100 (cm) as cut-off points, the sensitivity, specificity, positive and negative predictive values and Youden's index (sensitivity + specificity-100) were calculated for each risk factor and clustering of risk factors by gender and age-specific groups and age-combined groups.
5 In light of the foregoing analyses, the optional cut-off points were sought for body mass index or waist circumference with fairly good sensitivity and specificity. The percentage, *P*, of the study population with BMI or waist circumference above the optional cut-off points was calculated, and an estimate was made of the age-adjusted OR (odds ratio) of each risk factor at the values above the optional cut-off points. A calculation was made of the population-attributable risks percent [PAR(%)] for different risk factors according to the following equation:

$$\mathrm{PAR}\ (\%) = 100 \times P\ (\mathrm{OR} - 1)/[P\ (\mathrm{OR} - 1) + 1]\%.$$

Table 1. Gender, age-specific, mean and standard deviation of anthropometric measurements, and current prevalence of risk factors

		Height (cm) Mean (SD)	Body weight (kg) Mean (SD)	BMI (kg/m^2) Mean (SD)	WC (cm) Mean (SD)	HBP (%)	DM (%)	IFG (%)	HTC (%)	L HDL-C (%)	HTG (%)	≥2RFs (%)
Men	20-	168.7(7.1)	61.5(9.1)	21.6(2.7)	74.0(8.2)	6.6	0.6	4.5	6.1	10.3	6.9	7.9
	30-	168.9(6.5)	64.8(9.6)	22.8(3.5)	78.4(9.1)	13.3	2.6	7.3	21.8	7.5	12.6	17.2
	40-	167.7(6.2)	64.7(9.9)	23.2(3.1)	81.2(9.8)	21.5	3.7	10.0	27.5	8.9	15.5	25.5
	50-	166.6(6.2)	64.4(10.6)	23.2(3.1)	81.2(9.8)	32.6	5.9	13.8	30.3	7.8	14.3	33.0
	60-	164.9(6.7)	63.1(10.2)	23.0(3.4)	80.9(14.6)	42.4	8.5	17.6	33.6	8.5	15.5	38.6
	70-	163.3(7.0)	59.7(10.4)	22.3(3.7)	78.9(10.3)	48.6	9.0	15.7	34.9	9.3	13.3	41.2
	Total	167.3(6.5)	63.8(9.9)	22.8(3.3)	79.3(9.8)	23.5	4.8	11.5	27.4	8.3	14.2	27.8
Women	20-	157.5(6.7)	54.0(8.1)	22.7(5.5)	68.9(7.1)	2.5	0.8	7.0	9.0	2.6	3.3	3.7
	30-	157.5(6.2)	56.6(8.6)	22.8(3.1)	72.7(10.4)	7.6	2.1	7.1	16.8	4.6	4.8	8.2
	40-	156.4(5.9)	57.7(9.1)	23.5(3.4)	76.1(8.8)	19.0	3.0	8.4	26.0	5.5	8.2	18.0
	50-	155.1(5.9)	57.7(9.7)	23.8(3.8)	79.0(10.2)	33.5	6.1	13.5	41.8	5.7	14.2	34.5
	60-	153.2(5.9)	56.1(10.1)	3.9(3.9)	79.5(10.5)	45.6	9.8	18.7	48.4	7.3	19.4	46.2
	70-	150.9(6.6)	52.1(10.3)	22.6(3.8)	79.6(20.2)	52.9	11.2	19.2	51.1	9.2	20.5	52.1
	Total	156.0(6.1)	56.5(9.1)	23.3(3.8)	75.6(9.7)	20.6	4.7	11.0	31.3	5.6	11.0	25.2

BMI, body mass index; DM, diabetes mellitus; HBP, high blood pressure; HTC, high total cholesterol; HTG, high triglycerides; IFG, impaired fasting blood glucose; L HDL-C, low high density lipoprotein-cholesterol; WC, waist circumference; ≥2RFs, ≥2 risk factors.

