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Citation	Diabetes Research And Clinical Practice, 2005, v. 67 n. 3, p. 251-257
Issued Date	2005
URL	http://hdl.handle.net/10722/48557
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The US National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III) prevalence of the metabolic syndrome in a Chinese population: the Hong Kong Cardiovascular Risk Factor Study

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Short title: Metabolic syndrome in Chinese

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Abstract

To assess the prevalence of the metabolic syndrome disease cluster in the Hong Kong Chinese population we applied the US National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III) guidelines and was present if ≥3 of the following conditions are present: Hypertension ≥130/85mmHg; fasting plasma glucose was ≥6.1mmol/L; fasting plasma triglycerides ≥1.69mmol/L; fasting HDL-cholesterol <1.04 or <1.29mmol in males and females, respectively; or subjects were receiving treatment for their condition; waist circumference >88 or 102cm (Asian WHO criteria ≥80 or 90cm) in females and males, respectively. A total of 16.7% (17.1 (95%CI 15.7-18.5)% age and gender-adjusted) of the 2,893 subjects had the metabolic syndrome. The prevalence of having at least 2, 3, 4 or 5 components was 34.5, 16.7, 6.4 and 1.4%, respectively. The prevalence increased from 3.1% in those aged 25-29 years to 41.0% in those aged over 70 years. Using the 2001 Census, 880,499 Hong Kong residents would have the metabolic syndrome. If the WHO recommended waist circumference for Asians is used the age and gender-adjusted prevalence is significantly higher at 21.2% (21.9 (95%CI 20.4-23.4)%). In summary, the high prevalence of the metabolic syndrome in adult Hong Kong Chinese, particularly in the elderly forewarns a rapidly increasing problem in Mainland China, and other Asian populations, which may have overwhelming public health ramifications.

Keywords: blood pressure, cardiovascular disease, Chinese, cholesterol, dyslipidaemia, guidelines, hypertension, metabolic syndrome, obesity, Type 2 diabetes mellitus

Introduction

The constellation of cardiovascular risk factors that includes high central adiposity, blood pressure, glucose and triglycerides with low high-density lipoprotein (HDL) cholesterol levels is termed the metabolic syndrome. Individuals with this disease cluster have been reported to experience increased morbidity and mortality [1]. However, the criteria for defining the metabolic syndrome have yet to be standardised, which limit the ability to draw comparisons regarding the prevalence of this condition between different populations. The recent National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III) guidelines [2] provide a useful basis for the characterisation of this condition. This has led to the first reports on the prevalence of the metabolic syndrome in Caucasian populations [3-5], but are otherwise limited [6-8], highlighting the need for such data. In this study we report the prevalence of the metabolic syndrome and its components in a population-based study of 2,843 Chinese adults.

Methods

In a cardiovascular risk factors prevalence study, 7730 Chinese (25-74 years) were randomly selected for telephone interviews in Hong Kong from 1994 to 1996, with a response rate of 78%. Subjects with serious diseases such as cancer or who were hospitalised were excluded. Information collected included demographic characteristics, lifestyle factors and disease history were collected using a standardised questionnaire modified from that used in the 1992 Singapore National Health Survey. The method of telephone interview was validated in a morbidity survey in Hong Kong [9], and the study complied with the Declaration of Helsinki. The study was approved by the University of Hong Kong Ethics Committee and all subjects gave written, informed consent prior to participating in the study.

A total of 2843 subjects (aged 25-74 years) had physical examinations, including anthropometry and fasting blood tests. The detailed methods of measurement had been reported elsewhere [10,11]. The attendees and non-attendees were shown to match the general population and non-attendance bias should

be small [10]. This study is the only representative population-based study performed to date in Hong Kong

The NCEP ATP III guidelines [2] classify individuals as having the metabolic syndrome if they possess three or more of the following criteria:

- High blood pressure: if their systolic and/or diastolic blood pressures were ≥130/85 mm Hg or were receiving blood pressure lowering drugs
- Hyperglycaemia: fasting plasma glucose was ≥6.1 mmol/L (110 mg/dL) or were receiving glucose lowering drugs
- Hypertriglyceridaemia: fasting plasma triglycerides ≥1.69 mmol/L (150 mg/dL)
- Low HDL-cholesterol: fasting HDL-cholesterol <1.04 or 1.29 mmol (40 or 50 mg/dL) in males and females, respectively
- Central obesity: waist circumference >88 or 102 cm in females and males, respectively. However, the World Health Organisation has recognised the disproportionate contribution of obesity to the development of cardiovascular risk factors in Asians and has provisionally lowered the classification of central obesity to ≥80 or ≥90 cm in females and males, respectively [12], which we therefore included in a subanalysis of the data.