Results

General status of eligible samples

Overall, 13 study projects conformed with the criteria for recruitment, in which half of them consisted of population samples from several to more than 10 districts. These samples covered the sampling populations of 21 provinces, municipalities and autonomous regions including: Heilongjiang, Liaoning, Jilin, Beijing, Shanxi, Inner Mongolia, Tianjin, Shaanxi, Xinjiang, Ningxia, Gansu, Sichuan, Guangdong, Guangxi, Jiangsu, Anhui, Shanghai, Zhejiang, Shangdong, Henan, Hunan and Taiwan. Most of them were cluster samples. Data from the National Nutrition Examination Survey of Mainland and Taiwan were random samples. Study subjects included urban inhabitants, suburban peasants, inland peasants, fishermen, and industrial workers, among others.

General status of data collection

1 Overall, data of 239 972 persons (113 410 men and 126 562 women) were available for analysis. Except for the groups of men and women over the age of 70 years, the remaining gender and age-specific groups had at least 10 000 persons each. However, among them only 111 411 persons (53 103 men and 58 308 women) had waist circumference data. About 80 000 persons (similar numbers of men and women) had blood chemistry data. Except for a few groups, the subjects in each gender and age-specific group with specific risk factor data were more than 1000 persons.

2 The means and standard deviations of height, body weight and body mass index of each gender specific and age-specific group, and the mean and standard deviation of waist circumference, as well as the prevalence of risk factors, are shown in Table 1. Starting with the 20-year group, the mean body mass index increased for every 10-year group, and reached a maximum in the 50-year group, then decreased progressively with the 60-year group and beyond in men. The maximum mean body mass index was reached with the 60-year group of women, then decreased progressively in the 70-year and above group. The changes of waist circumference illustrated a similar pattern. Overall, the mean body mass index of women was higher than that of men; however, the waist circumference of men was higher than that of women. The prevalence of each risk factor increased with increasing age in both men and women.

Rate of risk factor stratified by body mass index or waist circumference, and age standardized rate

The age standardized rates of risk factor was stratified by body mass index of combined age groups (Fig. 1), and age standardized rates of abnormal risk factor was stratified by waist circumference (Fig. 2). Figures 1 and 2 showed an increasing trend for each risk factor with increasing levels of body mass index or waist circumference. However, the increase of abnormal serum total cholesterol was not significant in women.

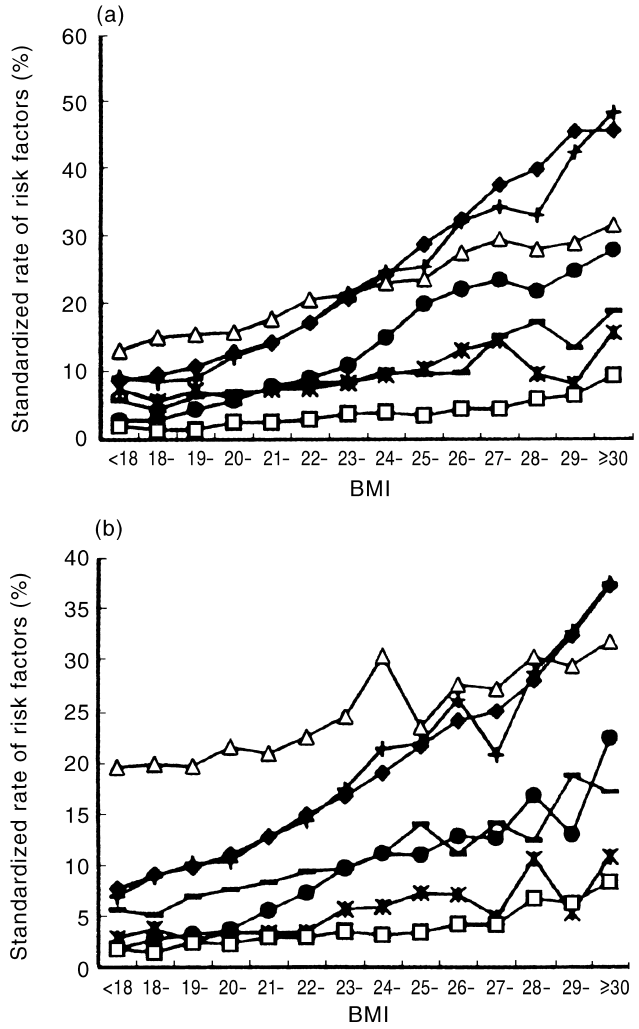

Figure 1. (a) Relation between body mass index in men and the standard rate of risk factor. (b) Relation between body mass index in women and the standard rate of risk factor.

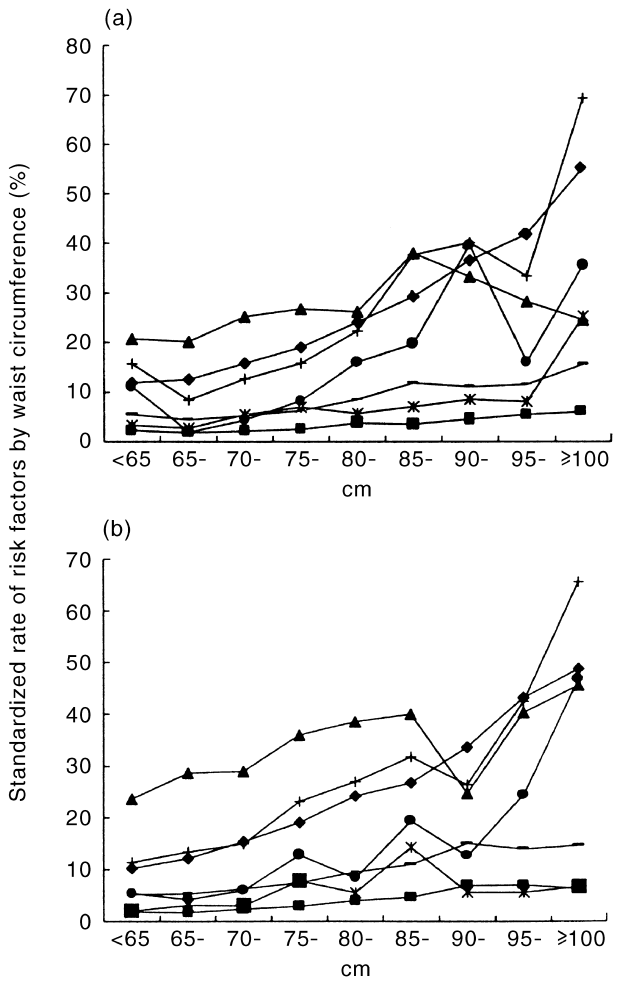

Figure 2. (a) Relation between waist circumference in men and standardized rate of risk factor. (b) Relation between waist circumference in women and standardized rate of risk factor.

Positive and negative predictive values, sensitivity, specificity for each risk factor of gender and age-specific groups stratified by different cut-off points of body mass indices

Owing to the small number of persons in the 70-year and above groups, the 60- and 70-year and above groups were merged in the analysis. The results demonstrated that specificity and positive predictive value increased progressively with increasing cut-off point of body mass index, and the sensitivity and negative predictive value decreased progressively with increasing cut-off point of body mass index in each gender and age-specific group. The cut-off points 23, 24, 25 (kg/m^2) of body mass index with fairly good sensitivity and specificity for each risk factor and clustering of risk factors in age-combined groups of men and women were selected as the optional cut-off points for overweight, and the cut-off point of 28 (kg/m^2) with specificity over 90% was selected as the reference cut-off point for obesity. The relevant data for identifying clustering of risk factors at these cut-off points are shown in Table 2. Positive and negative predictive values, sensitivity and specificity for identifying each risk factor at body mass indices of 24 and 28 (kg/m^2) are shown in Table 3.