The age and gender-adjusted prevalence rates of the metabolic syndrome and central obesity were determined using direct standardisation based on the population derived from the Hong Kong 2001 Census. The calculations were made using the statistical package Intercooled Stata 7.0 for Windows, 2002 (Stata Corporation, TX, USA) and presented as mean (95% confidence intervals).

Results

Of the 2,843 subjects, the 48.8% males generally presented with a worse metabolic profile having increased anthropometric, blood pressure and lipid levels (Table 1). Although fasting glucose levels were also higher in the males, the females appeared more insulin resistant with higher fasting insulin levels and

both 2 hour post load insulin and glucose levels. The proportion of the 2,843 adult Chinese subjects with the metabolic syndrome components hyperglycaemia, high blood pressure, hypertriglyceridaemia, low HDL-cholesterol and central obesity are described in Table 2. We found 65.4, 34.5, 16.7, 6.4 and 1.4% of the population had at least 1, 2, 3, 4 or 5 components, respectively (Figure 1). The NCEP ATP III guidelines consider subjects to have the metabolic syndrome if three or more components are present, therefore almost one fifth of the adult Hong Kong population can be classified as having this condition. Of the 6.71 million Hong Kong population determined in the 2001 Census, 4.68 million were aged over 25 years. Our data suggest 880,499 residents have the metabolic syndrome, with a direct age and gender standardised prevalence of 17.1 (15.7-18.5)%, with 15.3 (13.4-17.4) and 18.8 (16.9-20.8)% in males and females, respectively.

The WHO has revised their obesity guidelines for Asian populations, with waist circumferences of ≥80 or ≥90 cm in females and males, respectively, considered centrally obese [12]. Incorporating this definition of obesity, the age and gender-standardised prevalence of central obesity was considerably higher than those described by the NCEP (25.2 (23.5-26.8) vs 7.3 (6.2-8.3)%). Similar findings were observed in the gender-specific groups with prevalences of 29.3 (27.0-31.5) and 21.1 (18.9-23.3)% in the females and males, respectively. This had some impact on the proportion of metabolic syndrome components, with the prevalence being 66.4, 39.6, 21.2, 10.0, and 3.3% for at least 1, 2, 3, 4 or 5 components, respectively. This is shown for both males and females in Figure 1 B. The age and gender-standardised prevalence of the metabolic syndrome using the WHO Asian obesity criteria was 21.9 (20.4-23.4)%, and was 20.2 (18.0-22.4) and 23.6 (21.6-27.7)% in males and females, respectively. Therefore, when the WHO Asian obesity criteria were included, the prevalence of those considered to have the metabolic syndrome significantly increased from 17.1 to 21.9% of the population (McNemar test $p<0.001$). All of the subjects classified with NCEP central obesity and 91.5% of those with the Asian obesity guidelines had at least one other metabolic syndrome component.

There was a clear age-related increase in the prevalence of the metabolic syndrome in this population (Figure 2). The changes were gender-specific, with males in the lowest age range (25-29

years) initially having a prevalence of the metabolic syndrome nearly 5 times higher that in females, although the rates were still the lowest in this group (4.7 vs 1.0%). The prevalence in males continued to be greater than females until the fourth decade where the prevalence was similar (11.7 vs 11.8%). After the fourth decade, the metabolic syndrome was more common in females, with those in the seventh decade having almost twice the prevalence seen in the males (53.7 vs 27.7%). Using the Asian criteria for obesity these trends were again observed, but the absolute prevalence rates were higher (figure 2B).