Positive and negative predictive values, sensitivity and specificity for each risk factor of gender and age-specific groups stratified by different cut-off points of waist circumferences

For the selected cut-off points of waist circumference of 80, 85, 90 (cm) in men, and 75, 80, 85 (cm) in women with fairly good sensitivity and specificity, the relevant data for clustering of risk factor of age combined groups are shown in Table 4. The relevant data of each risk factor for waist circumference of 85 (cm) in men and 80 (cm) in women are shown in Table 5.

Population-attributable risk (PAR percentage) of risk factors above the cut-off points of body mass indices and waist circumference

The population-attributable risk percent of each risk factor at cut-off points 24 and 28 of BMI are summarized in Table 6.

Table 2. Positive and negative predictive values, sensitivity and specificity for identifying clustering of risk factors (= c2Rfs) at Body Mass Index cut-off points of 23, 24, 25 and 28 (kg/m^2)

	BMI (kg/m^2)	Prevalence of clustering of risk factors (%)	Positive predictive value (%)	Negative index (%)	Sensitivity (%)	Specificity (%)	Youden's index (%)
Men	≥23	27.8	37.04	83.71	73.79	51.79	25.58
	≥24	27.8	39.75	81.41	62.07	63.85	25.92
	≥25	27.8	42.96	79.37	49.42	74.79	24.21
	≥28	27.8	51.99	74.50	16.00	94.32	10.32
Women	≥23	25.2	33.47	85.06	73.41	50.92	24.33
	≥24	25.2	35.93	83.37	63.15	62.13	25.28
	≥25	25.2	38.43	81.52	51.20	72.42	23.62
	≥28	25.2	45.81	77.68	22.08	91.21	13.29

BMI, body mass index.

Table 3. Positive and negative predictive values, sensitivity and specificity for identifying risk factor at body mass index cut-off points of 24 and 28 (kg/m^2)

	BMI (kg/m^2)	Risk factor	Prevalence in population (%)	Positive predictive value (%)	Negative predictive value (%)	Sensitivity (%)	Specificity (%)
Men	≥24	HBP	3.5	9.10	83.70	52.43	74.94
		DM	4.8	6.73	96.59	58.45	59.25
		IFG	11.5	15.57	91.35	56.20	60.28
		HTC	27.4	32.52	76.21	49.31	61.34
		L HDL-C	8.3	11.27	93.86	57.26	59.17
		HTG	14.2	21.31	91.19	64.48	60.17
	≥28	HBP	23.5	52.62	78.37	13.39	96.30
		DM	4.8	10.20	95.68	17.00	92.48
		IFG	11.5	21.01	89.29	14.54	92.88
		HTC	27.4	35.80	73.31	10.43	92.93
		L HDL-C	8.3	13.88	92.10	12.62	92.27
		HTG	14.2	26.41	86.96	15.75	92.76
Women	≥24	HBP	0.6	33.71	86.61	58.11	70.33
		DM	4.7	6.61	96.78	60.67	57.94
		IFG	11.0	15.03	91.95	58.39	58.99
		HTC	31.3	36.33	72.52	49.88	60.20
		L HDL-C	5.6	7.43	95.73	56.82	57.78
		HTG	11.0	16.29	93.26	65.56	58.57
	≥28	HBP	20.6	46.62	81.89	20.50	93.91
		DM	4.7	9.00	95.88	22.15	89.01
		IFG	11.0	19.1	90.00	19.91	89.53
		HTC	31.3	39.36	69.78	14.55	89.79
		L HDL-C	5.6	8.81	94.79	18.16	88.78
		HTG	11.0	20.14	90.32	22.30	89.13

BMI, body mass index; DM, diabetes mellitus; HBP, high blood pressure; HTC, high total cholesterol; HTG, high triglycerides; IFG, impaired fasting blood glucose; L HDL-C, low high density lipoprotein-cholesterol.

Those for waist circumferences of 85 (cm) in men and 80 (cm) in women are summarized in Table 7.