Discussion

Using the NCEP ATP III guidelines, 16.7% (17.1 (15.7-18.5)% age and gender-adjusted) of the Hong Kong population had at least three metabolic syndrome components and were classified as having the condition. For females aged of 70 years, the metabolic syndrome was found in over half. Comparisons of the prevalence rates of the metabolic syndrome with other populations are generally unreliable due to the variety of definitions that have been applied in a variety of populations [1], highlighting the need for the application of standardised criteria. However, the same definition has been applied to the USA National Health and Nutrition Examination (NHANES III) survey, where a prevalence of 21.8% [3] was described which is slightly higher than that in the present study. The levels of white and African Americans were similar to the national average, yet the prevalence rate was nearly 10% higher in Hispanic Americans at 31.9% [3], which is also considerably higher than that in our Chinese population. In Singapore, the standardised prevalence of the metabolic syndrome by the NCEP ATP III guidelines was lower (12.1%) than in the current study [6]. The prevalence varied between the three major ethnic groups, being lowest in the Chinese at 9.4%, almost half that in the Hong Kong Chinese population, with Malays being intermediate (18.7%) and Indians having the highest prevalence at 20.4% [6]. In Taiwan 15.4% and in Korea 6.8% were found to have the metabolic syndrome using the same guidelines [7,8].

Similar prevalences of high blood pressure and low HDL-cholesterol were seen in Hong Kong and the USA, yet hypertriglyceridaemia was found in only two thirds of those seen in the USA (30.0%) and much lower than in a population-based study from Shanghai (54.7%) [3,13]. In contrast the prevalence of

hyperglycaemia in the Hong Kong population was double that in the USA (25.1 vs 12.6%), being found in one quarter of the adult population. The hyperglycaemia prevalence rate was higher than each of the ethnic groups reported from the USA, including Hispanic Americans (20.0%) and higher than in data from Turkey (16.7%) [5] or in an older Italian population (22.2%, aged 40-79 years) [4].

Obesity is a major determinant of components of the metabolic syndrome and data suggests that risk for these components can be observed at lower levels of both body mass index and waist circumference in Asians than in Caucasians [12,14-16]. In part this difference may be the result of a greater proportion of body fat for a given body mass index level in Asian subjects compared to equivalent Caucasians [17]. The use of the Asian WHO guidelines for central obesity significantly increased the proportion of the population characterised as obese in the current population from 7.1 to 25.8%. This large increase resulted in a significant increase in the age and gender-adjusted prevalence of the NCEP ATP III metabolic syndrome of 4.8 percentage points. These data show that the majority of subjects (91.5%) with a waistline of this magnitude, despite the use of lower waist circumference levels, already possess at least one component of the metabolic syndrome. Indeed we have previously shown the relationship between the presence of cardiovascular risk factors and waist circumference is continuous with the narrowest waist being associated with the lowest risk [14]. In that study, the risk for instance of having hypertension was 20% higher in subjects with a waist circumference of 70-75 cm compared to those with a waist less than 70 cm. The use of the lower waist circumference criterion, also significantly increased the prevalence of the metabolic syndrome in the Singaporean 18.2% (Chinese 14.8%, Malay 24.2%, and Indian 28.8) [6], Taiwanese 21.2% [7] and Korean 10.9% populations [8]. This highlights the importance of ethnicity-specific obesity guidelines and suggests that the cut off criteria for central obesity in Asians may still be too high, and thus may still underestimate the prevalence of the metabolic syndrome in this population.

The clear changes observed in the gender-specific relationship with age are likely the result of two factors. Male subjects carrying a number of components of the metabolic syndrome cluster are more likely to succumb earlier to the associated cardiovascular diseases, particularly when in conjunction with

adverse lifestyle patterns such as smoking, which would then lower the prevalence of this constellation of disorders [18]. In conjunction, in females hormonal changes associated with menopause are likely to increase prevalence of these components and subsequent risk of cardiovascular disease [19]. These age-related changes might have a significant impact on the health of the population, particularly in females where, by the age of 70 years, over half have the metabolic syndrome.

The prevalence of the metabolic syndrome in the adult Hong Kong population is alarmingly high, particularly in the elderly. As China increases its rate of modernisation and becomes more modernised and urbanised like Hong Kong and Singapore, the prevalence of the metabolic syndrome in Mainland China will approach that observed in Hong Kong and would suggest a high proportion of its 1.2 billion population are at risk of the adverse health consequences of this condition. Clearly, without prevention and aggressive treatment of these conditions the potential socioeconomic, medical and societal ramifications in Hong Kong and China may be overwhelming. Urgent public health actions are needed to control the worsening situation in Hong Kong, China, as well as in the Asia-Pacific Region.

Acknowledgements

The Hong Kong Cardiovascular Risk Factor Prevalence Study Steering Committee consisted of the following members: ED Janus (Chairman), CS Cockram, R Fielding, AJ Hedley, P Ho, CP Lau, M Lo, SL Lo, PL Ma, JRC Maserei, YT Tai, B Tomlinson, SP Wong, JLF Woo. Funding came from the Hong Kong Health Services Research Committee (HSRC# 411026), the University of Hong Kong Committee on Research and Conference Grants, the Hong Kong Research Grants Council (Grant 407/94m) and the Hong Kong Society for the Aged. We would like to thank MR Janus, survey centre nurse coordinator, SF Chung for her assistance in recruitment and telephone interview coordination, TJT Cheung, RWY Lam, RYH Leung and SCH Wong for special assistance in laboratory analysis, STS Siu for assistance in data processing, and all the interviewers.

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Table 1 Anthropometric, blood pressure and plasma biochemical characteristics in the male and female subjects.

Cohort	Males	Females	p value
Number (n=2843)	1388	1455	-
Age (years)	46.2±13.3	45.4±12.6	NS
Systolic blood pressure (mm Hg)	121±18	117±21	<0.001
Diastolic blood pressure (mm Hg)	77±10	73±11	<0.001
Mean arterial pressure (mm Hg)	92±12	87±14	<0.001
Total cholesterol (mmol/L)	5.1±0.9	5.0±1.0	0.038
HDL-cholesterol (mmol/L)	1.16±0.30	1.35±0.32	<0.001
LDL-cholesterol (mmol/L)	3.3±0.8	3.2±0.9	<0.001
Triglyceride (mmol/L)	1.23 (1.17-1.30)	1.01 (0.96-1.05)	<0.001
Fasting glucose (FPG, mmol/L)	5.3 (5.2-5.4)	5.1 (5.1-5.2)	<0.001
Fasting insulin (FPI, pmol/L)	5.1 (4.9-5.5)	5.8 (5.5-6.1)	<0.001
OGTT 2 hour glucose (mmol/L)	6.1 (6.3-6.8)	6.9 (6.8-7.1)	<0.001
OGTT 2 hour insulin (pmol/L)	48.7 (44.8-53.0)	57.8 (54.2-61.5)	<0.001
Body mass index (kg/m^2)	24.3±3.4	23.9±3.8	0.004
Waist circumference (cm)	83.0±9.6	75.3±9.5	<0.001
Waist-to-hip ratio	0.88±0.07	0.81±0.08	<0.001
Tobacco consumption (never, %)	55.4	19.4	<0.001
Alcohol consumption (never, %)	47.8	4.5	<0.001

Mean±SD, Geometric mean (geometric 95 % confidence intervals of the mean); NS=non-significant.