Discussion

Studies verified that overweight and obesity correlated significantly with risk factors of cardiovascular diseases, and some research articles reported the use of predictive values of body mass index or waist circumference for these risk factors to assess the optimal cut-off points of body mass index or waist circumference.[5–12]

These articles indicated that the optimal cut-off points varied with body mass index and waist circumference among different survey populations. Nevertheless, body mass index or waist circumference showed a continuous linear relation with these risk factors as well as the clustering of risk factors, without an obvious break point or threshold value,

Table 4. Positive and negative predictive values, sensitivity and specificity for identifying of clustering of risk factors at waist circumference cut-off points of 80, 85 and 90 (cm) in men and 75, 80 and 85 (cm) in women

	WC (cm)	Prevalence of clustering of risk factors (%)	Positive predictive value (%)	Negative predictive value (%)	Sensitivity (%)	Specificity (%)	Youden index (%)
Men	≥80	27.8	36.94	84.03	75.54	49.95	25.49
	≥85	27.8	42.06	80.36	55.84	70.15	25.99
	≥90	27.8	47.08	76.90	34.10	85.12	19.22
Women	≥75	25.2	31.16	85.98	74.00	49.38	23.38
	≥80	25.2	36.26	83.63	56.10	69.46	25.56
	≥85	25.2	41.53	80.67	34.16	85.11	19.27

WC, waist circumference.

Table 5. Positive and negative predictive values, sensitivity and specificity for identifying risk factor at waist circumference cut-off point of 85 cm in men and 80 (cm) in women

	WC (cm)	Risk factor	Prevalence in population (%)	Positive predictive value (%)	Negative predictive value (%)	Sensitivity (%)	Specificity (%)
Men	≥85	HBP	23.5	42.59	79.89	46.24	77.41
		DM	4.8	6.56	96.49	49.75	66.11
		IFG	11.5	16.30	90.83	48.48	67.21
		HTC	27.4	35.81	73.50	41.78	68.32
		L HDL-C	8.3	10.90	94.00	49.19	66.43
		HTG	14.2	19.70	91.50	57.18	66.41
Women	≥80	HBP	20.6	38.20	84.70	54.62	73.98
		DM	4.7	6.82	97.29	57.72	65.77
		IFG	11.0	15.90	91.98	51.87	66.80
		HTC	31.3	38.11	71.26	41.89	67.92
		L HDL-C	5.6	7.79	95.87	50.59	65.71
		HTG	11.0	15.23	94.41	61.01	46.30

DM, diabetes mellitus; HBP, high blood pressure; HTC, high total cholesterol; HTG, high triglycerides; IFG, impaired fasting blood glucose; L HDL-C, low high density lipoprotein-cholesterol; WC, waist circumference.

and a substantial overlap existed in the distribution curve of body mass index or waist circumference for populations with or without certain risk factors. Therefore any cut-off point is a relative, arbitrary value, yet it is based on the scientific evidence. The aim of the study on the optimal cut-off points of body mass index and waist circumference in Chinese adults is to offer an alert about the practical boundary for initiating intervention to prevent and control the increase in the risk factor of the most chronic diseases as early as possible, but not cause undue psychological pressure to the general public, as well as to accommodate the availability of manpower and material resources for prevention and treatment of these problems. For this purpose, the positive and negative predictive values, sensitivity and specificity for identifying each risk factor at different cut-off points of body mass indices and waist circumferences were analysed, and the cut-off points with fairly good sensitivity, specificity, and relatively low false positive rate were established. Population-attributable risks at different cut-off points were estimated and showed that if intervention started at these points, it would be possible to prevent the percentage of risk factors in the population. Based on the above results, the panel arrived at a recommendation for the optimal cut-off points for body mass index and waist circumference for Chinese adults.