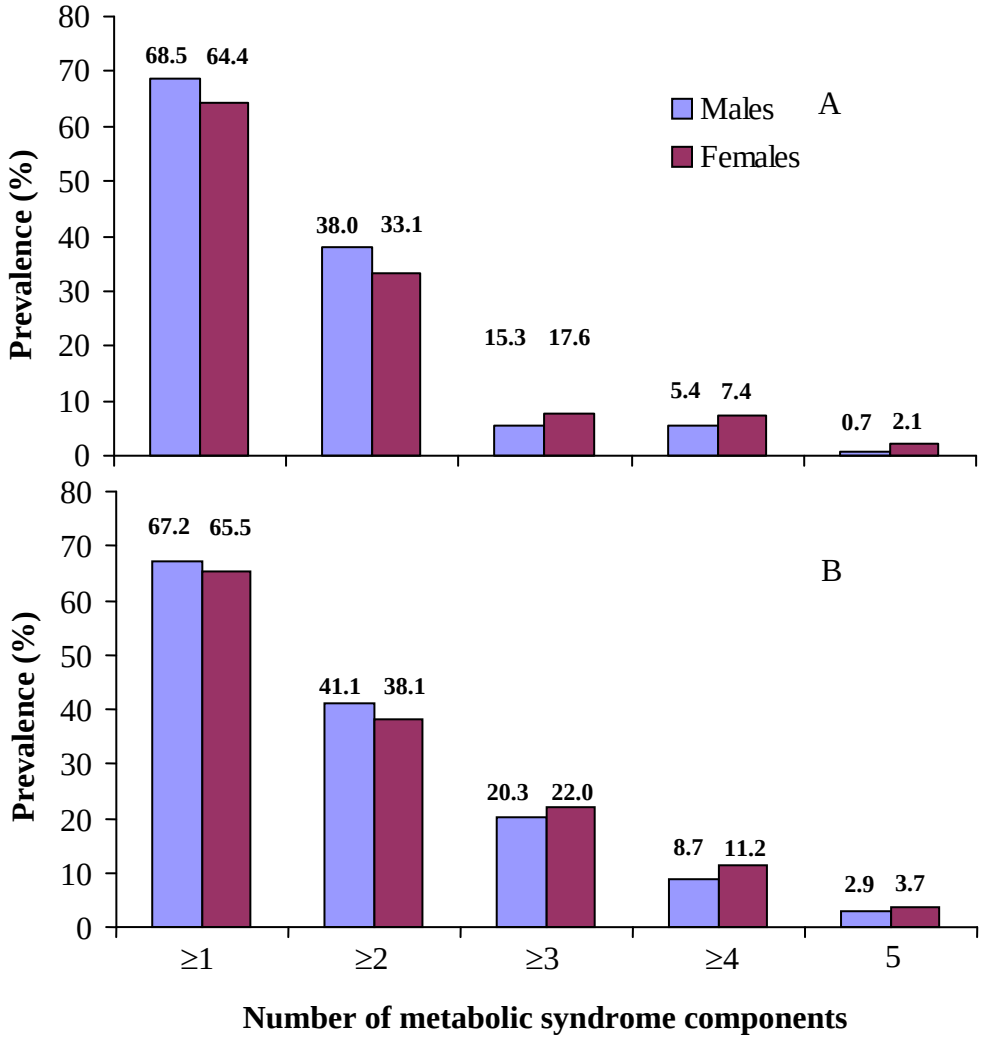
Table 2 Prevalence of individual components of the metabolic syndrome based on National Cholesterol Education Adult Treatment Panel III (NCEP ATP III) guidelines in 2843 Hong Kong Chinese