Recommendations on cut-off points of body mass index in Chinese adults

The panel recommended that a body mass index of 24 (kg/m^2) be nominated as the cut-off point of overweight for Chinese adults. This is based on the following:[1] At the cut-off point of 24 (kg/m^2), the specificity was slightly high – close to 60% – and the false positive rate was near 40%.[2] According to population-attributable risk analysis, approximately 34–40% of the population accounted for a body mass index ≥ 24 (kg/m^2). If the body mass index was controlled below this cut-off point, it was possible to prevent 38–45% of high blood pressure, 33–37% of diabetes mellitus, 23–33% of low high-density lipoprotein cholesterol, 50–60% of high triglyceride and 45–50% clustering of risk factors in Chinese

Table 6. Population-attributable risks [PAR(%)] for risk factors by body mass index cut-off points of 24 and 28 (kg/m2)

Risk factor		Men		Women	
		OR†	PAR (%)	OR†	PAR (%)
Overweight	HBP	3.69	45.9	2.76	38.4
BMI = B	DM	2.40	36.8	2.14	32.8
24 kg/m^2	IFG	2.12	31.8	2.02	30.4
	HTC	1.85	26.1	1.49	17.4
	L HDL-C	1.70	22.9	2.15	33.1
	HTG	4.26	58.5	3.26	49.9
	≥2RFs	3.49	51.9	2.84	44.9
Obesity	HBP	3.17	11.5	2.61	12.7
BMI = M	DM	2.55	11.0	2.52	14.9
28 kg/m^2	IFG	2.16	8.4	1.86	9.0
	HTC	1.65	5.0	1.44	4.8
	L HDL-C	1.29	2.3	2.04	10.7
	HTG	2.60	11.9	2.63	16.5
	≥2RFs	3.02	14.7	2.68	17.0

†Age-adjusted OR value

DM, diabetes mellitus; HBP, high blood pressure; HTC, high total cholesterol; HTG, high triglycerides; IFG, impaired fasting blood glucose; L HDL-C, low high density lipoprotein-cholesterol; OR, odds ratio; PAR, population-attributable risks; WC, waist circumference.

Table 7. Population-attributable risks [PAR(%)] for risk factors by waist circumference cut-off points of 85 (cm) in men and 80 (cm) in women

Risk factor	Waist circumference (cm)			
	Men ≥ 85		Women ≥ 80	
	OR†	PAR (%)	OR†	PAR (%)
HBP	3.44	41.3	3.30	42.8
DM	1.99	25.5	2.70	37.4
IFG	2.26	30.3	2.31	31.6
HTC	1.44	13.2	1.47	14.2
L HDL-C	2.76	38.0	1.97	25.4
HTG	4.21	54.0	3.80	50.5
≥2RFs	4.67	57.7	3.39	46.6

†Age-adjusted OR value

DM, diabetes mellitus; HBP, high blood pressure; HTC, high total cholesterol; HTG, high triglycerides; IFG, impaired fasting blood glucose; L HDL-C, low high density lipoprotein-cholesterol; OR, odds ratio; PAR, population-attributable risks.

adults. If a body mass index was set at a cut-off point of 23 (kg/m^2), a value recommended by the Asia Obesity Workshop, although the sensitivity was quite high, the false positive rate would be more than 50%. Besides, persons with body mass index of 23 (kg/m^2) and over would constitute more than 50% of the adult population, which would become a heavy burden on the society. If a body mass index was set at 25 (kg/m^2) as the cut-off point according to the current international criteria, the total population with this value of body mass index would account for 20–30%, and the sensitivity for identifying most of the risk factors would be less than 40%. After comparison, it was determined that a body mass index of 24 (kg/m^2) would be the optimal cut-off point for Chinese adults. The panel also recommended a body mass index of 28 (kg/m^2) as the cut-off point of 'obesity' for Chinese adults, both men and women; the specificity for identifying risk factors and clustering of risk factors would reach 90% or be close to it, that is, the false positive rate would be less than 10%. Persons with a body mass index of 28 (kg/m^2) and over accounted for 8–12% of the total population. If this part of population were treated with appropriate drugs, it would prevent clustering of risk factors in 14.7% of men and 17.0% of women and thus would assist in decreasing the incidence of atherosclerotic diseases.

Recommendations on cut-off points of waist circumference for Chinese adults

According to the assessment of sensitivity and specificity, if a waist circumference of 85 (cm) was set as the cut-off point in men, its sensitivity would be more than 40%, and the false positive rate would only be 30% or so, and persons with

Table 8. Classification of Overweight and Obesity in Chinese Adults

	Body mass index (kg/m^2)	Risk of related diseases† Waist circumference (cm)	
		Men <85 Women <80	Men ≥85 Women ≥80
Low body weight‡	<18.5	–	–
Normal body weight	18.5–23.9	–	Increased
Overweight	24.0–27.9	Increased	High
Obesity	≥28	High	Very high

†Related diseases including high blood pressure, diabetes mellitus, abnormal blood lipid and clustering of risk factors.

‡Low body mass index may predict the possibility of other health problems.

cut-off points of ≥85 (cm) would account for 35% of the total men population. If the waist circumference in men was maintained under 85 (cm), it would prevent about 58% clustering of risk factor. If a waist circumference was set at 80 (cm) as the cut-off point in women, the sensitivity for identifying most risk factors would reach over 50%, and the specificity would approach 70%. Persons with waist circumference ≥80 (cm) would account for 35% of the total female population. The effect of controlling waist circumference in women at <80 (cm) would be similar to controlling it to 85 (cm) in men; it may prevent 47% of clustering of risk factors. As a summary of the above discussion, the panel recommended 85 (cm) as the optimal cut-off point of waist circumference for men, and 80 (cm) for women (Table 8).

References

1. Collaborative Study Group on Trends of Cardiovascular Diseases in China and Preventive Strategy. Current status of major cardiovascular risk factor in Chinese populations and their trends in the past two decades. Chinese J Cardiovascular Dis 2001; 29: 74–79 (in Chinese).
2. Zhang HY, Yang J, Zhou BF, Wu YF, Li Y, Tao SC. Prospective investigation of risk factors for stroke among ten populations of China. Chronic diseases prevention and control of China. 1996; 4: 150–152, 172 (in Chinese).
3. Zhou BF, Wu YF, Li YH, Davis EC, Stamler J. Risk factors and 13-year incidence of coronary heart disease in a Chinese population cohort. Abstracts of the 5th International Conference on Preventive Cardiology. Japanese. J Cardiovascular Dis Prevention 2001; 36 (Suppl.): 110.
4. WHO. Obesity: Preventing and managing the global epidemic. Report of a consultation (2000). WHO Technical Report, Series 894. Geneva: WHO, 2000.
5. Willet WC, Dietz WH, Colditz GA. Guidelines for healthy weight. N Engl J Med, 1999; 341: 427–433.
6. Ashton WD, Nanchahal K, Wood DA. Body mass index and metabolic risk factors for coronary heart disease in women. Eur Heart J 2001; 22: 46–55.
7. Han TS, van Leer EM, Seidal JC, Lean ME. Waist circumference action levels in the identification of cardiovascular risk factors: Prevalence study in a random sample. BMJ 1995; 311: 1401–1405.
8. Okosun IS, Prewitt TE, Cooper RS. Abdominal obesity in the United States: Prevalence and attributable risk of hypertension. J Human Hyperten 1999; 13: 425–430.
9. Okosun IS, Cooper RS, Prewitt TE, Rotimi CN. The relation of central adiposity to components of the insulin resistance syndrome in a biracial US population samples. Ethn Dis 1999; 9: 218–229.
10. Okosun IS, Rotimi CN, Forrester TE, Fraser H, Osotimehin B, Muna WF, Cooper RS. Predictive value of abdominal obesity cut-off points for hypertension in blacks from West African and Caribbean island nations. International J Obesity 2000; 24: 180–186.
11. Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Varying sensitivity of waist action levels to identify subjects with overweight or obesity in 19 populations of the WHO MONICA Project. J Clin Epidemiol 1999; 52: 1213–1224.
12. Okosun IS, Liao YL, Rotimi CN, Choi S, Cooper RS. Predictive values of waist circumference for dyslipidemia, type 2 diabetes and hypertension in overweight white, black, and Hispanic American adults. J Clin Epidemiol 2000; 53: 401–408.

Appendix

The data for meta-analysis of this project came from 13 studies. Many individuals devoted themselves to this study. The collaborative institutions are as follows:

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