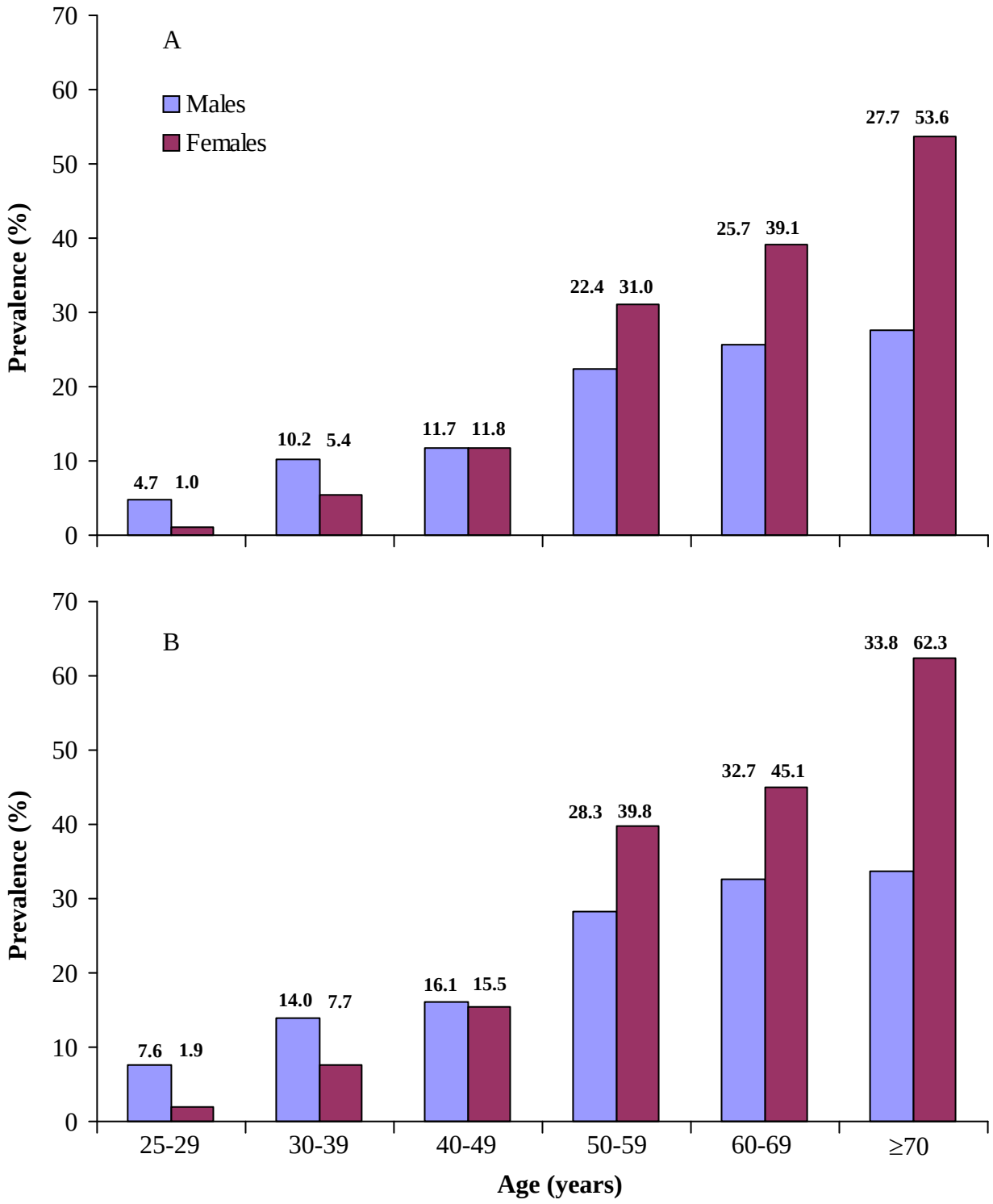
Metabolic syndrome components	Male (n=1388)	Female (n=1455)	Total (n=2843)
Hyperglycaemia	24.0	26.1	25.1
High blood pressure	32.3	26.5	29.3
Hypertriglyceridaemia	24.0	14.7	19.3
Low HDL-cholesterol	40.7	47.6	44.2
Central obesity NCEP	3.5	10.5	7.1
Central obesity WHO	22.0	29.4	25.8

High blood pressure: systolic/diastolic blood pressures were ≥130/85 mm Hg or were receiving blood pressure lowering drugs; Hyperglycaemia: fasting plasma glucose was ≥6.1 mmol/L or were receiving glucose lowering drugs; Hypertriglyceridaemia: fasting plasma triglycerides ≥1.69 mmol/L; Low HDL-cholesterol: fasting HDL-cholesterol <1.04 or 1.29 mmol in males and females, respectively; Central obesity: NCEP (WHO) waist circumference >88 or 102 cm (≥80 or ≥90 cm) in females and males, respectively [2,12]

Figure 1 Gender-specific prevalence of the 2,843 Chinese with one or more components of the National Cholesterol Education Adult Treatment Panel III (NCEP ATP III)-based metabolic syndrome (A) and including the World Health Organisation Asian waist circumference criteria (B)

Figure 2 Gender and age-specific prevalence of the 2,843 Chinese of the National Cholesterol Education Adult Treatment Panel III (NCEP ATP III)-based metabolic syndrome (A) and including the World Health Organisation Asian waist circumference criteria (B)


80
70
60
50
40
30
20
10
0
Prevalence (%)
68.5
64.4
38.0
33.1
15.3
17.6
5.4
7.4
0.7
2.1
Males
Females
A
67.2
65.5
41.1
38.1
20.3
22.0
8.7
11.2
2.9
3.7
B
≥1
≥2
≥3
≥4
5
Number of metabolic syndrome components


A
Males
Females
Prevalence (%)
70
60
50
40
30
20
10
0
4.7
1.0
10.2
5.4
11.7
11.8
22.4
31.0
25.7
39.1
27.7
53.6
B
Prevalence (%)
7.6
1.9
14.0
7.7
16.1
15.5
28.3
39.8
32.7
45.1
33.8
62.3
25-29
30-39
40-49
50-59
60-69
≥70
Age (years)